

# SOLUBILITIES

INORGANIC AND METAL-ORGANIC COMPOUNDS

## K - Z

*A Compilation of Solubility Data  
from the Periodical Literature*

### VOLUME II

#### FOURTH EDITION

by

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A Revision and Continuation of the Compilation

Originated by

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## PREFACE

This volume of SOLUBILITIES completes the fourth revision of the tables of Inorganic and Metal-Organic Compounds. Volume I, published several years ago, includes compounds whose formulas fall alphabetically from A through I. The present Volume, II, covers the solubilities of compounds from K through Z.

In compiling this volume, the systematic search of the literature was extended through the early sixties and thus included several hundred additional references not available at the time of publication of Volume I. The general plan of the tables is alphabetical by elements, both for single compounds and for multicomponent systems. For each compound the solubility in water is followed, in order, by the solubilities in acids, bases, salts, aqueous solvents, anhydrous solvents, and fused salts.

Volume II contains a complete Subject Index and Author Index to all compounds listed in *both* Volumes I and II. Locating data is thereby facilitated, and the systematic arrangement of the tables often allows related results to be found nearby.

The compilation has required accumulating and evaluating the results of a great many investigators. Data which are clearly in error have been omitted, but when there is no clear choice between conflicting results, both sets of data have been included in the tables. When a number of authors have been found to be in substantial agreement, composite tables have been constructed. In addition, much data have been plotted in order to read the average points from a smooth curve.

Dr. Atherton Seidell, through whose efforts three previous editions of this work were completed, passed away before publication of this volume. His dedication to the task of organizing and disseminating technical information has pointed the way toward continuing this series.

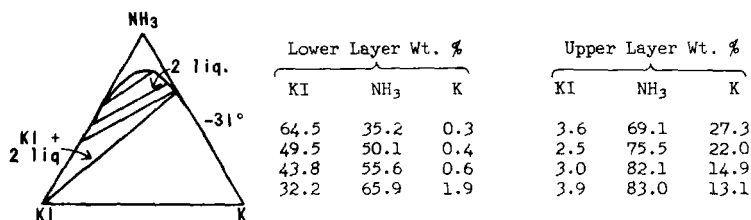
### SOLUBILITY IN LIQUID AMMONIA (Johnston and Meyer, 1949)

Birch and MacDonald, 1947 found the eutectic to occur at  $-157^{\circ}$ . The older data of Ruff and Geisel, 1906 are given in parentheses.

$t^{\circ}$	Gms. K per 100 gms. $\text{NH}_3$	
-100	---	(47.7)
- 50.38	45.56	(48.0)
- 33.5	46.38	
0	49.05	(48.5)

### THE SYSTEM POTASSIUM - POTASSIUM IODIDE - AMMONIA (liq.) AT $-31^{\circ}$ (Cubiceioti, 1949)

Two liquid layers are formed and K and KI are miscible in all proportions only when the mole fraction of  $\text{NH}_3$  is greater than 0.95.



Data for the solubility of potassium and sodium - potassium alloys in ethers (diethylene glycol, tetrahydrofuran, dimethyl ether, cyclic propylene oxide tetramer) are given by Down, Lewis, Moore and Wilkinson, 1957. Blue solutions are obtained.

### SOLUBILITY IN MOLTEN KOH (von Hevesy, 1909)

Difficulty was experienced due to the failure of the excess of K to separate completely from the saturated solution. Time of heating, 50 hours.

$t^{\circ}$	Gms. K per 100 Gms. KOH
480	7.8-8.9
600	3 -4
650	2 -2.7
700	0.5-1.3

A study of the reactions  $\text{KOH} + \text{Na} \rightleftharpoons \text{NaOH} + \text{K}$  at  $550^{\circ}$  was made by Klyashtorny, 1957. Equilibrium was attained within 15 minutes.



# K KALIUM

## SOLUBILITY IN SALTS

The melting point diagrams of these systems generally show a low solubility of metallic potassium in the liquid (~1 mole %), and a region of liquid immiscibility.

K+KBr (Johnson and Bredig, 1958; Rogener, 1937)

K+KCl ( " " " " ; Cubicciotti, 1949)

K+KF ( " " " " ; Bredig, Bronstein, and Smith, Jr., 1955)

K+KI ( " " " " )

Data for the solubility of potassium in solid halides is given by Mollwo, 1933.

Rinck, 1932 studied the reactions  $K + NaF \rightleftharpoons KF + Na$ ,  $K + NaCl \rightleftharpoons KCl + Na$ ,  $K + NaBr \rightleftharpoons KBr + Na$ , and  $K + NaI \rightleftharpoons KI + Na$  at 900° and  $K + NaOH \rightleftharpoons KOH + Na$  at 800°. Klyashtorny, 1957 studied the reaction  $K + NaCl \rightleftharpoons KCl + Na$  at 550°.

## AlO POTASSIUM ALUMINATE $K_2O \cdot Al_2O_3 \cdot 3H_2O$

THE SYSTEM POTASSIUM HYDROXIDE - ALUMINUM HYDROXIDE - WATER AT 30°  
(Jucaitis, 1934)

The mixtures were shaken for 3 months.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
K <sub>2</sub> O	Al <sub>2</sub> O <sub>3</sub>		K <sub>2</sub> O	Al <sub>2</sub> O <sub>3</sub>	
30.21	15.58	K <sub>2</sub> O·Al <sub>2</sub> O <sub>3</sub> ·3H <sub>2</sub> O	39.40	3.01	K <sub>2</sub> O·Al <sub>2</sub> O <sub>3</sub> ·3H <sub>2</sub> O
30.87	12.51	"	41.25	2.20	"
31.65	10.90	"	43.86	1.73	"
32.03	9.79	"	44.74	1.26	"
32.40	8.62	"	45.41	1.80	"
35.67	4.68	"	46.06	1.25	"
38.38	3.93	"	47.83	0.92	"

## AsO POTASSIUM ARSENITES $K_2As_4O_7$ , $K_6As_4O_9 \cdot 12H_2O$

THE SYSTEM POTASSIUM OXIDE, ARSENIC TRIOXIDE AND WATER AT 25°  
(Schreinemakers and De Baat, 1920)

For saturation 4 to 6 weeks agitation at 25° was employed.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
As <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O		As <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O		As <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O	
2.02	0.0	As <sub>2</sub> O <sub>3</sub>	49.21	18.61	D <sub>1.2</sub>	24.16	28.05	D <sub>3.2.12</sub>
22.63	5.61	"	49.02	20.19	"	20.98	32.93	"
36.29	8.79	"	49.47	22.01	(?)	22.47	35.96	"
41.93	9.69	"	49.65	23.00	(?)	29.61	38.32	"
54.02	11.62	"	48.96	24.16	D <sub>3.2.12</sub>	23.82	42.48	KOH·H <sub>2</sub> O
58.11	13.74	D <sub>1.2</sub>	44.84	23.61	"	17.57	43.52	"
53.49	15.24	"	39.49	23.49	"	11.53	44.13	KOH·2H <sub>2</sub> O
49.58	17.28	"	33.60	24.07	"	0.0	45.5	"

$D_{1.2} = K_2As_4O_7 = K_2O(As_2O_3)_2$ ,  $D_{3.2.12} = K_6As_4O_9 \cdot 12H_2O = (K_2O)_3(As_2O_3)_2 \cdot 12H_2O$

POTASSIUM ARSENATES  $xK_2O \cdot yAs_2O_5 \cdot zH_2O$ 

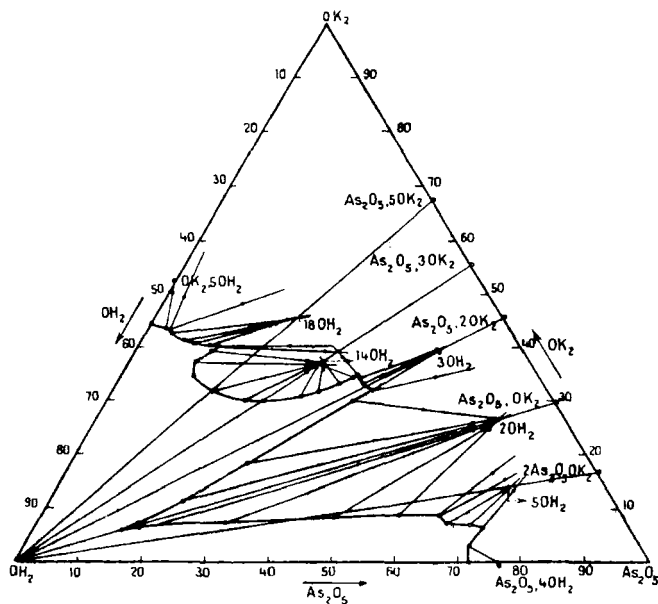
AsO

THE SYSTEM POTASSIUM OXIDE - ARSENIC PENTOXIDE - WATER  
 (20° - Guerin and Duc-Maugé, 1955; Duc-Maugé and Guerin, 1957a;  
 40°, 60° - Duc-Maugé, 1958)

Solid Phase composition ratios are  $K_2O:As_2O_5:H_2O$

% K <sub>2</sub> O	at 20° % As <sub>2</sub> O <sub>5</sub>	solid phase	% K <sub>2</sub> O	at 40° % As <sub>2</sub> O <sub>5</sub>	solid phase	% K <sub>2</sub> O	at 60° % As <sub>2</sub> O <sub>5</sub>	solid phase
0.3	70.3	0:1:4+	0.0	73.8	0:3:5	0.0	74.3	0:3:5
		1:3:4	0.2	73.8	0:3:5	0.2	74.2	0:3:5
6.9	68.7	1:3:4+	8.05	69.8	1:3:4	9.4	70.6	1:3:4
		1:2:5	9.25	65.7	1:2:5	10.4	70.0	1:2:5
~9	61.5	1:2:5+	7.4	18.4	1:1:2	9.15	23.2	1:1:2
		1:1:2	30.1	39.3	1:1:2	32.8	43.3	2:1:3
28.3	36.8	1:1:2+	30.2	36.2	2:1:7	33.2	42.1	2:1:3
		2:1:7	35.8	34.5	2:1:7	32.7	39.8	2:1:7
32.1	32.2	2:1:7+	35.1	33.6	3:1:6	34.8	39.3	2:1:3
		3:1:14	32.7	26.5	3:1:14	37.2	37.4	2:1:3
			40.0	19.7	3:1:14	37.7	30.7	3:1:6
			42.6	13.2	3:1:6	47.5	5.53	1:0:3
			46.8	5.6	5:1:18	49.2	0.0	1:0:3
			47.7	0.0	1:0:3			

(20° isotherm is plotted below)



# K KALIUM

## AsO POTASSIUM ortho ARSENATE $K_3AsO_4$

### THE SYSTEM AsO - POTASSIUM ortho ARSENATE - WATER (Duc-Maugé, 1957)

The results are presented in graphical form. Except for the invariant points, the following data were read from curves drawn by the author. The composition of the highest hydrate is uncertain. [  $x$  = degree of hydration; moles  $H_2O$  per mole  $K_3AsO_4$  in solid phase ]

$t^\circ$	Gms. $K_3AsO_4$ per 100 gms. sat. sol.	$x$	$t^\circ$	Gms. $K_3AsO_4$ per 100 gms. sat. sol.	$x$
-5	21.0	(ICE)	35	57.8	7
-10	29.7	(ICE)	40	59.5	7
-20	37.7	(ICE)	45	62.0	7
-25	40.9	(ICE)	50.3	66.8	7 + 3
-29	43.2	(ICE) + 10(11?)	50.5 *	67.5m	7
-25	45.8	10(11?)	40	66.1m	3
-23	46.9	7 + 10(11?)	60	68.1	3
-20	50.7m	10(11?)	80	70.6	3
-17*	56.2m	10(11?)	98	73.1	3 + 1
-20	48.0	7	110*	75.5m	3
-10	49.6	7	120	74.5	1
0	51.5	7	140	75.8	1
+20	54.6	7	160	77.1	1
30	56.6	7	171b	77.7	1

m = metastable

b = boiling point

\* = melting point

## AsO POTASSIUM MONOHYDROGEN ARSENATE $K_2HASO_4$

### THE SYSTEM POTASSIUM MONOHYDROGEN ARSENATE - WATER (Duc-Maugé, 1957a)

The results are presented graphically. Except for the invariant points, the following data were read from the author's curves. Compositions are expressed in terms of the anhydrous formula  $K_4As_2O_7$ , although this phase was not encountered.

#### STABLE EQUILIBRIA

$t^\circ$	Gms. $K_4As_2O_7$ per 100 gms. sat. sol.	Solid Phase
- 5	23.0	Ice
-10	33.0	"
-17	41.9	" + $K_2HASO_4 \cdot 6H_2O$
-10	44.3	"
0	48.5	"
+10	55.5	"
17	62.9	$K_2HASO_4 \cdot 3H_2O$ + $K_2HASO_4 \cdot 6H_2O$

## STABLE EQUILIBRIA--Cont.

t°	Gms. $K_4As_2O_7$ per 100 gms. sat. sol.	Solid Phase
+20	62.7	$K_2HAsO_4 \cdot 3H_2O$
30	64.5	"
40	67.0	"
60	72.5	"
66.5	74.9	" + $K_2HAsO_4 \cdot H_2O$
70	75.1	"
80	77.5	"
84	78.7	$K_2HAsO_4$ + "
100	79.8	"
120	81.0	"
130	82.4	"

## METASTABLE EQUILIBRIA

t°	Gms. $K_4As_2O_7$ per 100 gms. sat. sol.	Solid Phase
0	60.0	$K_2HAsO_4 \cdot 3H_2O$
18.8*	64.0	$K_2HAsO_4 \cdot 6H_2O$
10-11	71.5	" + $K_2HAsO_4 \cdot H_2O$
20	72.0	"
30	72.5	"
40	72.7	"
60	74.5	"
90	82.0	"
100	87.5	"
20	75.0	$K_2HAsO_4$
40	76.2	"
60	77.2	"
80	78.4	"

\*Melting point

POTASSIUM DIHYDROGEN ARSENATE  $KH_2AsO_4$ 

AsO

THE SYSTEM POTASSIUM DIHYDROGEN ARSENATE - WATER  
(Duc-Maugé, 1957a; Paul, Lal, Gaiind, and Bawa, 1953)

The earlier results (Paul, et.al.) indicate a transition from monohydrate to anhydrous salt at 59.6°. Duc-Maugé points out that the shape of the intersection of the curves at the transition seems to violate the laws of thermodynamics. Only the anhydrous salt was found in the later work.

# K KALIUM

t°	Duc-Mauge (Solid Phase KH <sub>2</sub> AsO <sub>4</sub> throughout)		Paul, Lal, Gaind and Bawa	
	Gms. KH <sub>2</sub> AsO <sub>4</sub> per 100 gms. sat. sol.		Gms. KH <sub>2</sub> AsO <sub>4</sub> per 100 gms. sat. sol.	Solid Phase
- 2.9	15.5*		--	--
- 3.61	--		20.15	ICE + KH <sub>2</sub> AsO <sub>4</sub> ·H <sub>2</sub> O
0	15.7		21.0	KH <sub>2</sub> AsO <sub>4</sub> ·H <sub>2</sub> O
6	(15.9) <sup>a</sup>		--	--
10	18.3		23.2	KH <sub>2</sub> AsO <sub>4</sub> ·H <sub>2</sub> O
20	22.0		25.8	"
30	25.2		28.3	"
40	28.0		31.7	"
50	32.0		32.7	"
59.6	--		34.1	KH <sub>2</sub> AsO <sub>4</sub> ·H <sub>2</sub> O + KH <sub>2</sub> AsO <sub>4</sub>
60	35.0		34.7	KH <sub>2</sub> AsO <sub>4</sub>
70	38.3		40.8	"
80	41.6		--	--
90	45.0		--	--
100	48.0		--	--
105	49.5		--	--

\*Solid Phase ICE + KH<sub>2</sub>AsO<sub>4</sub>

<sup>a</sup>Field, 1859; Sp. gr. = 1.1134. At 7°, Muthmann and Kunze, 1894 found 28.24 gms. KH<sub>2</sub>AsO<sub>4</sub> dissolved in 100 cc. sat. sol.

## THE SYSTEM KH<sub>2</sub>AsO<sub>4</sub> - H<sub>3</sub>AsO<sub>4</sub> - H<sub>2</sub>O AT 25° (Paul, Lal, Gaind, and Bawa, 1952)

Sat. Sol. Wt. %		Wet Residue Wt. %		Solid Phase
KH <sub>2</sub> AsO <sub>4</sub>	H <sub>3</sub> AsO <sub>4</sub>	KH <sub>2</sub> AsO <sub>4</sub>	H <sub>3</sub> AsO <sub>4</sub>	
3.40	53.90	2.01	67.00	H <sub>3</sub> AsO <sub>4</sub>
7.65	55.90	6.90	65.00	"
15.10	54.90	11.60	63.90	"
21.50	51.10	17.40	57.00	"
26.00	49.00	24.80	51.50	"
31.90	44.50	30.50	46.50	"
29.50	41.90	36.50	42.90	Solid Solution
27.00	35.00	35.00	41.20	"
25.90	9.28	60.90	3.90	"
30.13	14.79	56.60	10.04	"
26.30	25.60	56.69	18.01	"
25.80	31.80	49.50	28.20	"
28.50	39.00	39.90	38.00	"
26.90	36.90	32.50	36.00	KH <sub>2</sub> AsO <sub>4</sub> ·H <sub>2</sub> O
26.00	5.01	50.00	2.70	"
29.20	13.90	58.50	7.00	"
26.50	12.50	56.60	6.50	"

## SOLUBILITY OF KH<sub>2</sub>AsO<sub>4</sub> IN GLYCEROL

100 gms. glycerol (d<sub>15</sub> = 1.256) dissolve 50.1 gms. potassium arsenate at 15-16°. (Ossendowski, 1907)

POTASSIUM URANYL ARSENATE  $K(UO_2)AsO_4$ 

AsO

The solubility product in water containing  $H_2SO_4 + HNO_3$  over the pH range 2.05 - 5.30 is  $[K^+][UO_2^{++}][AsO_4^{---}] = 2.52 \times 10^{-23}$  (Chukhlantsev and Sharova, 1956).

POTASSIUM TETRAPHENYL BORATE  $KB(C_6H_5)_4$ 

B

t°	Ksp in H <sub>2</sub> O	Method	Author
20	$2.25 \times 10^{-8}$	radio tracers	Geilmann and Gebauhr, 1953
25	$3.3 \times 10^{-8}$	conductivity	Rudorff and Zannier, 1953

POTASSIUM BOROHYDRIDE  $KBH_4$ 

BH

SOLUBILITY IN WATER, METHANOL AND MIXTURES AT 20°  
(Barus, Bragdon and Hinckley, 1954)

Vol. % CH <sub>3</sub> OH in solvent	0	20	40	60	80	100
Gms. $KBH_4$ per 100 gms. solvent	19.0	13.5	9.1	5.0	2.1	0.4

SOLUBILITY IN OTHER SOLVENTS  
(Barus, Bragdon and Hinckley, 1954)

100 gms. 95%  $C_2H_5OH$  dissolve 0.25 g  $KBH_4$  at 25°.

Less than 0.01 gms.  $KBH_4$  dissolve in 100 gms. benzene, hexane, ether, dioxane, isopropylamine, tetrahydrofuran, acetonitrile.

POTASSIUM FLUOBORATE  $KBF_4$ 

BF

SOLUBILITY IN WATER

t°	Gms. $KBF_4$ per 100 gms. Sat. Sol.	Author
20	0.44	Stolba, 1889
25	0.574	Ray and Mitra, 1934; Ray and Chatterji, 1932
Room (?)	0.59	deBoer and van Liempt, 1927
35	0.92	Ray and Mitra, 1935
100	5.90	Stolba, 1889

THE SYSTEM POTASSIUM FLUOBORATE-POTASSIUM PERCHLORATE-WATER AT 25°  
(Ray and Mitra, 1934)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$KF_4B$	$KClO_4$		$KF_4B$	$KClO_4$	
0.574	0.0	$KF_4B$	0.420	0.814	$8KF_4B \cdot KClO_4$
0.562	0.213	"	0.427	0.943	"
0.569	0.276	"	0.437	1.012	" + $2KF_4B \cdot KClO_4$
0.589	0.328	"	0.406	1.077	$2KF_4B \cdot KClO_4$
0.588	0.393	" + $8KF_4B \cdot KClO_4$	0.385	1.165	"
0.558	0.432	$8KF_4B \cdot KClO_4$	0.337	1.433	"
0.476	0.549	"	0.243	1.616	$KClO_4$
0.433	0.684	"	0.0	1.971	"

# K KALIUM

## THE SYSTEM POTASSIUM FLUOBORATE - POTASSIUM PERIODATE - WATER AT 35° (Ray and Mitra, 1935)

The results are given only in the form of a triangular diagram from which the following approximate values were read.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
KF <sub>4</sub> B	KIO <sub>4</sub>		KF <sub>4</sub> B	KIO <sub>4</sub>	
0.92	0.0	KF <sub>4</sub> B	0.60	0.48	KIO <sub>4</sub>
0.91	0.2	"	0.40	0.55	"
0.90	0.4	" + KIO <sub>4</sub>	0.20	0.68	"
0.80	0.42	KIO <sub>4</sub>	0.0	0.80	"

## THE SYSTEM POTASSIUM FLUOBORATE - POTASSIUM PERMANGANATE - WATER AT 25° (Ray and Chatterji, 1932)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
KF <sub>4</sub> B	KMnO <sub>4</sub>		KF <sub>4</sub> B	KMnO <sub>4</sub>	
0.57	0.0	KF <sub>4</sub> B	0.48	4.78	KF <sub>4</sub> B·6KMnO <sub>4</sub>
0.54	1.12	"	0.37	5.42	"
0.46	1.58	"	0.22	6.03	" + KMnO <sub>4</sub>
0.22	2.07	" + KF <sub>4</sub> B·6KMnO <sub>4</sub>	0.33	6.32	KMnO <sub>4</sub>
0.41	3.19	KF <sub>4</sub> B·6KMnO <sub>4</sub>	0.28	6.76	"
0.50	4.08	"	0.0	6.90	"

At 2° a saturated solution of KBF<sub>4</sub> in HF is 0.48 molar. (Clifford and Morris, 1957)

Melting points in the system KBF<sub>4</sub>-KF are given by Selivanov and Stender, 1958.

## B0 POTASSIUM BORATES xK<sub>2</sub>O·yB<sub>2</sub>O<sub>3</sub>

### THE SYSTEM K<sub>2</sub>O - B<sub>2</sub>O<sub>3</sub> - H<sub>2</sub>O AT 30° (Dukelski, 1906)

References to other data are also given.

Gms. per 100 Gms. Solution		Gms. per 100 Gms. Residue		Solid Phase
K <sub>2</sub> O	B <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O	B <sub>2</sub> O <sub>3</sub>	
47.50	--	--	--	KOH·2H <sub>2</sub> O
46.36	0.91	46.13	9.02	K <sub>2</sub> O·B <sub>2</sub> O <sub>3</sub> ·2½H <sub>2</sub> O
40.51	1.25	41.62	9.71	"
36.82	1.80	39.90	13.19	"
32.74	3.51	37.22	14.58	"
29.63	6.98	35.05	17.92	"
24.84	17.63	30.02	21.70	"
23.30	18.19	26.84	31.49	K <sub>2</sub> O·2B <sub>2</sub> O <sub>3</sub> ·4H <sub>2</sub> O
16.21	13.10	25.12	33.18	"

THE SYSTEM  $K_2O - B_2O_3 - H_2O$  AT  $30^\circ$ —Cont.

Gms. per 100 Gms. Solution		Gms. per 100 Gms. Residue		Solid Phase
$K_2O$	$B_2O_3$	$K_2O$	$B_2O_3$	
11.78	9.82	20.57	26.43	$K_2O \cdot 2B_2O_3 \cdot 4H_2O$
9.18	8.00	22.38	31.30	"
6.22	9.13	20.87	31.06	"
7.73	13.37	22.21	36.24	$K_2O \cdot 2B_2O_3 \cdot 4H_2O + K_2O \cdot 5B_2O_3 \cdot 8H_2O$
7.81	13.28	17.50	34.18	" + "
7.71	13.21	11.49	34.81	$K_2O \cdot 5B_2O_3 \cdot 8H_2O$
7.63	13.28	12.51	40.52	"
3.42	7.59	10.77	37.35	"
1.80	4.15	5.88	20.00	"
0.51	3.19	10.81	40.89	"
0.33	4.58	7.72	34.21	$K_2O \cdot 5B_2O_3 \cdot 8H_2O + B(OH)_3$
0.31	4.46	3.91	30.68	"
--	3.54	--	--	"

POTASSIUM tetra BORATE  $K_2B_4O_7$   
(POTASSIUM di BORATE)  $K_2O \cdot 2B_2O_3$

B0

## SOLUBILITY IN WATER

t°	Solid Phase	Solubility	Author
0	.5 or .6 $H_2O$	10.5 gms. $K_2B_4O_7$ per 100 cc. sat. sol.	(Rosenheim and Leyser, 1921)
35	.4 $H_2O$	21.3 gms. $K_2B_4O_7$ per 100 gms. $H_2O$	(Teeple, 1929)

THE SYSTEM POTASSIUM TETRABORATE-PENTABORATE-CHLORIDE-WATER AT  $35^\circ$   
(Teeple, 1929)

Gms. per 100 gms. $H_2O$			Solid Phase
KCl	$K_2B_4O_7$	$K_2B_{10}O_{16}$	
39.0	--	--	KCl
--	21.3	--	$K_2B_4O_7 \cdot 4H_2O$
--	--	5.0	$K_2B_{10}H_{16} \cdot 8H_2O$
37.3	5.9	--	KCl + $K_2B_4O_7 \cdot 4H_2O$
38.1	--	3.0	KCl + $K_2B_{10}O_{16} \cdot 8H_2O$
--	23.8	8.0	$K_2B_4O_7 \cdot 4H_2O + K_2B_{10}O_{16} \cdot 8H_2O$
36.8	6.7	3.5	KCl + " + "

POTASSIUM penta BORATE  $K_2O \cdot 5B_2O_3$ 

SOLUBILITY OF POTASSIUM PENTABORATE IN WATER  
(Bollet and Andres, 1930)

The pentaborate was prepared by the action of boric acid upon potassium chloride and upon potassium nitrate at temperatures above  $100^\circ$  in presence of water vapor. The anhydrous salt hydrates easily in moist air.



# K KALIUM

The authors also found that at about 170° the solid phase is transformed to  $K_2O \cdot 5B_2O_3 \cdot 2H_2O$  and above 350° it becomes the anhydrous compound—which melts at 780°.

The values in parentheses are by Menzel, 1927.

t°	Gms. $K_2O \cdot 5B_2O_3$ per 100 gms. sat. sol.	Solid Phase
- 0.53 (Eutec)	1.54 (1.50)	Ice + 1:5:8
0	1.56 (1.55)*	$K_2O \cdot 5B_2O_3 \cdot 8H_2O$
5	1.77	"
18	2.66 (2.75)	"
25	-- (3.41)	"
30	3.8	"
35	4.76 <sup>a</sup>	"
45	5.72	"
57.6	8.45	"
62.8	9.85	"
69.0	11.5	"
75	13.22	"
76.65	13.62	"
82.3	15.5	"
87.15	17.02	"
89.8	18.00	"
94.8	19.85	"
100	22.3	"
101.65	23.0	"
102.3 (b. pt.)	23.4	"

\*Rosenheim and Leyser, 1921

<sup>a</sup>Teepie, 1929

## BO POTASSIUM PERBORATE $2KB_3 \cdot H_2O$ POTASSIUM PEROXYBORATE $2KB_3 \cdot H_2O_2$

SOLUBILITY OF EACH IN WATER  
(v. Girsewald and Wolokitin, 1929)

Borate	% Active O in Borate	t°	Gms. Salt per 100 Gms. Water
$2KB_3 \cdot H_2O$	14.93	0	1.25
$2KB_3 \cdot H_2O$	14.93	15	2.50
$2KB_3 \cdot H_2O_2$	20.84	15	0.70

## POTASSIUM BARIUM BORATE

The solubility of  $K_2O \cdot BaO \cdot 4B_2O_3 \cdot 14H_2O$  at room temperature is 2 gm. per liter. (Kesans and Streipa, 1954)

## POTASSIUM MAGNESIUM BORATES

Salt	t°	Solubility	Author
$K_2O \cdot MgO \cdot 3B_2O_3 \cdot 15H_2O$	5-6	10 gm. salt per liter	Kesans and Svarcs, 1953
$K_2O \cdot 4MgO \cdot 11B_2O_3 \cdot 18H_2O$	25	0.48-0.51 wt. % $B_2O_3$ in sat. sol.	Spiryagina, 1953

## POTASSIUM SODIUM AMMONIUM BORATES

80

Data on the composition of solutions prepared by shaking mixtures of sodium, potassium and ammonium di and pentaborates with added boric acid and/or ammonia in water are given by Rothbaum, Todd, and Walker, 1956. pH and densities were also determined, and compositions leading to maximum solubility are given.

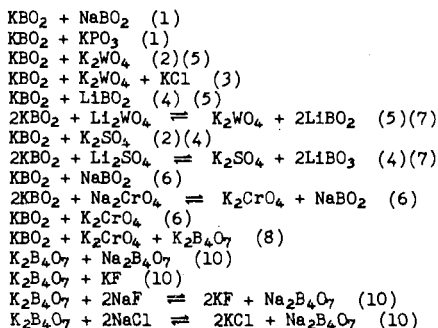
EQUILIBRIUM IN THE SYSTEM BORON OXIDE, POTASSIUM OXIDE  
DETERMINED BY THERMAL ANALYSIS  
(Rollet, 1935)

Considerable difficulty was experienced on account of the slowness of crystallization and tendency of the mixtures to form glass.

t°	Gms. K <sub>2</sub> O per 100 gms. mixture	Solid Phase
950 (f.pt.)	57.5	B <sub>2</sub> O <sub>3</sub> ·K <sub>2</sub> O
787 (Eutec.)	45.3	" + 2B <sub>2</sub> O <sub>3</sub> ·K <sub>2</sub> O
815 (f.pt.)	40.3	2B <sub>2</sub> O <sub>3</sub> ·K <sub>2</sub> O
770 (Eutec.)	37.5	" + 3B <sub>2</sub> O <sub>3</sub> ·K <sub>2</sub> O
decomposes before melting		3B <sub>2</sub> O <sub>3</sub> ·K <sub>2</sub> O
825 (tr.pt.)	33.5	3B <sub>2</sub> O <sub>3</sub> ·K <sub>2</sub> O + 4B <sub>2</sub> O <sub>3</sub> ·K <sub>2</sub> O
857 (f.pt.)	25.2	4B <sub>2</sub> O <sub>3</sub> ·K <sub>2</sub> O
780 (tr.pt.)	21.3	" + 5B <sub>2</sub> O <sub>3</sub> ·K <sub>2</sub> O
780 (f.pt.)	20.8	5B <sub>2</sub> O <sub>3</sub> ·K <sub>2</sub> O

Data for the systems K<sub>2</sub>O + B<sub>2</sub>O<sub>3</sub> + KCl and K<sub>2</sub>O + B<sub>2</sub>O<sub>3</sub> + KBr are given by Stahlhane, 1930.

Melting point data are given for the following systems:



(1) van Klooster, 1910-11 (2) Kislova, Posypaiko and Bergman, 1955 (3) Posypaiko, Bergman and Kislova, 1956 (4) Bergman, Kislova and Posypaiko, 1955 (5) Bergman, Kislova and Posypaiko, 1955a (6) Bergman and Bartbaronov, 1957b (7) Bergman, Kislova and Posypaiko, 1953 (8) Bergman and Bartbaronov, 1957 (9) Bergman and Bartbaronov, 1957a (10) Bergman and Nikonova, 1942.

## K KALIUM

## Br POTASSIUM BROMIDE KBr

## SOLUBILITY IN WATER

The results of most investigators are in good agreement. The values below are averages of the data of Meusser, 1905; Etard, 1884; de Coppet, 1883; Tilden and Shenstone, 1884; Hering, 1936; Flottmann, 1928; Scott and Durham, 1930; Scott and Frazier, 1927; Bronstead, 1933; Klein and Svanberg, 1920; Rodebush, 1918; Joseph, 1920; Larson and Hunt, 1939; Guerassimow, 1934; Ricci, 1934; Fock, 1897; Bogoyavlenskii, 1949; Mikimov, Kapkaeva and Bergman, 1952. The results of Bergman and Vlassov (1942, 1949) are up to 1% lower than these below 20°. An  $\alpha \rightarrow \beta$  transition occurs at 20-22° (B. and V.). Most of the results above 100° were determined by the synthetic method by Benrath, Gjedebo, Schiffers, and Wunderlich, 1937. For references to the solubility of KBr near the critical temperature see Booth and Bidwell, 1948 and Schroer, 1927.

t°	Grams KBr per 100 Grams		t°	Grams KBr per 100 Grams	
	Solution	Water		Solution	Water
- 3.19*	10.31	11.53	60	46.1	85.5
- 5.61*	16.95	20.42	70	47.4	90.0
- 6.57*	19.24	23.82	80	48.7	95.0
- 8.51*	23.65	30.37	90	49.8	99.2
-10.90*	28.3	39.5	100	51.0	104.0
-12.6**	31.3	45.6	103	51.5	106.2
-10	31.6	46.7	110	52.3	109.5
- 5	33.3	40.0	140	54.7	120.9
0	34.9	53.5	167	57.5	135.3
5	36.2	56.7	181	59.3	145.6
10	37.3	59.5	208	61.1	157.1
15	38.5	62.5	232	63.1	171.0
20	39.4	65.0	251	65.2	187.4
25	40.4	67.7	275	66.7	200.3
30	41.4	70.6	301	67.7	209.6
35	42.6	74.3	359	70.7	241.3
40	43.2	75.9	421	73.3	274.5
50	44.7	80.6			

\*Solid phase ICE

\*\*Eutectic

Densities of saturated solutions:

0°	1.3237	35°	1.3941
15°	1.3597	50.21°	1.4160
20°	1.3701	91.95°	1.4590
25°	1.3793	100°	1.465

SOLUBILITY OF POTASSIUM BROMIDE IN WATER AND DEUTERIUM OXIDE  
(Eddy and Menzies, 1940)

Small closed vessels containing about one gram of solvent were used, and the D<sub>2</sub>O had a purity of 99.4%, determined from its freezing point. Including corrections for the volume of water in the vapor phase, the authors estimate the accuracy of each determination at 1%. The experimental results were plotted, and the authors read the following rounded values from the curve. The original data are given as moles of salt per 55.51 moles of solvent.

t°	Gms. KBr per 100 gms.		t°	Gms. KBr per 100 gms.	
	H <sub>2</sub> O	D <sub>2</sub> O		H <sub>2</sub> O	D <sub>2</sub> O
0	52.8	38.8	90	100.0	84.7
5	56.0	42.5	95	102.4	86.8
10	59.1	45.8	100	104.8	89.0
15	62.2	48.9	105	107.2	91.1
20	65.2	51.8	110	109.6	93.2
25	68.0	54.6	115	111.9	95.4
30	70.7	57.3	120	114.3	97.5
35	73.3	59.8	125	116.7	99.6
40	76.0	62.4	130	119.1	101.8
45	78.4	64.8	135	121.5	103.9
50	80.9	67.1	140	123.9	106.1
55	83.4	69.4	145	126.2	108.3
60	85.8	71.6	150	128.6	110.4
65	88.2	73.8	155	131.0	112.6
70	90.5	76.1	160	133.4	114.7
75	92.9	78.3	165	135.8	116.9
80	95.3	80.4	170	138.1	119.0
85	97.7	82.5			

Br

SOLUBILITY OF POTASSIUM BROMIDE IN AQUEOUS SOLUTIONS  
OF HYDROBROMIC ACID AT 25°  
(Scott and Durham, 1930)

Gms. per 100 gms. sat. solution	
HBr	KBr
0.0	40.62
6.88	30.99
13.23	22.69
18.07	17.60

SOLUBILITY OF POTASSIUM BROMIDE IN BROMINE WATER AT 32.4°  
(Joseph, 1920)

[For data at 0°, 1 atm. see Harris, 1932]

The mixtures were constantly agitated in a thermostat for 24 hours.

d of sat. sol.	Gms. per 100 gms. H <sub>2</sub> O		d of sat. sol.	Gms. per 100 gms. H <sub>2</sub> O	
	Br	KBr		Br	KBr
1.3917	0.0	72.56	1.4753	13.72	77.11
1.4063	2.40	73.39	1.5236	22.97	80.13
1.4070	3.21	73.82	1.5980	38.21	84.59
1.4132	3.96	74.07	2.596	430.4	210.4*
1.4356	7.43	75.02	2.860	1472.0	279.6*
1.4633	12.09	76.43			

\*In these two cases the mixtures were simply left in bottles for some days at about 28°, and the heavy dark liquid filtered through glass wool and analyzed. The densities were taken by means of a Westphal balance.

## K KALIUM

## SOLUBILITY OF POTASSIUM BROMIDE IN POTASSIUM HYDROXIDE SOLUTIONS

Results of Ditte, 1897 at 17°

Grams per 1000 Grams H <sub>2</sub> O		Grams per 1000 Grams H <sub>2</sub> O	
KOH	KBr	KOH	KBr
36.4	558.4	277.6	248.1
113.5	433.6	434.7	137.1
177.2	358.1	579.6	64.8
231.1	281.2	806.9	33.4

Results of Brönsted, 1920a at 20°

Gm. mols. per liter		Gm. mols. per liter		Gm. mols. per liter	
KOH	KBr	KOH	KBr	KOH	KBr
7.90	1.012	12.19	0.348	14.02	0.246
9.41	0.693	12.92	0.306	14.85	0.214
10.95	0.512	13.84	0.247	15.02	0.210
11.10	0.451				

## SOLUBILITY OF POTASSIUM BROMIDE IN AMMONIA SOLUTIONS

(Distanov and Kiselev, 1953)

Solubilities in the system KBr-NH<sub>3</sub>-H<sub>2</sub>O were determined from -74° to +135°. Small amounts of NH<sub>3</sub> decrease the solubility of KBr, but above 13-16 wt. % NH<sub>3</sub>, the solubility increases. KBr can be separated from NaCl by utilizing the differences in their solubilities in NH<sub>3</sub>-H<sub>2</sub>O mixtures.

## THE SYSTEM POTASSIUM BROMIDE - POTASSIUM BROMATE - WATER

(Guerassimow, 1934; Ricci, 1934 (at 25°))

A = KBr			B = KBrO <sub>3</sub>		
Gms. per 100 Gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
KBr	KBrO <sub>3</sub>		KBr	KBrO <sub>3</sub>	
Results at 0°			Results at 25°--Cont.		
35.30	0.0	A	26.05	2.06	B
35.08	0.57	A	17.48	2.73	B
35.16	0.65	A, B	7.82	4.29	B
0.0	2.96	B	0.0	7.533	B
Results at 20°			Results at 40°		
39.4	0.0	A	43.54	0.0	A
39.26	1.22	A, B	42.97	0.34	A
22.20	1.85	B	42.44	1.28	A
11.80	2.73	B	42.34	2.19	A, B
0.0	6.43	B	35.97	2.60	B
Results at 25°*			20.84	4.32	B
			8.50	7.32	B
			0.0	11.70	B
Results at 60°--Cont.			Results at 80°		
			49.93	3.75	B
			44.56	3.73	B
			31.90	5.71	B
			12.69	12.09	B
			10.07	12.74	B
			9.52	12.83	B
			9.37	13.14	B
			4.48	14.92	B
			4.35	15.58	B
			3.94	16.43	B
			0.0	18.21	B
			Results at 80°		
			49.72	0.0	A
			46.5	5.62	A, B
			45.57	5.60	B
			7.45	20.74	B
			0.0	25.53	B

\*see next page

Densities of saturated solutions at 25°: 1.381 (KBr), 1.389 (KBr), 1.392 (KBr & KBrO<sub>3</sub>), 1.328 (KBrO<sub>3</sub>), 1.237 (KBrO<sub>3</sub>), 1.161 (KBrO<sub>3</sub>), 1.089 (KBrO<sub>3</sub>), 1.054 (KBrO<sub>3</sub>).

# THE SYSTEM POTASSIUM BROMIDE - POTASSIUM CHLORIDE - WATER

The continuous solid solutions in this system have been studied many times, with good agreement among the various data. The solid solutions are of Roozeboom Type II. Additional results are given by most of the authors listed, and also by Touren (1900), Etard (1897), Fock (1897), Amadori and Pampanini (1911) at 25°.

Results from 200°-650°, up to 350 atm. pressure, are given by Ravich and Borovaya, 1949. See also Schlesinger and Zorkin, 1939.

Br

B. & V.	= Bergman and Vlassov, 1942
B. & V., 1949	= Bergman and Vlassov, 1949
Z	= Zhdanov, 1948
F	= Flatt and Burkhardt, 1944
D	= Durham, Rock, and Frayn, 1953
S.Z. & N.	= Schlesinger, Zorkin, and Novogonova, 1938

Figures in parentheses are densities ( $t^{\circ}/4^{\circ}$ ) of the saturated solutions.

Sat. soln. wt. %		Solid Phase Wt. % KCl	Sat. soln. wt. %		Solid Phase Wt. % KCl
KBr	KCl		KBr	KCl	
At -10° (B. & V.)			At 5° (B. & V.)		
0.0	19.0	ICE	0.0	25.6	--
8.8	12.4	ICE	8.2	18.4	--
19.0	5.0	ICE	16.2	13.6	--
26.6	0.0	ICE	25.7	8.2	--
0.0	20.2	--	30.7	4.2	--
8.4	15.8	--	35.2	0.0	--
17.8	11.0	--	At 10° (B. & V.)		
26.5	4.9	--	0.0	23.4	--
31.4	0.0	--	8.1	19.1	--
At -5° (B. & V.)			17.1	14.4	--
0.0	12.	ICE	25.2	9.6	--
9.6	4.3	ICE	30.4	5.2	--
16.0	0.0	ICE	36.6	0.0	--
0.0	20.8	--	At 15° (B. & V.)		
8.3	16.1	--	0.0	24.2	--
17.6	11.7	--	8.1	20.0	--
26.3	5.8	--	16.9	15.4	--
31.7	1.3	--	25.0	10.7	--
32.8	0.0	--	30.0	6.5	--
At 0° (S.Z. & N.)			36.8	0.0	--
0.54	21.92 (1.155)	99.59	At 20° (B. & V.)		
0.64	21.85 (1.154)	99.51	0.0	25.0	--
3.36	20.36 (1.169)	96.84	8.0	20.8	--
8.18	18.05 (1.196)	90.11	16.8	16.2	--
19.52	12.48 (1.264)	68.08	24.7	11.7	--
22.31	11.05 (1.280)	43.47	29.6	7.8	--
26.25	8.11 (1.296)	22.22	39.2	0.0	--
30.50	4.57 (1.312)	7.52			
31.2	2.7	--			

(Cont.)

# K KALIUM

Sat. soln. wt. %				Sat. soln. wt. %			
KBr		KCl	Solid Phase	KBr		KCl	Solid Phase
			Wt. % KCl				Wt. % KCl
Br	At 25°			At 35° (S.Z. & N.)			
	0.0	26.27 Z	100	0.0	42.59 (1.397)	0.0	
	2.85	24.75 Z	--	2.77	39.64 (1.387)	4.05	
	5.66	23.33 Z	--	5.09	36.50 (1.373)	8.59	
	8.51	21.96 Z	--	9.19	32.11 (1.359)	20.16	
	10.01	20.91 D	92.11	10.34	30.40 (1.350)	26.14	
	10.4	20.9 F	89.6	10.64	30.18 (1.349)	27.65	
	14.48	18.22 Z	--	13.76	25.22 (1.324)	52.85	
	17.12	17.20 Z	--	14.23	24.24 (1.320)	56.19	
	19.2	15.8 F	73.7	20.14	14.63 (1.265)	84.48	
	20.21	15.31 D	73.05	20.67	13.02 (1.253)	87.63	
	22.4	14.3 F	61.3	21.75	11.12 (1.242)	89.66	
	22.85	13.83 D	62.22	21.65	10.68 (1.239)	90.38	
	22.62	11.56 D	40.0	23.08	8.15 (1.224)	92.91	
	26.9	11.2 F	34.9	23.69	7.30 (1.221)	93.84	
	28.93	9.85 Z	--	26.46	2.91 (1.198)	97.70	
	29.7	9.5 F	22.9	26.79	1.60 (1.192)	98.88	
	30.50	8.70 D	19.0	27.40	0.61 (1.186)	99.58	
	32.7	7.0 F	13.6	28.04	0.18 (1.186)	99.88	
	35.09	4.89 D	7.1	27.95	0.0 (1.185)	100.0	
35.2	4.7 F	7.6					
38.3	2.1 F	2.7					
40.57	0.0 D	0.0					
			At 50° (B. & V., 1949)				
			0.0	30.0	--		
			15.4	21.1	--		
			15.9	20.6	--		
			24.0	16.4	--		
			27.1	14.0	--		
			32.2	10.7	--		
			34.1	9.4	--		
			37.5	6.6	--		
			38.2	6.4	--		
			44.5	0.0	--		

## THE SYSTEM POTASSIUM BROMIDE - POTASSIUM CHLORIDE - 50% AQUEOUS ETHANOL AT 35° (Simons and Blum, 1951)

The system is similar to that in pure water and forms solid solutions of Roozeboom Type II.

Sat. soln. Wt. %		d.	Solid Soln. Wt. % KBr	Sat. soln. Wt. %		d.	Solid Soln. Wt. % KBr
KCl	KBr			KCl	KBr		
0.0	17.21	--	100	3.18	12.65	0.990	61.61
0.75	16.28	1.010	99.01	3.50	11.91	.993	57.01
1.02	15.96	1.006	95.70	3.80	11.27	.983	47.19
1.51	15.34	1.004	92.82	4.11	10.35	.978	37.17
1.76	15.00	1.001	89.25	4.70	8.47	.971	24.13
2.27	14.22	0.998	83.91	5.64	5.45	.958	11.34
2.56	13.81	1.001	76.22	6.69	2.09	.938	2.54
3.00	12.95	0.995	69.27	7.31	0.0	--	0.0

The system  $\text{KBr} + \text{KCl} + \text{HBr} + \text{H}_2\text{O}$  was studied by Petrov and Ilin, 1939 by adding conc.  $\text{HBr}$  to solutions of  $\text{KBr} + \text{KCl}$ , and by isothermal evaporations.

The compositions of several saturated solutions in the system  $\text{KBr} + \text{KCl} + \text{HI} + \text{H}_2\text{O}$  at  $25^\circ$  are also given by Zhdanov, 1948.

THE SYSTEM POTASSIUM BROMIDE - POTASSIUM CHLORATE - WATER AT  $25^\circ$   
(Ricci, 1937)

d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	
	KBr	$\text{KClO}_3$		
1.380	40.63	0.0	KBr	Br
1.356	40.02	1.42	" + $\text{KClO}_3$	
1.376	39.47	1.42	$\text{KClO}_3$	
1.292	31.66	1.87	"	
1.216	24.20	2.41	"	
1.160	16.99	3.21	"	
1.100	9.30	4.59	"	
1.047	0.0	7.905	"	

THE SYSTEM POTASSIUM BROMIDE - POTASSIUM DICHROMATE - WATER  
(Bogoyavlenskii, 1949)

The results are also given in mole %.

Gms. per 100 gms. Saturated Solution			Gms. per 100 gms. Saturated Solution		
$\text{K}_2\text{Cr}_2\text{O}_7$	KBr	Solid Phase	$\text{K}_2\text{Cr}_2\text{O}_7$	KBr	Solid Phase
Results at $0^\circ$			Results at $20^\circ$ --Cont.		
4.43	0.0	$\text{K}_2\text{Cr}_2\text{O}_7$	1.93	22.1	$\text{K}_2\text{Cr}_2\text{O}_7$
2.20	2.90	"	1.19	30.81	"
1.20	6.90	"	0.88	34.75	"
0.70	14.90	"	0.65	39.15	$\text{K}_2\text{Cr}_2\text{O}_7 + \text{KBr}$
0.40	25.76	"	0.0	39.40	KBr
0.30	34.30	$\text{K}_2\text{Cr}_2\text{O}_7 + \text{KBr}$	Results at $30^\circ$		
0.0	34.5	KBr	15.40	0.0	$\text{K}_2\text{Cr}_2\text{O}_7$
Results at $10^\circ$			10.32	6.04	"
7.50	0.0	$\text{K}_2\text{Cr}_2\text{O}_7$	4.94	16.53	"
4.90	2.85	"	2.56	26.47	"
3.20	6.78	"	1.56	34.33	"
1.40	14.80	"	0.95	40.94	$\text{K}_2\text{Cr}_2\text{O}_7 + \text{KBr}$
1.00	19.82	"	0.0	41.45	KBr
0.50	37.90	$\text{K}_2\text{Cr}_2\text{O}_7 + \text{KBr}$	Results at $40^\circ$		
0.0	38.1	KBr	20.60	0.0	$\text{K}_2\text{Cr}_2\text{O}_7$
Results at $20^\circ$			14.58	6.84	"
11.10	0.0	$\text{K}_2\text{Cr}_2\text{O}_7$	7.23	18.70	"
8.06	3.96	"	4.21	23.50	"
4.53	9.92	"	1.65	42.42	$\text{K}_2\text{Cr}_2\text{O}_7 + \text{KBr}$
2.55	16.96	"	0.0	43.2	KBr



# K KALIUM

## THE SYSTEM POTASSIUM BROMIDE - POTASSIUM IODIDE - WATER (Mikimov, Kapkaeva, and Bergman, 1952)

Limited solid solutions of each salt in the other are formed at all temperatures.

	Sat. sol. wt. %		Density	Wet Residue Wt. %		Solid Phase
	KBr	KI		KBr	KI	
Results at 0°						
A = solid solution I (90.5-100% KBr) B = solid solution II (0-6.5% KBr)						
Br	34.56	--	1.3215	100.0	--	KBr
	30.75	8.84	1.3660	92.35	6.45	A
	27.46	14.69	1.3902	90.19	3.68	A
	23.50	22.16	1.4425	89.41	6.08	A
	16.83	37.26	1.5210	77.41	12.13	A
	14.81	39.08	1.5700	78.23	14.62	A
	11.74	45.36	1.6200	83.22	13.47	A
	10.85	47.01	1.6562	45.95	46.00	B
	10.23	47.51	1.6596	6.95	83.57	B
	7.83	49.54	1.6638	5.56	89.25	B
	4.70	52.71	--	4.31	84.82	B
	--	55.79	1.6669	--	100.0	KI
Results at 15°						
A = solid solution I (86.5-100% KBr) B = solid solution II (0-9.5% KBr)						
Br	38.55	--	1.3569	100.0	--	KBr
	36.23	5.89	1.3641	96.74	0.73	A
	32.21	12.67	1.4225	86.13	4.36	A
	26.80	20.78	1.4743	91.80	4.76	A
	23.97	26.74	1.5013	91.20	6.38	A
	16.14	39.58	1.6176	84.22	12.67	A
	15.58	42.34	1.6450	86.50	12.46	A
	12.34	46.38	1.6755	--	--	A
	11.47	47.86	1.6840	43.07	55.02	A
	11.15	48.61	1.6930	9.47	83.03	B
	9.20	50.06	1.6966	7.62	87.65	B
	4.92	53.60	1.7000	4.38	94.20	B
	--	58.25	1.7026	--	100.0	KI
Results at 35°						
A = solid solution I (81-100% KBr) B = solid solution II (0-13.5% KBr)						
Br	41.30	--	1.4035	100.0	--	KBr
	37.05	8.10	1.4452	90.70	1.65	A
	32.40	16.74	1.4912	88.50	3.92	A
	29.77	20.20	1.5106	92.03	4.40	A
	27.15	25.76	1.5530	82.51	10.10	A
	20.21	35.47	1.6203	88.10	10.84	A
	16.84	41.82	--	78.26	16.59	A
	14.06	46.57	1.7060	71.51	21.78	A
	12.78	48.45	--	74.51	21.78	A
	12.02	50.07	1.7412	49.25	34.70	A
	11.32	51.57	1.7441	12.05	83.50	B
	9.83	52.03	--	9.03	86.05	B
	7.84	54.06	1.7458	6.34	90.12	B
	4.95	56.96	1.7540	2.98	85.50	B
	--	61.20	1.7590	--	100.0	KI

Sat. sol. wt. %		Density	Wet Residue Wt. %		Solid Phase
KBr	KI		KBr	KI	
Results at 50°					
A = solid solution I (73.9-100% KBr)			B = solid solution II (0-23% KBr)		
44.53	--	1.4106	--	--	KBr
39.70	7.96	1.4339	94.56	1.03	A
37.80	10.16	1.4482	90.20	2.30	A
30.41	19.68	1.4884	84.56	7.03	A
25.69	26.88	1.5120	76.39	11.87	A
21.68	33.11	1.5990	79.83	12.90	A
16.92	41.06	1.6434	71.05	18.23	A
15.09	45.47	1.6834	--	--	A
14.62	45.59	1.6900	81.36	16.62	A
12.65	50.63	1.7623	40.60	57.14	B
12.45	50.94	1.7614	20.04	68.21	B
9.25	54.53	1.7606	10.86	78.83	B
4.94	58.63	1.7473	3.93	84.13	B
--	62.77	1.7460	--	--	KI

Br

Results at 25° (Amadori and Pampanini, 1911)					
Gms. per 100 gms. H <sub>2</sub> O		Gms. per 100 gms. H <sub>2</sub> O		Gms. per 100 gms. H <sub>2</sub> O	
KBr	KI	KBr	KI	KBr	KI
53.21	35.92	30.08	119.52	21.88	127.31
42.32	66.63	29.62	119.00	18.54	130.61
34.14	95.36	22.15	127.10	0.0	149.26

THE SYSTEM POTASSIUM BROMIDE - POTASSIUM IODATE - WATER  
(Ricci, 1934)

B = KBr				I = KIO <sub>3</sub>			
Sat. sol. wt. %		Density	Solid Phase	Sat. sol. wt. %		Density	Solid Phase
KBr	KIO <sub>3</sub>			KBr	KIO <sub>3</sub>		
Results at 5°				Results at 25°--Cont.			
36.25	0.0	1.333	B	17.40	3.26	1.168	I
35.71	1.80	1.352	B, I	8.35	4.53	1.106	I
30.50	1.77	1.290	I	0.0	8.452	1.071	I
22.59	1.80	1.208	I	Results at 50°			
14.80	1.95	1.136	I				
7.58	2.45	1.080	I				
0.0	5.186	1.043	I	44.77	0.0	--	B
Results at 25°				43.88	2.22	--	B
				43.50	3.07	--	B, I
				38.03	3.32	--	I
40.62	0.0	1.381	B	30.57	3.87	--	I
40.28	0.98	1.396	B	23.19	4.66	--	I
39.75	2.36	1.407	B, I	15.65	5.80	--	I
34.38	2.47	1.341	I	8.18	8.16	--	I
25.91	2.73	1.294	I	0.0	13.20	--	I

# K KALIUM

## THE SYSTEM POTASSIUM BROMIDE - POTASSIUM NITRATE - WATER

Results of Touren, 1900

Results at <u>14.2°</u>			Results at <u>25.2°</u>		
Gms. per liter		Solid Phase	Gms. per liter		Solid Phase
KBr	KNO <sub>3</sub>		KBr	KNO <sub>3</sub>	
515.9	0.0	KBr	566.2	0.0	KBr
494.9	36.6	"	561.0	13.3	"
487.4	71.4	"	549.1	53.3	"
469.1	124.9	"	540.8	72.9	"
421.1	132.3	KNO <sub>3</sub>	533.0	110.3	"
302.7	142.2	"	528.8	118.4	"
187.8	160.6	"	521.1	152.2	"
130.0	175.0	"	422.8	182.8	KNO <sub>3</sub>
93.4	185.7	"	341.8	198.1	"
42.4	205.0	"	143.3	224.3	"
0.0	225.4	"	163.1	252.2	"
			110.8	272.0	"
			45.3	306.2	"
			0.0	325.5	"

Results of Bogoyavlenskii, 1955 at 25°

Sat. sol. wt. %		Solid phase	Sat. sol. wt. %		Solid Phase
KNO <sub>3</sub>	KBr		KNO <sub>3</sub>	KBr	
27.16	0.0	KNO <sub>3</sub>	12.05	35.69	KNO <sub>3</sub> + KBr
23.36	7.82	"	10.31	36.46	KBr
18.47	16.47	"	7.51	37.87	"
16.08	22.56	"	3.32	39.63	"
14.12	28.08	"	0.0	40.87	"

## COMPOSITION OF AQUEOUS SOLUTIONS SATURATED WITH KBr + AgBr (Lambert, 1926)

(See also Vol. I, pp. 12, 13)

t°	Gms. per 100 gms. sat. sol.		Solid Phase	t°	Gms. per 100 gms. sat. sol.		Solid Phase
	AgBr	KBr			AgBr	KBr	
-13	1.67	39.87	AgBr + KBr	70	5.80	45.48	AgBr + KBr
+30	1.636	39.54	"	70	5.60	45.53	"
40	2.24	40.88	"	80	6.72	46.91	"
50	3.25	43.09	"	90	8.47	48.15	"
50	3.12	42.43	"	90	9.00	47.98	"
60	4.20	44.24	"	100	10.55	48.66	"

THE SYSTEM POTASSIUM BROMIDE - AMMONIUM BROMIDE - WATER AT 25°  
(Fock, 1897; Flatt and Burkhardt, 1944)

Two series of solid solutions are formed.

The data are in fairly good agreement. Flatt and Burkhardt found more  $\text{NH}_4\text{Br}$  (75.7 mol. %) at the invariant point than did Fock (70.27%).

(\*) Denotes the invariant solutions.

Results of Fock

Grams per Liter Solution		Mol. per cent in Solution		Sp. Gr. of Solutions	Mol. per cent in Solid Phase		Br
$\text{NH}_4\text{Br}$	KBr	$\text{NH}_4\text{Br}$	KBr		$\text{NH}_4\text{Br}$	KBr	
0.00	558.1	0.0	100	1.3756	0.00	100	
6.4	554.2	1.38	98.62	1.3745	0.26	99.74	
24.64	536.5	5.29	94.71	1.3733	1.27	98.73	
51.34	516.8	10.77	89.23	1.3721	3.02	96.98	
152.9	441.2	29.63	70.37	1.3711	8.42	91.58	
262.2	347.3	47.84	52.16	1.3715	17.20	82.80	
347.6	262.3	61.69	38.31	1.3753	27.98	72.02	
381.4	260.3	64.03	35.97	1.3753	32.53	67.47	
417.8	232.2	68.61	31.39	1.3766	39.45	60.55	
432.5	222.3	*70.27	29.73	1.3777	variable	variable	
480.8	179.9	76.47	23.53	1.3766	98.53	1.47	
577.3	0.0	100.0	0.0	1.3763	100.0	0.0	

Results of Flatt and Burkhardt

Moles $\text{NH}_4\text{Br}$ per 100 moles Dissolved Salts	Moles $\text{H}_2\text{O}$ per mole of Dissolved Salts	Moles $\text{NH}_4\text{Br}$ per 100 moles Solid Phase
0.0	9.63	0.0
27.8	8.56	8.7
48.1	7.63	18.2
54.4	7.17	23.5
63.6	6.87	33.1
64.4	6.70	--
69.4	6.42	43.6
69.5	6.48	43.0
73.4	6.25	49.5
74.6	6.20	50.4
*75.7	6.22	93.8
75.8	6.19	--
76.2	6.23	98.4
78.7	6.22	98.7
84.3	6.42	98.8
100.0	6.92	100.0

THE SYSTEM POTASSIUM BROMIDE - SODIUM BROMIDE - WATER  
(Vlassov and Bergman, 1943; Bergman and Vlassov, 1949)

The system was studied from the eutectic ( $-32^\circ$ ) to  $50^\circ$ , and the transition temperatures for  $\alpha\text{KBr} \rightleftharpoons \beta\text{KBr}$  were determined as a function of the amount of sodium bromide in solution.

Results in good agreement with the following are given by Mukimov and Kapkaeva, 1952.

# K KALIUM

Sat. sol. wt. %			Sat. sol. wt. %		
NaBr	KBr	Solid Phase	NaBr	KBr	Solid Phase
Results at -20°			Results at 20°		
32.8	0.0	Ice	47.6	0.0	NaBr·2H <sub>2</sub> O
31.0	1.8	"	46.4	2.5	"
28.2	6.5	"	45.3	3.6	"
22.4	13.3	KBr + Ice	43.8	6.3	NaBr·2H <sub>2</sub> O + KBr
26.9	10.7	KBr	41.6	7.5	KBr
35.5	6.1	"	38.0	9.4	"
38.0	4.4	"	33.4	11.7	"
38.0	3.5	KBr + NaBr·2H <sub>2</sub> O	24.9	17.5	"
40.2	2.1	NaBr·2H <sub>2</sub> O	14.8	25.6	"
Br 41.7	0.0	"	6.5	33.2	"
			0.0	39.4	"
Results at -10°			Results at 25°		
21.6	0.0	Ice			
12.4	3.0	"	48.6	0.0	NaBr·2H <sub>2</sub> O
8.3	16.0	"	47.1	2.6	"
0.0	26.6	"	45.6	5.2	"
0.0	31.4	KBr	44.4	6.7	NaBr·2H <sub>2</sub> O + KBr
7.4	25.6	"	41.2	8.2	KBr
16.1	18.6	"	37.7	10.1	"
26.4	12.2	"	33.2	12.4	"
35.0	7.6	"	24.6	18.4	"
39.6	4.6	"	14.6	26.8	"
39.8	4.5	KBr + NaBr·2H <sub>2</sub> O	6.4	34.4	"
40.3	4.0	NaBr·2H <sub>2</sub> O	0.0	40.6	"
41.5	2.2	"			
43.2	0.0	"	Results at 30°		
Results at 0°			49.4	0.0	NaBr·2H <sub>2</sub> O
			47.9	2.6	"
44.3	0.0	NaBr·2H <sub>2</sub> O	46.3	5.3	NaBr·2H <sub>2</sub> O + KBr
43.0	2.3	"	45.0	7.1	KBr
41.5	4.7	"	43.6	7.0	"
41.2	4.8	NaBr·2H <sub>2</sub> O + KBr	40.8	9.0	"
39.4	6.1	KBr	37.5	10.7	"
34.3	9.1	"	33.0	13.0	"
25.9	14.0	"	24.3	19.3	"
15.8	21.0	"	14.4	27.9	"
7.1	28.2	"	6.2	35.8	"
0.0	34.0	"	0.0	39.0	"
Results at 10°			Results at 50°		
45.9	0.0	NaBr·2H <sub>2</sub> O	53.7	0.0	NaBr
44.4	2.4	"	49.38	6.78	"
43.0	5.0	"	48.15	8.18	"
42.6	5.4	NaBr·2H <sub>2</sub> O + KBr	37.64	13.48	KBr
42.3	5.7	KBr	36.94	14.42	"
38.6	7.9	"	34.28	17.42	"
33.8	10.6	"	33.10	18.60	"
25.4	15.6	"	32.76	17.20	"
15.3	23.2	"	14.57	31.18	"
6.8	30.7	"	13.39	32.42	"
0.0	36.7	"	0.0	44.5	"

$\alpha \rightleftharpoons \beta$ KBr Transition Points

(22.0°)	0.0	40.0	$\alpha$ -KBr + $\beta$ -KBr
(19.0°)	6.7	23.2	"
(16.0°)	14.8	25.2	"
(12.0°)	25.5	16.5	"
(10.0°)	33.8	10.6	"
(9.0°)	39.8	7.6	"

## Invariant Points

(-32.0°)	36.5	4.0	Ice + $\alpha$ -KBr + NaBr·5H <sub>2</sub> O	Br
(-20.0°)	38.0	3.6	$\alpha$ -KBr + NaBr·5H <sub>2</sub> O + NaBr·2H <sub>2</sub> O	
(46°)	47	7.8	NaBr·2H <sub>2</sub> O + NaBr + $\beta$ -KBr	
(7.0°)	41.4	5.4	$\alpha$ -KBr + $\beta$ -KBr + NaBr·2H <sub>2</sub> O	

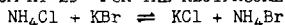
Data for the reciprocal system  $2\text{KBr} + \text{MgCl}_2 \rightleftharpoons 2\text{KCl} + \text{MgBr}_2 + (\text{H}_2\text{O})$  recalculated from the results of Boeke, 1908 and others are given by Jänecke, 1938.

THE SYSTEM POTASSIUM BROMIDE - RUBIDIUM BROMIDE - WATER AT 25°  
(Durham, Rock and Frayn, 1953)

Continuous solid solutions are formed. Equilibrium was approached from two directions for each point.

Sat. soln. wt. %		Solid Phase Wt. % RbBr	Sat. soln. wt. %		Solid Phase Wt. % RbBr
KBr	RbBr		KBr	RbBr	
40.65	0.0	0.0	15.20	36.14	72.5
32.08	12.89	13.40	15.44	35.78	74.5
32.14	12.87	13.22	10.85	41.21	84.5
25.29	22.94	33.60	10.87	40.97	86.4
25.26	23.08	33.70	6.95	45.54	93.2
19.41	30.88	58.9	6.97	45.22	93.9
19.30	31.01	58.9	0.71	52.23	100.0

## EQUILIBRIUM AT 25° FOR THE RECIPROCAL SALT PAIR



(Flatt and Burkhardt, 1944)

Saturated Solution			Solid Solution I		Solid Solution II	
Moles Br <sup>-</sup> per 100 moles Br <sup>-</sup> + Cl <sup>-</sup>	Moles NH <sub>4</sub> <sup>+</sup> per 100 moles NH <sub>4</sub> <sup>+</sup> + K <sup>+</sup>	Moles H <sub>2</sub> O per mole of Dissolved Salts	Moles Br <sup>-</sup> per 100 moles Br <sup>-</sup> + Cl <sup>-</sup>	Moles NH <sub>4</sub> <sup>+</sup> per 100 moles NH <sub>4</sub> <sup>+</sup> + K <sup>+</sup>	Moles Br <sup>-</sup> per 100 moles Br <sup>-</sup> + Cl <sup>-</sup>	Moles NH <sub>4</sub> <sup>+</sup> per 100 moles NH <sub>4</sub> <sup>+</sup> + K <sup>+</sup>
0	74.2	6.67	0.0	26.6	0.0	98.6
10	74.3	6.58	4.2	30.7	1.5	98.2
20	75.0	6.06	10.6	36.4	4.6	97.6
30	76.3	5.75	20.0	43.8	9.0	97.2
40	78.6	5.52	33.0	52.6	16.6	97.2
50	81.0	5.41	48.3	60.2	36.0	98.0
60	81.0	5.40	64.4	62.1	72.0	98.0
70	79.4	5.52	76.5	59.2	84.8	97.2
80	77.7	5.71	86.0	56.0	91.2	97.2
90	75.9	5.94	94.2	52.9	95.6	97.6
100	75.7	6.20	100.0	50.4	100.0	98.4

## K KALIUM

## SOLUBILITY OF POTASSIUM BROMIDE IN AQUEOUS METHANOL SOLUTIONS

(Densities 25°/4° of sat. soln's. are given in parentheses)

Wt. % CH <sub>3</sub> OH in Solvent	10.2° (Zeitlin, 1926) moles KBr per liter	19.9° (Zeitlin, 1926) moles KBr per liter	25°	
			(Akerlof and Turck, 1935) moles KBr per 1000 gms. solvent	(Herz and Anders, 1907) gms. KBr per 100 cc. sat. sol.
0.0	--	--	5.784	56.04 (1.3797)
10.6	--	--	--	46.28 (1.300)
20.0	--	--	3.711	--
25.96	2.475	2.493	--	--
30.8	--	--	--	29.98 (1.159)
40.82	--	--	2.180	--
45.13	1.426	1.466	--	--
47.1	--	--	--	19.28 (1.058)
59.56	--	--	1.182	--
64	--	--	--	10.35 (0.9801)
72.39	--	--	0.7697	--
74.88	0.411	0.434	--	--
78.1	--	--	--	5.24 (0.8906)
80.03	--	--	0.4625	--
89.79	--	--	0.2629	--
94.76	--	--	0.2049	--
98.9	--	--	--	2.74 (0.8411)
100.0	0.1374	0.142	0.1805	1.69 (0.8047)

## SOLUBILITY OF POTASSIUM BROMIDE IN AQUEOUS ETHANOL SOLUTIONS

(0° - Armstrong and Eyre, 1910-11; 10.2°, 19.9° - Zeitlin, 1926;

25° - Armstrong, Eyre, Hussey, and Paddison, 1907; 30°, 40° - Taylor 1896-7)

Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	0°	10.2°	19.9°	25°	30°	40°
	Wt. % KBr in sat. sol.	Moles KBr per liter	Moles KBr per liter	Wt. % KBr in sat. sol.	Wt. % KBr in sat. sol.	Wt. % KBr in sat. sol.
0	34.92	--	--	40.78 <sup>a</sup>	41.62	43.40
1.14	34.35	--	--	39.98 <sup>b</sup>	--	--
2.25	32.96	--	--	39.54 <sup>c</sup>	--	--
4.41	31.99	--	--	38.41 <sup>d</sup>	--	--
5	--	--	--	--	38.98	40.85
8.44	29.43	--	--	--	--	--
10	--	--	--	--	36.33	38.37
12.14	--	--	--	34.97 <sup>e</sup>	--	--
18.73	--	--	--	30.91 <sup>f</sup>	--	--
20	--	--	--	--	31.09	33.27
25.07	--	2.327	2.437	--	--	--
30	--	--	--	--	25.98	28.32
40	--	--	--	--	21.24	23.22
50	--	--	--	--	16.27	18.11
50.01	--	1.016	1.161*	--	--	--
60	--	--	--	--	11.50	13.02
70	--	--	--	--	6.90	7.98
75.03	--	0.2704	0.2955	--	--	--
80	--	--	--	--	3.09	3.65
90	--	--	--	--	0.87	1.03
97.03	--	--	0.0114	--	--	--

\*Wt. % KBr in sat. sol. at 20° = 16.4 (Wright, 1926).

d<sub>25</sub> of sat. sol.: a = 1.3824, b = 1.3727, c = 1.3634, d = 1.3443,  
e = 1.2815, f = 1.2322.

SOLUBILITY OF POTASSIUM BROMIDE IN 95% ETHYL ALCOHOL  
CONTAINING INCREASING AMOUNTS OF HYDROBROMIC ACID AT 25°  
(Yagoda, 1930)

Normality of HBr in 95% C <sub>2</sub> H <sub>5</sub> OH	d. of sat. sol.	Gms. KBr per 100 gms. solvent	Normality of HBr in 95% C <sub>2</sub> H <sub>5</sub> OH	d. of sat. sol.	Gms. KBr per 100 gms. solvent
0.0	0.7997	0.289	0.400	0.839	0.176
0.05	0.805	0.191	0.537	0.853	0.186
0.10	0.810	0.165	0.800	0.878	0.190
0.204	0.820	0.162	0.954	0.893	0.242

THE SYSTEM POTASSIUM BROMIDE - TERTIARY BUTYL ALCOHOL - WATER AT 30°  
(Ginnings and Robbins, 1930)

Br

The points on the binodal curve of this system were determined by observing the appearance or disappearance of clouding in a mixture of weighed amounts of KBr and one of the liquids, upon addition of a weighed amount of the other. Conjugated points were found by determination of KBr in two liquid phases in contact with each other and from these the plait point (p.p.) was obtained by plotting.

Gms. per 100 gms. mixture		Gms. per 100 gms. mixture		Gms. per 100 gms. mixture		Gms. per 100 gms. mixture	
(CH <sub>3</sub> ) <sub>3</sub> COH	KBr	(CH <sub>3</sub> ) <sub>3</sub> COH	KBr	(CH <sub>3</sub> ) <sub>3</sub> COH	KBr	(CH <sub>3</sub> ) <sub>3</sub> COH	KBr
70.2	3.1	50.3	6.7	27.7	12.6	11.3	22.6
65.7	4.2	44.7	7.8	25.6	13.4	9.2	25.3
60.7	4.8	42.0	8.7 p.p.	20.0	15.7	7.7	28.5
56.9	5.4	35.7	10.0	17.0	17.0	6.8	30.4
53.4	6.1	29.7	11.9	13.4	19.8	6.1	33.1

Results at 25°

Ginnings, Herring and Webb, 1933 found the plait point of the system to be: 11.5% KBr, 35.1% (CH<sub>3</sub>)<sub>3</sub>COH, 53.4% H<sub>2</sub>O.

The original results for the remaining points of the binodal curve are not given but only the values of a series of arbitrary constants calculated from them by means of empirical equations.

THE SYSTEM POTASSIUM BROMIDE - ETHYLENE GLYCOL - WATER AT 30°  
(Trimble, 1931)

d. of sat. solution	Gms. per 100 gms. sat. solution		
	KBr	CH <sub>2</sub> OHCH <sub>2</sub> OH	H <sub>2</sub> O
1.3876	41.58	0.0	58.42
1.3417	35.82	12.73	51.45
1.2995	29.64	28.29	42.07
1.2637	23.58	46.08	30.34
1.2338	18.03	65.67	16.30
1.2131	13.68	86.32	0.0



# K KALIUM

## SOLUBILITY OF POTASSIUM BROMIDE IN AQUEOUS GLYCEROL

At 20°  
(Holm, 1921, 1922)

100 gms. Glycerol of d = 1.2326 (= 86.5%) dissolve 20.59 gms. KBr.  
 " " d = 1.2645 (= 98.5%) " 17.15 "

At 25°  
(Herz and Knoch, 1905)

Br	Wt. % Glycerol in Solvent	KBr per 100 cc. sat. sol.		Sp. Gr. Solutions
		Millimols	Gms.	
	0	481.3	57.32	1.3793
	13.28	444.3	52.91	1.3704
	25.98	404	48.11	1.3655
	45.36	340.5	40.55	1.3594
	54.23	310.4	36.98	1.3580
	83.84	219.25	26.11	1.3603
	100	172.65	20.56	1.3691

## SOLUBILITY OF POTASSIUM BROMIDE IN AQUEOUS ACETONE AT 25° (Herz and Knoch, 1905)

cc. Acetone per 100 cc. Solvent	Per 100 cc. Sat. Solution			Sp. Gr. Solutions
	Millimols KBr	Gms. KBr	Gms. KBr	
0	481.3	57.3	80.6	1.3793
20	366.7	43.67	69.5	1.2688
30	310.5	36.98	62.97	1.2118
40	259.0	30.85	55.60	1.1558
50	202.9	24.16	47.60	1.0918
60	144.9	17.22	39.15	1.0275
70	95.3	11.35	29.78	0.9591
80	46.5	5.54	20.10	0.8942
90	10.1	1.20	10.15	0.8340

## SOLUBILITY OF POTASSIUM BROMIDE IN AQUEOUS SOLUTIONS OF DIOXANE AT 25° (Herz and Lorentz, 1929)

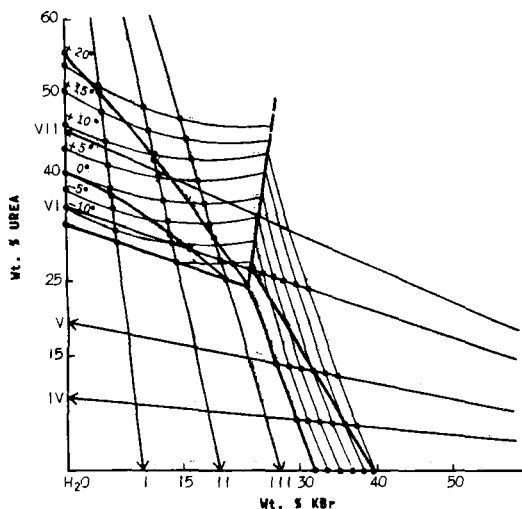
Two liquid layers are formed between 47 and 85 vol. percent Dioxane. The lower contains 2.1 gm. mol. KBr per liter and the upper 0.03 gm. mol. per liter.

cc. Dioxane per 100 cc. solvent	Gm. Mol. KBr per liter sat. sol.	Gms. KBr per liter sat. solution
10	4.20	500
20	3.70	440
30	2.90	345

THE SYSTEM POTASSIUM BROMIDE - UREA - WATER  
(Bokhovkin and Bokhovkina, 1949)

Results are given from the eutectic to 26°. The eutectic solution contains 24.3% KBr, 24.6% Urea, and freezes at -20.8° in equilibrium with ice,  $\alpha$ -KBr, and  $\gamma$ -urea. The data are presented as the freezing points of solutions of urea + water with small additions of KBr, and KBr + water with additions of urea.

The figure shows the area of saturation with the various phases at several temperatures. Numerical data for solutions saturated with ice are also given in the original.



SOLUBILITY OF POTASSIUM BROMIDE IN AQUEOUS SOLUTIONS OF URETHAN AT 25°  
(Palitzsch, 1928, 1929)

Gm. Mols. per 1000 gms. H <sub>2</sub> O		Solid Phase
NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>	KBr	
0.0	5.797	KBr
1.1225	5.616	"
7.215	4.886	"
14.60	4.421	" + NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>
53.09	0.0	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>

SOLUBILITY OF POTASSIUM BROMIDE IN ANHYDROUS METHANOL  
(Lloyd, Brown, Glynwyn, Bonnell and Jones, 1928)

The individual determinations of Turner and Bissett (1913), Akerlof and Turck (1935), Larson and Hunt (1939), Herz and Anders (1907), and Pavlopoulos and Strehlow (1954) at 18° and 25° are in reasonable agreement. The results of Germuth (1931) are incorrect in showing a negative

# K KALIUM

temperature coefficient. The values of Rohland (1898) and de Bruyn (1892) are too low; those of Zeitlin (1926) are too high.

t°	Gms. KBr per 100 gms. CH <sub>3</sub> OH	t°	Gms. KBr per 100 gms. CH <sub>3</sub> OH
0	1.82	30	2.23
10	1.93	40	2.37
15	2.00	50	2.55
20	2.08	60	2.74
		Crit. Temp.	0.2*

\*Centnerszner, 1910.

## Br

### SOLUBILITY OF POTASSIUM BROMIDE IN OTHER ALCOHOLS

- |                           |                              |
|---------------------------|------------------------------|
| (1) Rohland, 1898         | (4) de Bruyn, 1892           |
| (2) Germuth, 1931         | (5) Turner and Bissett, 1913 |
| (3) Larson and Hunt, 1939 | (6) Yagoda, 1930             |

Alcohol	t°	Gms. KBr per 100 gms. solvent	Density sat. sol.	Author
Ethyl	Room (?)	0.28	0.81	(1)
	20	0.451	--	(2)
	25	0.135	0.7861	(3)
		0.13	--	(4)
		0.142	--	(5)
	30	0.499	--	(2)
	40	0.561	--	(2)
	50	0.566	--	(2)
	55	0.535	--	(2)
n-Propyl	Room (?)	0.055	--	(1)
	25	0.035	--	(5)
		0.0314	0.8010	(3)
iso-Propyl	25	0.0110	0.7810	(3)
n-Butyl	20	0.0112	--	(2)
	25	0.0132	0.8058	(3)
	40	0.0137	--	(2)
	50	0.0148	--	(2)
	55	0.0148	--	(2)
sec-Butyl (2-Butanol)	25	0.0044	0.8022	(3)
iso-Butyl (2-methyl-1- propanol)	25	0.0076	0.7980	(3)
n-Amyl	25	0.003	--	(5)
		0.0048	0.8096	(3)
iso-Amyl	25	0.00175	--	(6)

## SOLUBILITY OF POTASSIUM BROMIDE IN VARIOUS ORGANIC SOLVENTS

(1) Semenchenko and Shakparonov, 1948a; (2) Isbin and Kobe, 1945; (3) Lannung, 1932; (4) Robinson, 1928; (5) Walden, 1906; (6) Trimble, 1941; (7) Aschan, 1913; (8) Krug and McElroy, 1892; (9) Stuckgold, 1917; (10) Griswold, Jones and Birdwhistell, 1953.

Solvent	t°	Solubility	Author
Ethylene Glycol	-0.7	12.0 gms. KBr per 100 gms. sat. sol.	(1)
	+7.7	12.5 "	(1)
	17	13.0 "	(1)
	25	12.5 "	(2)
	25.7	13.5 "	(1)
	31.5	14.0 "	(1)
	51.8	15.0 "	(1) Br
Acetone	18	0.0359 gms. KBr per liter sat. sol. (d. = 0.792)	(3)
	25	0.044 "	(4)
		0.023(?) gms. KBr per 100 gms. solvent	(8)
	37	0.0328 gms. KBr per liter sat. sol. (d. = 0.770)	(3)
Furfural	25	0.12 gms. KBr per 100 gms. solvent	(5)
		0.05 "	(6)
Ethylene diamine	25	0.78 gms. KBr per 100 gms. solvent	(2)
Monoethanol amine	25	3.27 gms. KBr per 100 gms. solvent	(2)
Formic acid (95%)	18.5	23.2 gms. KBr per 100 gms. solvent	(7)
Ethyl urethan (m.p. 49.6°)	60	0.387 gms. KBr per 100 cc. sat. sol.	(9)
Acetic acid	30	0.2185 gms. KBr per 100 gms. solvent	(10)

SOLUBILITY OF POTASSIUM BROMIDE IN ACETONE SOLUTIONS OF SEVERAL SALTS AT 25°  
(Robinson, 1928)

Added Salt	Gm. Equiv. salt per liter	Gm. Equiv. KBr per liter sat. sol.
None	(= Pure Acetone)	0.000369*
BaBr <sub>2</sub>	0.000240	0.000430
"	0.000730	0.000482
"	0.001206	0.000531
BaI <sub>2</sub>	0.000137	0.000424
"	0.000408	0.000510
"	0.001206	0.000623
KI	0.000343	0.000414
"	0.000877	0.000489
"	0.001763	0.000579
NaI	0.000382	0.000418
"	0.000939	0.000494
"	0.001849	0.000571
"	0.003542	0.000657

\*Equals 0.044 gms. per liter.

# K KALIUM

## SOLUBILITY OF POTASSIUM BROMIDE IN ACETIC ACID SOLUTIONS CONTAINING SODIUM ACETATE AT 30° (Griswold, Jones and Birdwhistell, 1953)

C = moles  $\text{NaC}_2\text{H}_3\text{O}_2$  per 1000 gms.  $\text{HC}_2\text{H}_3\text{O}_2$   
S = moles KBr per 1000 gms.  $\text{HC}_2\text{H}_3\text{O}_2$

C	S	C	S	C	S
0.0	0.01837	.003307	.02108	.02856	.03166
.000208	.01871	.007700	.02332	.04804	.03710
.000444	.01895	.01007	.02469	.05763	.03946
.001435	.01978	.01873	.02844	.07996	.04402
.002220	.02039	.01997	.02853	.09695	.04760

Br

## SOLUBILITY OF POTASSIUM BROMIDE IN VARIOUS INORGANIC SOLVENTS

(1) Johnson and Kromboltz, 1933; (2) Linhard and Stephen, 1933, 1934;  
(3) Hunt, 1932; (4) Welsh and Broderson, 1915; (5) de Bruyn, 1892; (6) Jander and Ruppolt, 1937; (7) Shatenstein and Viktorov, 1937; (8) Watt, Jenkins and Robinson, 1950; (9) Gutmann, 1952.

Solvent	t°	Solubility	Author
Ammonia (liq.)	-33.9	40.32 gms. KBr/100 gms. $\text{NH}_3$	(1)
	0	26.87 "	(2)
	+25	13.50 "	(3)
Hydrazine	Approx. 20	60.0 gms. KBr/100 gms. $\text{N}_2\text{H}_4$	(4)
Hydroxylamine	17-18	44.7 gms. KBr/100 gms. $\text{NH}_2\text{OH}$	(5)
Sulfur dioxide	0	2.81 gms. KBr/100 gms. $\text{SO}_2$	(6)
	25	0.50 "	(7)
		0.38 "	(8)
Phosphorus oxychloride	20	0.51 gms. per liter	(9)

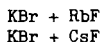
Melting point data are given for the following:

KBr + KF	(Kurnakow and Wrzesnewsky, 1912; Ruff and Plato, 1903)
KBr + KCl	(Wrzesnewsky, 1912; Amadori and Pampanini, 1911; Ruff and Plato, 1903; Tammann and Krings, 1923; Wallace and Fineman, 1948)
KBr + KI	(Wrzesnewsky, 1912; Amadori and Pampanini, 1911; Ruff and Plato, 1903)
KBr + NaCl	(Ruff and Plato, 1903)
KBr + KOH	(Scarpa, 1915)
KBr + $\text{KNO}_3$	( " " )
KBr + $\text{RbCl}$	(Tammann and Krings, 1923)
KBr + $\text{SrBr}_2$	(Kellner, 1917)
KBr + $\text{TlBr}$	(Rostowski, 1929)
KBr + $\text{TlNO}_3$	( " " )
KBr + $\text{MgSO}_4$	(Bergman and Golubova, 1953)
KBr + $\text{K}_2\text{CO}_3$	(Nyankovskaya, 1952)
KBr + $\text{K}_2\text{CrO}_4$	(Gromakov, 1951)
KBr + $\text{K}_2\text{SO}_4$	( " " )
KBr + $\text{PbBr}_2$	(Pokotilo and Pokotilo, 1940; Gromakov, 1950)
KBr + $\text{ZnSO}_4$	(Luzhnaya and Vereshchetina, 1954; Anosov and Patsukova, 1956)
KBr + $\text{RbBr}$	(Gromakov and Gromakova, 1953)

## Melting point data--Continued

KBr + KCl + K <sub>2</sub> SO <sub>4</sub>	(Glitsenko, 1940)
KBr + KCl + KNO <sub>3</sub>	(Lifshitz, 1955)
KBr + TlCl = KCl + TlBr	(Il'yasov, Rozhkovskaya, and Bergman, 1957a)
KBr + AgNO <sub>3</sub> = KNO <sub>3</sub> + AgBr	(Lifshitz, 1956)
2KBr + Na <sub>2</sub> CO <sub>3</sub> = K <sub>2</sub> CO <sub>3</sub> + 2NaBr	(Nyankovskaya, 1952; Nyankovskaya and Yaroslav, 1953)
KBr + NaOH = KOH + NaBr	(Unzhakov, 1953)
KBr + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaBr	(Nyankovskaya, 1952a)
KBr + NaF = KF + NaBr	(Dombrovskaya, 1950)
KBr + NaI = KI + NaBr	( " " )
KBr + RbCl = KCl + RbBr	(Wood and Breithaupt, Jr., 1952; Ricci, 1952)
KBr + LiF = KF + LiBr	(Volkov and Dubinskaya, 1953)
KBr + LiOH = KOH + LiBr	(Reshetnikov and Unzhakov, 1953a)
K <sup>+</sup> , Na <sup>+</sup>    F <sup>-</sup> , Br <sup>-</sup> , I <sup>-</sup>	(Dombrovskaya, 1943, 1950)
K <sup>+</sup> , Na <sup>+</sup>    F <sup>-</sup> , Br <sup>-</sup> , I <sup>-</sup> , Cl <sup>-</sup>	(Bergman, Radishchev and Dombrovskaya, 1951)
K <sup>+</sup> , Na <sup>+</sup> , Ag <sup>+</sup>    Br <sup>-</sup> , Cl <sup>-</sup> , NO <sub>3</sub> <sup>-</sup>	(Dombrovskaya and Alekseeva, 1956)

The reactions below the melting points were studied by Link and Wood, 1940 for the following salt pairs:

POTASSIUM IODO DIBROMIDE KIBr<sub>2</sub>

Br

DATA OF CREMER AND DUNCAN, 1931

In H<sub>2</sub>O One gm. H<sub>2</sub>O dissolves 10-12 gms. KIBr<sub>2</sub>, at 18°.

In CCl<sub>4</sub> At 25°, one liter of saturated solution of potassium iodo dibromide in carbon tetrachloride contains 0.0473 gm. atoms of Halogen produced by the dissociation of the compound into KBr and IBr.

POTASSIUM TIN BROMIDES KSnBr<sub>3</sub>, K<sub>4</sub>SnBr<sub>4</sub>

SOLUBILITY OF MONO POTASSIUM STANNO BROMIDE IN WATER  
(Rimbach and Fleck, 1916)

t°	Gms. per 100 gms. sat. sol.					Solid Phase
	Br	+	Sn	+	K = SnBr <sub>3</sub> K	
0.2*	11.21		3.88		2.94	KSnBr <sub>3</sub> ·H <sub>2</sub> O + SnBr <sub>3</sub> ·H <sub>2</sub> O
17.1*	16.17		6.05		3.94	" "
36.3*	24.56		10.84		4.90	" "
46.3	30.83		15.22		5.09	KSnBr <sub>3</sub> ·H <sub>2</sub> O
74.6	40.88		20.24		6.70	"
					67.82	

\*At these temperatures the atomic ratios of the constituents in solution do not correspond to the double compound, hence the solid phase is not a single substance.

# K KALIUM

## SOLUBILITY OF TETRA POTASSIUM STANNO BROMIDE IN WATER (Rimbach and Fleck, 1916)

t°	Gms. per 100 gms. sat. sol.			Solid Phase
	Br	Sn	K	
0.3*	19.26	1.00	8.77	$K_4SnBr_4 \cdot H_2O + SnBr_3 \cdot H_2O$
16.4*	28.62	2.33	12.48	" "
43.3*	33.38	4.28	13.52	" "
62.1*	39.43	8.44	13.75	" "
77.1*	43.76	12.73	13.03	" "

\*At these temperatures the atomic ratios of the constituents in solution do not correspond to the double compound, hence the solid phase is not a single substance.

## BrO POTASSIUM BROMATE $KBrO_3$

### SOLUBILITY IN WATER

The various results are in good agreement. The data below 100° are those of Ricci (1934) and Guerassimow (1934). The data of Kremens (1856), Rammelsberg (1842), Pohl (1851), Rothmund (1910), Geffcken (1904), Swensor and Ricci (1930), and Ricci and Offenbach (1951) are similar. The values from 134° to 312° were determined by Benrath, Gjedebo, Schiffers and Wunderlich (1937) by the synthetic method. The salt is anhydrous at all temperatures.

t°	d of sat. solution	Gms. $KBrO_3$ per 100 gms. sat. sol.	t°	Gms. $KBrO_3$ per 100 gms. sat. sol.
0	--	2.96	134	43.6
5	1.024	3.642	149	48.4
10	1.035	4.510	160	51.1
15	1.042	5.397	170	54.1
20	1.048	6.460	186	59.9
25	1.054	7.533	204	64.2
30	1.062	8.785	226	70.6
35	1.074	10.13	249	72.6
40	1.083	11.58	265	77.2
45	--	13.08	279	81.1
50	--	14.69	297	83.1
60	--	18.21	312	86.4
80	--	25.53		
100	--	33.3		

THE SYSTEMS  $\text{KBrO}_3 + \text{KCl}$ ,  $\text{KI}$ ,  $\text{KNO}_3$ ,  $\text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  AT  $25^\circ$   
(Ricci, 1934)

$\text{KBrO}_3 + \text{KCl} + \text{H}_2\text{O}$				$\text{KBrO}_3 + \text{KI} + \text{H}_2\text{O}$			
d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{KBrO}_3$	$\text{KCl}$			$\text{KBrO}_3$	$\text{KI}$	
1.054	7.533	0.0	$\text{KBrO}_3$	1.054	7.533	0.0	$\text{KBrO}_3$
1.058	4.63	4.33	"	1.103	4.54	8.77	"
1.082	3.24	9.03	"	1.182	2.96	18.85	"
1.112	2.44	14.45	"	1.278	2.17	28.60	"
1.147	1.97	19.71	"	1.402	1.63	38.99	"
1.183	1.65	24.87	"	1.565	1.21	50.06	"
1.192	1.61	25.89	" + $\text{KCl}$	1.707	0.99	58.14	"
1.187	1.48	25.93	$\text{KCl}$	1.729	0.96	59.20	" + $\text{KI}$
1.179	0.0	26.36	"	1.718	0.0	59.76	$\text{KI}$

$\text{KBrO}_3 + \text{KNO}_3 + \text{H}_2\text{O}$				$\text{KBrO}_3 + \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$			
d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{KBrO}_3$	$\text{KNO}_3$			$\text{KBrO}_3$	$\text{K}_2\text{SO}_4$	
1.074	5.61	5.05	$\text{KBrO}_3$	1.066	6.08	2.67	$\text{KBrO}_3$
1.110	4.64	11.10	"	1.083	5.02	5.44	"
1.148	4.23	16.98	"	1.100	4.27	8.20	"
1.193	4.00	23.17	"	1.108	4.00	9.35	" + $\text{K}_2\text{SO}_4$
1.225	3.90	27.01	" + $\text{KNO}_3$	1.103	3.40	9.45	$\text{K}_2\text{SO}_4$
1.211	2.64	27.27	$\text{KNO}_3$	1.094	1.69	10.12	"
1.193	0.0	27.71	"	1.083	0.0	10.76	"

THE SYSTEM POTASSIUM BROMATE - POTASSIUM CHLORATE - WATER AT  $25^\circ$   
(Swenson and Ricci, 1930)

d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{KBrO}_3$	$\text{KClO}_3$			$\text{KBrO}_3$	$\text{KClO}_3$	
1.054	7.533	0.0	$\text{KBrO}_3$	1.072	4.02	6.75	SS2(96.0)
--	6.46	2.26	SS1(0.46)	1.064	2.79	7.08	" (97.2)
1.067	5.75	4.08	" (1.10)	--	2.07	7.26	" (98.3)
--	5.63	4.29	" (2.0)	1.053	1.02	7.60	" (99.1)
1.078	4.945	6.531	" + SS2	1.048	0.0	7.895	$\text{KClO}_3$

SS1 = Solid solution of  $\text{KClO}_3$  in  $\text{KBrO}_3$  with a limit of 3%  $\text{KClO}_3$ .

SS2 = Solid solution of  $\text{KBrO}_3$  in  $\text{KClO}_3$  with a limit of 5%  $\text{KBrO}_3$ .

The figures in parentheses show the percentage of  $\text{KClO}_3$  in the solid solutions.



# K KALIUM

## SOLUBILITY OF POTASSIUM BROMATE IN AQUEOUS SOLUTIONS OF SODIUM NITRATE AND OF SODIUM CHLORIDE AT 25° (Geffcken, 1904)

NaNO <sub>3</sub> gms. per liter	KBrO <sub>3</sub>		NaCl gms. per liter	KBrO <sub>3</sub>	
	gms. per liter	moles per liter		gms. per liter	moles per liter
0.0	78.79	0.4715	1.0	78.79	0.4715
42.54	96.01	0.574	29.25	82.24	0.5220
85.09	108.6	0.6497	58.50	93.87	0.5616
170.18	128.3	0.7680	117.0	100.9	0.6042
255.27	150.9	0.9026	175.5	104.3	0.6244
340.36	172.3	1.031	234.0	106.9	0.6400

BrO

## SOLUBILITY OF POTASSIUM BROMATE IN AQUEOUS SOLUTIONS OF VARIOUS COMPOUNDS AT 25° (Rothmund, 1910)

Solvent, 0.5 Normal Aq. Sol. of:	Mols. KBrO <sub>3</sub> per Liter	Gms. KBrO <sub>3</sub> per Liter	Solvent, 0.5 Normal Aq. Sol. of:	Mols. KBrO <sub>3</sub> per Liter	Gms. KBrO <sub>3</sub> per Liter
Water alone	0.478	79.84	Dimethylpyrone	0.478	79.84
Methyl Alcohol	0.444	74.16	Ammonia	0.445	74.33
Ethyl Alcohol	0.421	70.33	Dimethylamine	0.384	64.13
Propyl Alcohol	0.409	68.31	Pyridine	0.415	69.31
Tertiary Amyl Alcohol	0.383	63.97	Piperidine	0.396	66.15
Acetone	0.425	70.99	Urethan	0.433	72.33
Ethyl Ether	0.395	65.08	Formamide	0.473	79.02
Formaldehyde	0.397	66.31	Acetamide	0.445	74.33
Glycol	0.448	74.84	Glycocol	0.501	83.68
Glycerol	0.451	75.34	Acetic Acid	0.456	76.17
Mannitol	0.451	75.34	Phenol	0.426	71.15
Grape Sugar	0.431	71.99	Methylal	0.405	67.66
Urea	0.477	79.68	Methyl Acetate	0.420	70.15

## SOLUBILITY OF KBrO<sub>3</sub> IN ANHYDROUS ORGANIC SOLVENTS

Solvent	t°	Solubility	Author
Ethanol	15	8.088 x 10 <sup>-5</sup> moles/liter	Gross, Kuzmany and Wald; 1937
Furfural	25	0.01 gm./100 gm. sat. sol.	Trimble, 1941
Ethylene diamine	25	<0.005 gm./100 gm. solvent	Isbin and Kobe, 1945

## SOLUBILITY OF POTASSIUM BROMATE IN LITHIUM CHLORIDE

SOLUTIONS IN ALCOHOL AT 15°

(Gross, Kuzmany, and Wald, 1937)

100% C<sub>2</sub>H<sub>5</sub>OH was used  $d_{4}^{15} = 0.79359$ 

Moles LiCl per liter	Moles KBrO <sub>3</sub> per liter x 10 <sup>4</sup>	Moles LiCl per liter	Moles KBrO <sub>3</sub> per liter x 10 <sup>4</sup>
0.0	0.8088	11.07	1.015
1.191	.8583	15.87	1.076
2.942	.8947	20.34	1.139
5.769	.9465	24.52	1.169

100 gms. liquid Ammonia dissolve 0.002 gm. KBrO<sub>3</sub> at 25°. (Hunt and Boneyk, 1933.)

POTASSIUM METHIONATE K<sub>2</sub>[CH<sub>2</sub>·(SO<sub>3</sub>)<sub>2</sub>]

CH

100 gms. sat. solution of Potassium Methionate in Water contain 4.46 gms. K<sub>2</sub>[CH<sub>2</sub>(SO<sub>3</sub>)<sub>2</sub>] at 25°. (Backer, 1929; Baker and Terpstra, 1929.)

POTASSIUM CHLOR METHIONATE K<sub>2</sub>[CHCl(SO<sub>3</sub>)<sub>2</sub>]

100 gms. sat. solution of Potassium Chlor Methionate in water contain 34.2 gms. K<sub>2</sub>[CHCl(SO<sub>3</sub>)<sub>2</sub>] at 25°. (Baker, 1930.)

## POTASSIUM FORMATE HCOOK

CH

## THE SYSTEM POTASSIUM FORMATE - WATER

(Groschuff, 1903; Sidgwick and Gentile, 1922)

t°	Gms. HCOOK per 100 gms. sat. sol.	Solid Phase	t°	Gms. HCOOK per 100 gms. sat. sol.	Solid Phase
- 2.62	5.71 (S.G.)	ICE	-20	72.8 (G.)	HCOOK
- 6.72	12.95 (S.G.)	"	+18	76.8*(G.)	"
-10.42	18.42 (S.G.)	"	50	80.7 (G.)	"
-15.82	25.03 (S.G.)	"	90	86.8 (G.)	"
-17.39	26.04 (S.G.)	"	120	92.0 (G.)	"
			140	96.0 (G.)	"
			157 m.pt.	100.0 (G.)	"

\*Sp. Gr. 18° = 1.573

## POTASSIUM ACID FORMATE HCOOK·HCOOH

## SOLUBILITY IN WATER

(Groschuff, 1903)

t°	0	25	50	80
Gms. HCOOK per 100 gms. sat. sol.	60.4	69.8	79.2	90.7

## K KALIUM

Since the acid salt is less soluble at ordinary temperatures than the neutral salt, it can be precipitated from the solution of the neutral salt by addition of aqueous formic acid. Proceeding in this way an impure product is obtained, giving solubility values (expressed in HCOOK) as shown below:

t°	Gms. HCOOK per 100 Gms. Solution	Moles HCOOH per 1 mole HCOOK	t°	Gms. HCOOK per 100 Gms. Solution	Moles HCOOH per 1 mole HCOOK
0	36.3	3.21	60	44.0	2.33
19.5	38.2	2.96	70	45.9	2.16
39.3	40.8	2.65	90	52.1	1.68

Freezing-point data for the system HCOOK + HCOOH are given by Kendall and Adler, 1921.

## CH POTASSIUM ACETATE CH<sub>3</sub>COOK

THE SYSTEM POTASSIUM ACETATE - WATER  
(Abe, 1911; Sidgwick and Gentile, 1922 (f. pts.))

t°	Gms. CH <sub>3</sub> COOK per 100 Gms. H <sub>2</sub> O	Solid Phase	t°	Gms. CH <sub>3</sub> COOK per 100 Gms. H <sub>2</sub> O	Solid Phase
-2.15	5.26	ICE	35	301.8	2CH <sub>3</sub> COOK·3 H <sub>2</sub> O
-3.36	8.01	"	38	314.2	"
-9.32	20.53	"	40	323.3	"
-12.32	25.85	"	41	327.7	2CH <sub>3</sub> COOK·3H <sub>2</sub> O
-17.92	34.25	"	41.3 tr. pt.	--	" + 2CH <sub>3</sub> COOK·H <sub>2</sub> O
+0.1	216.7	2CH <sub>3</sub> COOK·3H <sub>2</sub> O	42	329	2CH <sub>3</sub> COOK·H <sub>2</sub> O
5	223.9	"	45	332.2	"
10	233.9	"	50	337.3	"
15	243.1	"	60	350	"
20	255.6	"	70	364.8	"
25	269.4	"	80	380.1	"
	219.6*	"	90	396.3	"
30	283.8	"	96	406.5	"

\*Seidell, 1910, d. = 1.417

SOLUBILITY OF POTASSIUM ACETATE IN AQUEOUS ETHANOL SOLUTIONS AT 25°  
(Seidell, 1910)

Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. CH <sub>3</sub> COOK per 100 Gms. Solvent	Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. CH <sub>3</sub> COOK per 100 Gms. Solvent
0	1.417	219.6	70	1.156	118.3
20	1.363	219.6	80	1.085	87.6
40	1.302	192.4	90	0.990	52.9
50	1.260	171.8	95	0.922	34.2
60	1.210	147.5	100	0.850	16.3

SOLUBILITY OF POTASSIUM ACETATE IN ACETIC ACID, DETERMINED  
BY THE FREEZING-POINT METHOD

The results of Davidson and McAllister (1930) and Bakunin and Vitale, 1935 are in considerable disagreement.

1:2 =  $\text{CH}_3\text{COOK} \cdot 2\text{CH}_3\text{COOH}$ ; 1:1 =  $\text{CH}_3\text{COOK} \cdot \text{CH}_3\text{COOH}$ ; 2:1 =  $2\text{CH}_3\text{COOK} \cdot \text{CH}_3\text{COOH}$

(Davidson and McAllister, 1930)

t°	Gm. Mols. $\text{CH}_3\text{COOK}$ per 100 gm. mols. mixture	Solid Phase	t°	Gm. Mols. $\text{CH}_3\text{COOK}$ per 100 gm. mols. mixture	Solid Phase
16.50	0.0	$\text{CH}_3\text{COOH}$	110.0	30.67	1:1
15.82	1.22	"	118.0	32.47	"
10.95	6.70	"	124.5	34.41	"
7.45	9.10	"	126.0	35.27	"
5.95	10.03	"	137.0	39.5	"
14.76	10.97	1:2	145.0	44.88	"
28.03	12.71	"	147.5	48.30	"
49.90	15.75	"	148.0	50.22	"
64.1	18.71	"	147.5	52.32	"
73.5	20.48	"	170	58.45	$\text{CH}_3\text{COOK}$
83.6	23.85	"	206	64.16	"
99.0	28.44	1:1	245	76.50	"
			292	100.00	"

(Bakunin and Vitale, 1935)

16	0.0	$\text{CH}_3\text{COOH}$	134	42.88	2:1
9	5.23	"	138.6	50.06	"
3	10.33	"	147	58.05	$\text{CH}_3\text{COOK}$
0 Eutec.	--	" + 1:2	175	60.20	"
14	16.22	1:2	234	71.83	"
64	23.43	2:1	258	81.73	"
101	29.43	"	292	98.24	"
112	37.27	"	297	100.00	"

SOLUBILITY OF POTASSIUM ACETATE IN SEVERAL SOLVENTS

Solvent	t°	Solubility	Author
Methanol*	15	24.24 gm./100 gms. $\text{CH}_3\text{OH}$	Henstock, 1934
	73.4 b.pt.	53.54 "	" "
	sat. sol.		
Glycerol:			
86.5% (d=1.2326)	20	77.4 gm./100 gm. solvent	Holm, 1921, 1922
98.5% (d=1.2646)	20	65.5 "	" "
Ammonia (liq.)	-33.9	1.026 gm./100 gm. $\text{NH}_3$	Johnson and Krumboltz, 1933
Sulfur dioxide (liq.)	0	0.006 gm./100 gm. $\text{SO}_2$	Jander and Rup- pott, 1937

\*The salt gives extremely hygroscopic crystals of the alcoholate,  
 $\text{CH}_3\text{COOK} \cdot \text{CH}_3\text{OH}$ .

## K KALIUM

Melting point data are given for:

$\text{CH}_3\text{COOK} + \text{CH}_3\text{COONa}$  Baskof, 1915, 1917  
 $\text{CH}_3\text{COOK} + (\text{CH}_3\text{COO})_2\text{Pb}$  Lehrman and Leifer, 1938  
 $\text{CH}_3\text{COOK} + \text{LiNO}_3 \rightleftharpoons \text{CH}_3\text{COOLi} + \text{KNO}_3$  Diogenov, Nurminskii and Gimelshtein, 1957

### POTASSIUM TRIFLUORO ACETATE $\text{CF}_3\text{COOK}$

At 29.8°, 50.13 gms.  $\text{CH}_3\text{COOK}$  dissolve in 100 gms.  $\text{CF}_3\text{COOH}$ . The solid phase is  $\text{CF}_3\text{COOK} \cdot \text{CF}_3\text{COOH}$ . (Hara and Cady, 1954)

### CH POTASSIUM PROPIONATE $\text{C}_2\text{H}_5\text{COOK} \cdot \text{H}_2\text{O}$

100 gms. methyl alcohol ( $\text{CH}_3\text{OH}$ ) dissolve 39.0 gms. anhydrous potassium propionate at 15° and 55.33 gms. at 71.3° (= b. pt. of sat. sol.). (Henstock, 1934)

### POTASSIUM LACTATE $\text{CH}_3\text{CHONCOOK}$

#### FREEZING POINTS OF POTASSIUM LACTATE SOLUTIONS (Dietz, Degering, and Schopmeyer, 1941)

Gms. Potassium Lactate per 100 gms. Sat. Sol.	t°	Gms. Potassium Lactate per 100 gms. Sat. Sol.	t°
5	-1.6	30	-16.1
10	-3.7	40	-28.1
20	-8.6	50	-51.0

The density, refractive index, viscosity, boiling points and surface tension of various potassium lactate solutions are also reported.

### CH POTASSIUM *n*-BUTYRATE $\text{C}_3\text{H}_7\text{COOK}$

100 gms. water dissolve 296.8 gms.  $\text{C}_3\text{H}_7\text{COOK}$ , or 100 gms. sat. solution contain 74.8 gms. at 31.25°.

100 gms. of an aq. solution saturated with sugar and  $\text{C}_3\text{H}_7\text{COOK}$  contain 49.19 gms. sugar + 34.78 gms.  $\text{C}_3\text{H}_7\text{COOK}$  + 16.03 gms.  $\text{H}_2\text{O}$  at 31.25°. (Köhler, 1897)

100 gms. methyl alcohol ( $\text{CH}_3\text{OH}$ ) dissolve 51.04 gms. *n* potassium butyrate,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOK}$ , at 15° and 120.84 gms. at 70.9° (= b. pt. sat. sol.). (Henstock, 1934.)

### POTASSIUM *iso*-BUTYRATE $(\text{CH}_3)_2\text{CHCOOK}$

#### EQUILIBRIUM IN THE SYSTEM POTASSIUM *iso*-BUTYRATE, *iso*-BUTYRIC ACID AND WATER AT 25° (Bury and Mends, 1939)

Suitable mixtures were shaken in hard glass vessels until analysis showed that equilibrium was established. *iso* butyric acid was determined by titration and potassium *iso* butyrate by conversion into potassium

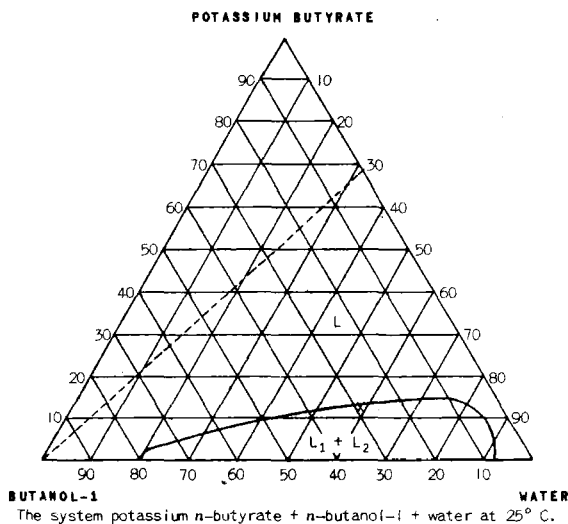
chloride. The two liquid layers which were formed in all cases had the following compositions.

Upper Layer Gms. per 100 gms. sat. sol.		Lower Layer Gms. per 100 gms. sat. sol.		Upper Layer Gms. per 100 gms. sat. sol.		Lower Layer Gms. per 100 gms. sat. sol.	
Acid	Salt	Acid	Salt	Acid	Salt	Acid	Salt
27.26	0.0	24.0	0.0	51.20	0.20	30.17	0.32
57.08	0.02	24.23	0.09	49.81	0.23	30.99	0.33
56.90	0.05	25.09	0.18	49.00	0.24	31.21	0.34
55.54	0.08	26.43	0.23	47.91	0.26	31.80	0.34
54.76	0.10	27.14	0.25	46.89	0.28	32.56	0.34
53.81	0.13	27.72	0.27	45.72	0.29	34.02	0.35
53.17	0.16	28.00	0.28	44.54	0.30	35.21	0.36
52.50	0.18	29.03	0.29	43.48	0.32	37.62	0.36
51.72	0.19	29.69	0.30	42.00	0.34	39.57	0.37
51.11	0.20	30.08	0.32				

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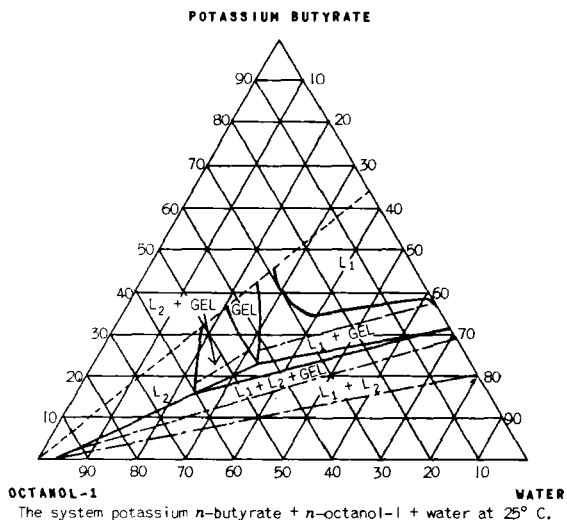
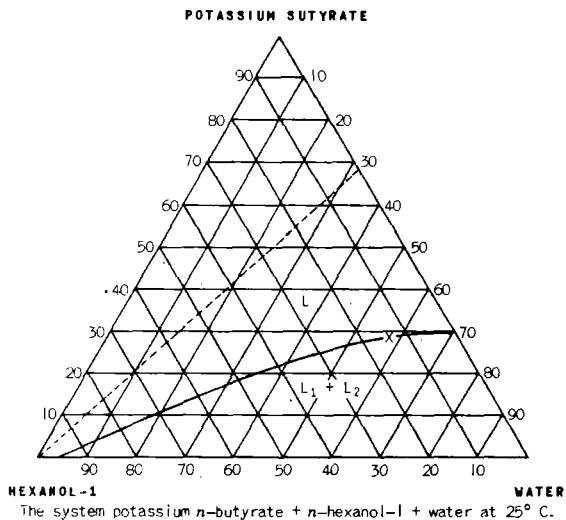
THE SYSTEMS POTASSIUM BUTYRATE - ALCOHOLS - WATER AT 25°  
(Lumb, 1951)

- $L$   $L_1$   $L_2$  Isotropic liquid phases.  
 $x$  Plait point.  
 ----- Limit of composition range studied.  
 ----- Tie line.

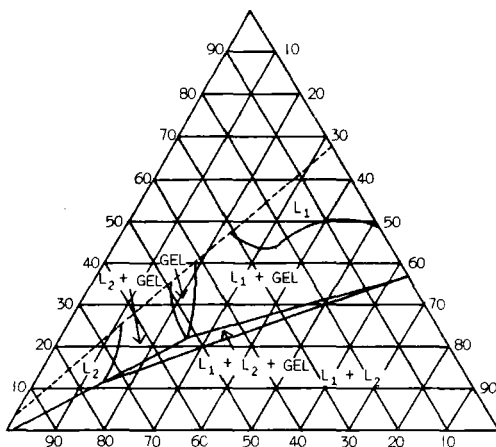


K KALIUM

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## POTASSIUM BUTYRATE



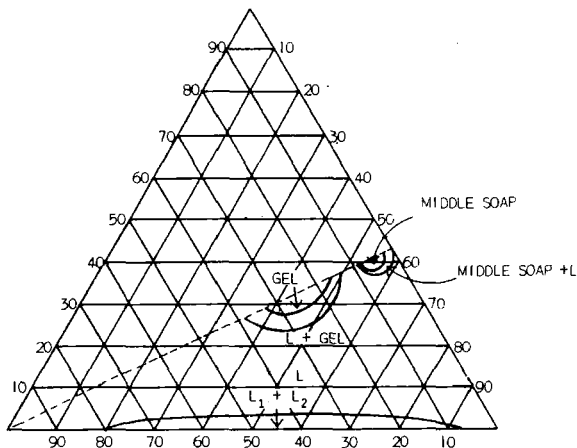
DODECANOL-1

WATER

The system potassium *n*-butyrate + *n*-dodecanol-1 + water at 25°C.

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## POTASSIUM OCTANOATE



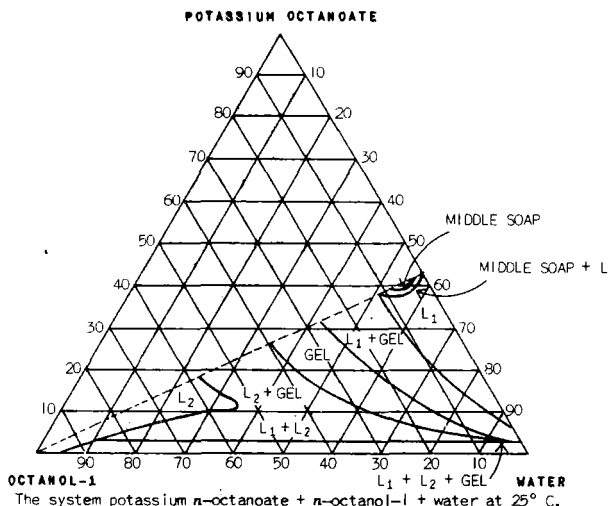
BUTANOL-1

WATER

The system potassium *n*-octanoate + *n*-butanol-1 + water at 25° C.



# K KALIUM



## POTASSIUM DILUTURATE (18.52%K) $C_8H_{17}O_2K$

t°	Solubility	Author
18	0.0022 moles per 1000 gms. Sat. Sol.	(Fredholm, 1936)
30	0.086 gms. (0.40 millimoles) salt per 100 gms. H <sub>2</sub> O	(Dermer and Dermer, 1939)

## CH POTASSIUM ACID TARTRATE $KHC_4H_4O_6$ (Cream of tartar)

### SOLUBILITY IN WATER

The early results of Alluad, 1865; Roelofsen, 1894; Blarez, 1891; Magnanini, 1901; Noyes and Clement, 1894, Pierrat, 1921 are generally too high. The data below are those of Paul, 1926 and Carpenter and Mack, 1934.

t°	Gms. $KHC_4H_4O_6$ per 100 gms. sat. sol.		density sat. sol.	
	Paul	C. & M.	Paul	C. & M.
0	0.2650	0.2305	1.00145	1.0012
5	0.2969	0.2870	1.00224	1.0016
10	0.3656	0.3579	1.00180	1.0020
14	0.4294	(0.422) <sup>b</sup>	1.00172	--
15	--	0.4338	--	1.0016
18	0.4890	--	1.00120	--
20	0.5332	0.5323	1.00100	1.0012
	--	(0.5337) <sup>a</sup>	--	--
	--	(0.5415) <sup>d</sup>	--	--
	--	(0.599) <sup>b</sup>	--	--
22	--	0.6412	1.00079	1.0003
25	0.6406	(0.649) <sup>e</sup>	--	--
	--	--	1.00026	--
30	0.7621	--	--	--
40	(1.3) <sup>e</sup>	--	--	--
50	(1.8) <sup>e</sup>	--	--	--
60	(2.4) <sup>e</sup>	(3.87) <sup>b</sup>	--	--
80	(4.4) <sup>e</sup>	--	--	--
100	(6.5) <sup>e</sup>	--	--	--

<sup>a</sup>Richert, 1930; <sup>b</sup>Warrington, 1875; <sup>c</sup>Seidell, 1910; <sup>d</sup>Moser and Ritschel, 1925; <sup>e</sup>Alluad, 1865 - may be too high.

SOLUBILITY OF POTASSIUM ACID TARTRATE IN TARTARIC ACID SOLUTIONS  
(Carpenter and Mack, 1934)

Gms. $\text{H}_2\text{C}_4\text{H}_4\text{O}_6$ per 100 gms. sat. sol.	Gms. $\text{KHC}_4\text{H}_4\text{O}_6$ per 100 gms. sat. solution at:		
	0°	10°	25°
0.0	0.2305 (1.0012)	0.03579 (1.0020)	0.6412 (1.0003)
0.025	0.2162 (1.0013)	0.3457 (1.0020)	0.6220 (1.0003)
0.050	0.2075 (1.0013)	0.3352 (1.0021)	0.6063 (1.0004)
0.100	0.1962 (1.0014)	0.3205 (1.0021)	0.5842 (1.0005)
0.200	0.1842 (1.0016)	0.3003 (1.0026)	0.5558 (1.0008)
0.400	0.1680 (1.0024)	0.2715 (1.0033)	0.5243 (1.0014)
0.600	0.1600 (1.0035)	0.2502 (1.0042)	0.4981 (1.0021)
0.800	0.1503 (1.0047)	--	0.4716 (1.0027)

CH

The figures in parentheses are the densities of the saturated solutions.

At 20°  
(Richert, 1930)

Gm. Mols. per liter sat. solution	
$\text{H}_2\text{C}_4\text{H}_4\text{O}_6$	$\text{KHC}_4\text{H}_4\text{O}_6$
0.0030	0.0268
0.0055	0.0260
0.0105	0.0240
0.0335	0.0238
0.0485	0.0238

At 14°

100 cc. of a solution containing 1.03 gms. tartaric acid will dissolve 0.322 gms.  $\text{KHC}_4\text{H}_4\text{O}_6$ . (Warrington, 1875.)

SOLUBILITY OF POTASSIUM ACID TARTRATE IN VARIOUS ACID SOLUTIONS  
Results of Warrington, 1875

In Hydrochloric Acid			In other Acids and in Salt Solutions at 14°		
Conc. of HCl Gms. per 100 Gms. Sol.	Gms. $\text{KHC}_4\text{H}_4\text{O}_6$ per 100 Gms. Solvent		Acid or Salt	Gms. Acid or Salt per 100 cc. Sol.	Gms. $\text{KHC}_4\text{H}_4\text{O}_6$ per 100 cc. Sol.
	At 22°	At 80°			
0	0.600	4.027	None	--	0.422
0.68	3.01	5.35	Acetic Acid	0.81	0.422
2.15	6.88	11.35	Citric Acid	0.84	0.546
4.26	11.19	20.23	Sulphuric Acid	0.685	1.701
8.36	22.75	40.93	Hydrochloric Acid	0.504	1.947
16.13	48.31	80.12	Nitric Acid	0.845	1.969

At 25°  
(Noyes and Clement, 1894)

Gms. per liter	
HCl	$\text{KHC}_4\text{H}_4\text{O}_6$
0.45	6.90
0.91	8.06
1.82	11.09

(cont'd.)

# K KALIIUM

Results of Ostwald; Huecke, 1884 at 20°

Purified tartrate was added in excess to normal solutions of the acids, and, after shaking, clear 1 cc. portions of each solution were withdrawn and titrated with approximately 0.1 N Ba(OH)<sub>2</sub> solution; 1 cc. normal acid required 10.63 cc. of the Ba(OH)<sub>2</sub> solution, and the excess was the KHC<sub>4</sub>H<sub>4</sub>O<sub>6</sub>.

	Gms. Acid		Gms.		Gms. Acid		Gms.	
	per		KHC <sub>4</sub> H <sub>4</sub> O <sub>6</sub>		per		KHC <sub>4</sub> H <sub>4</sub> O <sub>6</sub>	
	100 cc.		per 100 cc.		100 cc.		per 100 cc.	
	Acid	Solvent	Solution		Acid	Solvent	Solution	
CH	HNO <sub>3</sub>	6.31	10.21		C <sub>2</sub> H <sub>5</sub> SO <sub>3</sub> H	11.0	8.87	
	HCl	3.65	9.42		HO·(CH <sub>2</sub> ) <sub>2</sub> SO <sub>3</sub> H	12.61	9.43	
	HBr	8.10	9.75		C <sub>6</sub> H <sub>5</sub> SO <sub>3</sub> H	15.81	9.29	
	HI	12.80	9.61		HCOOH	4.60	0.80	
	H <sub>2</sub> SO <sub>4</sub>	4.90	7.03		CH <sub>3</sub> COOH	6.00	0.48	
	HCH <sub>3</sub> SO <sub>4</sub>	11.21	12.44		CH <sub>2</sub> ClCOOH	9.45	1.79	
	HC <sub>2</sub> H <sub>5</sub> SO <sub>4</sub>	12.61	9.58		C <sub>2</sub> H <sub>5</sub> COOH	7.40	0.42	
	HC <sub>3</sub> H <sub>7</sub> SO <sub>4</sub>	14.01	9.22		C <sub>3</sub> H <sub>7</sub> COOH	8.81	0.41	

## SOLUBILITY OF POTASSIUM ACID TARTRATE IN AQUEOUS SOLUTIONS OF NEUTRAL DI POTASSIUM TARTRATE AT SEVERAL TEMPERATURES (Carpenter and Mack, 1934)

The figures in parentheses are the densities of the saturated solutions.

Gms. K <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>6</sub> per 100 gms. sat. sol.	Gms. KHC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> per 100 gms. sat. solution at:		
	0°	5°	10°
0.00	0.2305 (1.0012)	0.2870 (1.0016)	0.3579 (1.0020)
0.025	0.2010 (1.0010)	0.2562 (1.0016)	0.3272 (1.0020)
0.050	0.1772 (1.0009)	0.2322 (1.0017)	0.3000 (1.0021)
0.100	0.1394 (1.0011)	0.1936 (1.0021)	0.2557 (1.0024)
0.200	0.0978 (1.0014)	0.1437 (1.0025)	0.1924 (1.0027)
0.300	0.0758 (1.0018)	0.1098 (1.0029)	0.1540 (1.0030)
0.400	0.0617 (1.0024)	0.0902 (1.0035)	0.1317 (1.0036)
0.500	0.0523 (1.0031)	0.0784 (1.0041)	0.1143 (1.0042)
0.600	0.0480 (1.0038)	0.0703 (1.0047)	0.1039 (1.0048)
0.700	0.0433 (1.0046)	0.0638 (1.0053)	0.0935 (1.0054)
0.800	0.0379 (1.0052)	0.0562 (1.0059)	0.0824 (1.0060)

Gms. K <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>6</sub> per 100 gms. sat. sol.	Gms. KHC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> per 100 gms. sat. solution at:		
	15°	20° (Also see below)	25°
0.00	0.4338 (1.0014)	0.5323 (1.0012)	0.6412 (1.0003)
0.025	0.4050 (1.0017)	0.5010 (1.0012)	0.6120 (1.0003)
0.050	0.3793 (1.0017)	0.4737 (1.0013)	0.5894 (1.0004)
0.100	0.3307 (1.0018)	0.4228 (1.0014)	0.5424 (1.0006)
0.200	0.2651 (1.0021)	0.3492 (1.0016)	0.4560 (1.0008)
0.300	0.2186 (1.0025)	0.2939 (1.0020)	0.2898 (1.0011)
0.400	0.1890 (1.0028)	0.2532 (1.0021)	0.3428 (1.0015)
0.500	0.1652 (1.0031)	0.2208 (1.0023)	0.3060 (1.0020)
0.600	0.1492 (1.0037)	0.1977 (1.0025)	0.2773 (1.0022)
0.700	0.1357 (1.0041)	--	0.2522 (1.0024)
0.800	0.1220 (1.0149)	--	0.2292 (1.0028)

cont'd.

Data of Richert, 1930 at 20° (Also see above)

Gm. Mols. per liter of sat. solution		Gm. Mols. per liter of sat. solution	
$K_2C_4H_4O_6$	$KHC_4H_4O_6$	$K_2C_4H_4O_6$	$KHC_4H_4O_6$
0.000443	0.0284 (= 5.342 gms.)	0.00443	0.00667
0.000443	0.0218	0.00714	0.00540
0.000886	0.0176	0.0143	0.00360
0.00177	0.0124	0.0214	0.00280
0.00266	0.0096	0.0286	0.00264
0.00354	0.00805	0.0357	0.00260

SOLUBILITY OF MONO POTASSIUM TARTRATE ( $KHC_4H_4O_6$ ) IN AQUEOUS  
SOLUTIONS OF ELECTROLYTES AT 25°

(Noyes and Clement, 1894; Magnanini, 1901)

CH

The results of Klapproth, 1922 at 13-15° are not in internal agreement, and may not represent equilibrium conditions.

Electrolyte	Gm. Equiv. per Liter		Gms. per Liter	
	Electrolyte	$KHC_4H_4O_6$	Electrolyte	$KHC_4H_4O_6$
KCl	0.025	0.0254	1.86	4.788
"	0.05	0.0196	3.73	3.680
"	0.10	0.0133	7.46	2.509
"	0.20	0.0087	14.92	1.636
KClO <sub>3</sub>	0.025	0.0256	3.06	4.821
"	0.05	0.0197	6.13	3.716
"	0.10	0.0138	12.26	2.601
"	0.20	0.0097	24.52	1.728
KBr	0.05	0.0192	5.95	3.699
"	0.10	0.0134	11.91	2.517
"	0.20	0.0087	23.82	1.629
KI	0.05	0.0196	8.30	3.687
"	0.10	0.0132	16.61	2.492
"	0.20	0.0086	33.22	1.619
KNO <sub>3</sub>	0.05	0.0195	5.06	3.676
"	0.10	0.0136	10.12	2.551
"	0.20	0.0090	20.24	1.696
K <sub>2</sub> SO <sub>4</sub>	0.05	0.0208	4.36	3.921
"	0.10	0.0147	8.72	2.769
"	0.20	0.0100	17.44	1.888
CH <sub>3</sub> COOK	0.05	0.0410	4.91	7.718
"	0.10	0.0504	9.82	9.486
"	--	--	13.87	7.44 (?) <sup>a</sup>
"	0.20	0.0634	19.63	11.930
KHSO <sub>4</sub> (20°)	0.01	0.0375	1.36	7.06
"	0.02	0.0500	2.72	9.41
"	0.10	0.1597	13.62	30.06
KHC <sub>2</sub> O <sub>4</sub> * (20°)	0.01	0.0369	1.28	6.94
"	0.02	0.0424	2.56	7.98
"	0.10	0.1132	12.82	21.30
NaCl	0.05	0.0376	2.92	7.08
"	0.10	0.0397	5.85	7.48
"	0.20	0.0428	11.70	8.05
NaClO <sub>3</sub>	0.05	0.0382	5.32	7.18
"	0.10	0.0405	10.65	7.63
"	0.20	0.0446	21.30	8.40
K Citrate	--	--	13.97	8.43 <sup>a</sup>

\* = acid potassium oxalate.

<sup>a</sup> = Warington, 1875.

# K KALIUM

## SOLUBILITY OF POTASSIUM ACID TARTRATE IN AQUEOUS ETHANOL (For additional data from 5° to 25° see Ivanov, 1947)

### Results at 14° (Pierrat, 1921)

Saturation was obtained by agitating the mixtures for several hours. The sat. solution was evaporated to dryness in a current of air and the residue dissolved in enough water to yield the original volume of the solution. The tartrate in this was determined by electrolytic conductivity.

	Wt. per cent C <sub>2</sub> H <sub>5</sub> OH in solvent	Gms. KHC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> per 100 cc. sat. sol.	Wt. per cent C <sub>2</sub> H <sub>5</sub> OH in solvent	Gms. KHC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> per 100 cc. sat. sol.
CH	0.0 (= H <sub>2</sub> O)	4.8	42.4	0.42
	8.7	2.2	58.5	0.20
	15.9	1.5	94.7	0.05
	27.3	0.77		

### Results at 18° (Paul, 1927, 1926)

The figures in parentheses show the  $\frac{d_t}{t}$  of the saturated solutions.

The author also gives data for the pH and the electrolytic conductivity of the saturated solutions.

	Gms. KHC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> per 100 cc. sat. solution in aq. C <sub>2</sub> H <sub>5</sub> OH of		
t°	5.0 gms. C <sub>2</sub> H <sub>5</sub> OH per 100 cc. ( $\frac{d_{20}}{t}$ = 0.98650)	8.0 gms. C <sub>2</sub> H <sub>5</sub> OH per 100 cc. ( $\frac{d_{20}}{t}$ = 0.98155)	10.0 gms. C <sub>2</sub> H <sub>5</sub> OH per 100 cc. ( $\frac{d_{20}}{t}$ = 0.97513)
0	0.1746 (0.98998)	0.1375 (0.98247)	0.1248 (0.97805)
10	0.2605 (0.98974)	0.2078 (0.98203)	0.1905 (0.97746)
18	0.358	0.294	0.258
20	0.3924 (0.98876)	0.3371 (0.98170)	0.3003 (0.97678)
25	0.4747 (0.98785)	0.4045 (0.98141)	0.3662 (0.97546)
30	0.5846 (0.98673)	0.4965 (0.98118)	0.4323 (0.97364)

### Results at 25° (Seidell, 1910)

Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. KHC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> per 100 gms. Sat. Sol.	Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. KHC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> per 100 gms. Sat. Sol.
0	1.002	0.649	50	0.912	0.064
10	0.985	0.358	60	0.890	0.043
20	0.970	0.210	80	0.842	0.023
30	0.953	0.131	92.3	0.807	0.014
40	0.933	0.087	100	0.789	0.010

## SOLUBILITY OF KHC<sub>4</sub>H<sub>4</sub>O<sub>6</sub> IN METHANOL

100 gms. Methyl Alcohol (CH<sub>3</sub>OH) dissolve 0.6 gm. KHC<sub>4</sub>H<sub>4</sub>O<sub>6</sub> at 66°. (b.pt.). (Henstock, 1934.)

SOLUBILITY OF  $\text{KHC}_4\text{H}_4\text{O}_6$  IN AQUEOUS UREA AND DIOXANE SOLUTIONS  
(Pederson, 1941)

UREA AT 17.85°		DIOXANE AT 18.00°	
Moles Urea per 1000 ml. of Solvent	Moles $\text{KHC}_4\text{H}_4\text{O}_6$ per 1000 ml. Sat. Sol.	Moles Dioxane per 1000 ml. Solvent	Moles $\text{KHC}_4\text{H}_4\text{O}_6$ per 1000 ml. Sat. Sol.
0.0	0.02600	0.0	0.02617
.250	.02646	.250	.02417
.500	.02688	.500	.02227
.750	.02734	.750	.02052
1.000	.02772	1.000	.01883

SOLUBILITY OF POTASSIUM ACID TARTRATE IN AQUEOUS SOLUTIONS  
OF SUGARS AT 20°  
(Carpenter and Kucera, 1934)

Wt. % Sugar	Gms. $\text{KHC}_4\text{H}_4\text{O}_6$ per 100 gms. sat. solution in aqueous:		
	d-Glucose Solution	d-Fructose Solution	Sucrose Solution
0	0.5323 (1.0012)	0.5323 (1.0012)	0.5323 (1.0012)
5	-- --	0.5180 (1.0210)	-- --
10	0.4924 (1.0405)	0.5037 (1.0414)	0.4715 (1.0409)
20	0.4442 (1.0824)	0.4637 (1.0843)	0.4237 (1.0835)
30	0.4010 (1.1272)	0.4269 (1.1303)	0.3707 (1.1293)
40	-- --	0.3833 (1.1796)	0.3114 (1.1784)

SOLUBILITY OF POTASSIUM ACID TARTRATE IN INVERT SUGAR  
SOLUTIONS (GLUCOSE + FRUCTOSE) AT 20°

Data of Richert, 1930

Data of Carpenter &amp; Kucera, 1934

Wt. % Sugar	Gm. Mols. $\text{KHC}_4\text{H}_4\text{O}_6$ per:		Wt. % Sugar	Gms. $\text{KHC}_4\text{H}_4\text{O}_6$ per 100 gms. sat. sol.	Density
	1000 cc. sat. solution	1000 gms. sat. sol.			
0	0.0284	0.0284	0	0.5323	1.0012
15	0.0276	0.0260	5	0.5171	1.0209
30	0.0264	0.0232	10	0.4979	1.0411
45	0.0240	0.0198	20	0.4570	1.0837
60	0.0200	0.0155	30	0.4152	1.1296
80	0.0123	0.0087	40	0.3700	1.1788

POTASSIUM TARTRATE  $\text{K}_2\text{C}_4\text{H}_4\text{O}_6$

CH

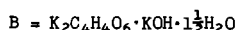
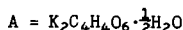
SOLUBILITY IN WATER

16.6° - 58.0 gms. per 100 gms. sat. sol. (Sp.gr. = 1.49) (Greenish and Smith, 1901)  
 17° - 58.25 " " " (Peyronel, 1949b)

# K KALIUM

## THE SYSTEM POTASSIUM TARTRATE - POTASSIUM HYDROXIDE - WATER AT 17° (Peyronel, 1949b)

CH	Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
	$K_2C_4H_4O_6$	KOH		$K_2C_4H_4O_6$	KOH		$K_2C_4H_4O_6$	KOH	
	58.25	0.0	A	21.70	32.50	A	6.00	48.30	B
	53.30	2.26	A	21.40	34.33	A	5.96	48.25	B
	51.92	2.73	A	22.09	35.02	A	5.44	48.81	B
	43.60	9.33	A	21.25	35.34	A	4.15	50.12	B
	41.20	10.11	A	25.00	36.17	A + B	4.18	50.85	B
	29.90	19.52	A	20.80	36.75	B	4.47	51.45	B + C
	29.74	20.25	A	19.45	37.57	B	7.84	50.43	C
	22.05	25.52	A	18.65	38.55	B	9.76	48.70	C
	20.20	28.36	A	14.90	40.30	B	10.75	47.80	C
	22.32	29.00	A	14.30	41.50	B	13.25	46.28	C
	22.68	29.22	A	11.56	42.90	B	16.00	44.50	C
	22.42	30.72	A	8.85	45.71	B	2.93	52.35	C
	20.75	32.38	A	6.15	47.55	B	0.0	52.00	C
	21.67	32.18	A						

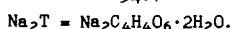
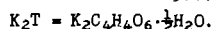


## THE SYSTEM POTASSIUM TARTRATE - POTASSIUM CARBONATE - WATER AT 17° (Peyronel, 1949b)

	Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
	$K_2C_4H_4O_6$	$K_2CO_3$		$K_2C_4H_4O_6$	$K_2CO_3$	
	58.25	0.0	$K_2C_4H_4O_6 \cdot \frac{1}{2}H_2O$	11.63	38.93	$K_2C_4H_4O_6 \cdot \frac{1}{2}H_2O$
	49.80	4.08	"	6.37	46.20	"
	43.55	8.76	"	4.73	48.75	"
	31.35	19.06	"	4.17	49.70	"
	31.00	18.80	"	5.66	49.60	"
	28.75	21.67	"	5.00	49.75	$K_2C_4H_4O_6 \cdot \frac{1}{2}H_2O + K_2CO_3 \cdot 2H_2O$
	19.18	31.50	"	0.0	52.64	$K_2CO_3 \cdot 2H_2O$
	15.32	35.25	"			

## THE SYSTEM POTASSIUM TARTRATE - SODIUM TARTRATE - WATER SOLUBILITY OF SOME MIXTURES AT SEVERAL TEMPERATURES (van Leeuwen, 1897)

t°	Gms. per 100 Gms. Sat. Sol.		Solid Phase
	$K_2C_4H_4O_6$	$Na_2C_4H_4O_6$	
18	19.2	16.5	$KNaC_4H_4O_6 \cdot 4H_2O$
38	26.6	22.8	"
20.9	11.8	28.0	" + $Na_2T$
38	25.8	24.7	"
50	36.7	23.9	"
26.6	56.0	4.2	$KNaC_4H_4O_6 \cdot 4H_2O + K_2T$
48.3	51.6	13.2	"
59.7	44.5	25.3	$K_2T + Na_2T$
80	39.7	34.7	"



POTASSIUM SODIUM TARTRATE,  $\text{KNaC}_4\text{H}_4\text{O}_6 \cdot 3\text{H}_2\text{O}$  and  $\cdot 4\text{H}_2\text{O}$ , *r* and *d*.  
(Rochelle salt; Seignette salt)

CH

SOLUBILITY OF THE POTASSIUM SODIUM SALT OF DEXTRO AND OF  
RACEMIC TARTARIC ACIDS IN WATER  
(Brönsted, 1921, 1926)

Salt of Racemic Acid		Salt of Dextro Acid			
t° of Cryst.	Gms. $\text{KNaC}_4\text{H}_4\text{O}_6$ per 100 $\text{H}_2\text{O}$ gms.	t° of Cryst.	Gms. $\text{KNaC}_4\text{H}_4\text{O}_6$ per 100 $\text{H}_2\text{O}$ gms.	t° of Cryst.	Gms. $\text{KNaC}_4\text{H}_4\text{O}_6$ per 100 $\text{H}_2\text{O}$ gms.
- 6.98	42.7	- 4.7	28.7	0.0	32.0
- 5.95	36.5	- 4.34	26.0	9.7	46.1
+ 9.7	58.0	- 3.38	19.0	18.0	62.9
29.5	92.3	- 1.875	10.2	29.5	100.7

Salt of Mixture of <i>d</i> and <i>l</i> Acids	
t° of Cryst.	Gms. $\text{KNaC}_4\text{H}_4\text{O}_6$ per 100 gms. $\text{H}_2\text{O}$
- 6.42	39.3
+ 9.7	64.4
29.5	140.5

SOLUBILITY OF SEVERAL POTASSIUM SALTS OF TARTARIC ACIDS IN WATER AT 20°  
(Schlossberg, 1900)

Salt	Formula	Gms. Salt per 100 gms. sat. sol.
Potassium Sodium Salt of Racemic Acid	$\text{KNa}(\text{C}_4\text{H}_4\text{O}_6) \cdot 3\text{H}_2\text{O}$	62.84
Potassium Sodium Salt of <i>d</i> Tartaric Acid	$\text{KNa}(\text{C}_4\text{H}_4\text{O}_6) \cdot 4\text{H}_2\text{O}$	63.50
Potassium Neutral Inactive Pyrotartrate	$\text{K}_2\text{C}_5\text{H}_6\text{O}_6 \cdot \text{H}_2\text{O}$	56.33
Potassium Neutral Dextropyrotartrate	$\text{K}_2\text{C}_5\text{H}_6\text{O}_6$	57.62

100 gms. sat. aq. solution contain 36.66 gms.  $\text{KNaC}_4\text{H}_4\text{O}_6$  at 9.7° and 47.97 gms. at 29.5°. (van't Hoff and Goldschmidt, 1895.)

100 gms.  $\text{H}_2\text{O}$  dissolve 53.53 gms.  $\text{KNaC}_4\text{H}_4\text{O}_6$  at 15°, Sp. Gr. of sol. = 1.2713. (Greenish and Smith, 1901.)

THE SYSTEM POTASSIUM SODIUM TARTRATE - SODIUM HYDROXIDE - WATER AT 25°  
(Campbell and Campbell, 1932)

The three sections of the solubility curve are considered to correspond respectively to hydrated Rochelle Salts, anhydrous Rochelle Salts and a solid complex which resembles a stiff gel. Further data are given by Tsuzuki and Hayakawa, 1949.

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
$\text{KNaC}_4\text{H}_4\text{O}_6$	$\text{NaOH}$	$\text{KNaC}_4\text{H}_4\text{O}_6$	$\text{NaOH}$	$\text{KNaC}_4\text{H}_4\text{O}_6$	$\text{NaOH}$
39.0	0.0	29.5	7.6	21.6	15.3
33.3	3.7	20.2	13.5	35.2	24.8
31.0	5.8	22.6	12.2	25.7	23.9
29.0	7.3	16.1	13.85		



# K KALIUM

## THE SYSTEM $\text{KNaC}_4\text{H}_4\text{O}_6 - \text{PbO} - \text{H}_2\text{O}$ AT $25^\circ$ (Dombrovskaya and Bruile, 1955)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
PbO	$\text{KNaC}_4\text{H}_4\text{O}_6$		PbO	$\text{KNaC}_4\text{H}_4\text{O}_6$	
2.25	3.96	PbO	16.81	25.50	$5\text{PbO} \cdot 3\text{KNaC}_4\text{H}_4\text{O}_6$
5.67	6.50	$5\text{PbO} \cdot 3\text{KNaC}_4\text{H}_4\text{O}_6$	14.20	32.80	"
7.23	7.80	"	13.08	34.41	"
10.50	10.66	"	10.50	37.70	" + $\text{KNaC}_4\text{H}_4\text{O}_6 \cdot 4\text{H}_2\text{O}$
12.20	12.75	"	8.01	37.30	$\text{KNaC}_4\text{H}_4\text{O}_6 \cdot 4\text{H}_2\text{O}$
13.30	14.47	"	6.38	37.60	"
16.04	19.25	"	4.85	37.80	"
17.24	20.78	"	1.60	38.97	"
17.40	22.20	"	0.0	39.13	"

## SOLUBILITY OF POTASSIUM SODIUM TARTRATE IN AQ. ALCOHOL SOLUTIONS AT $25^\circ$ (Seidell, 1910)

Wt. % $\text{C}_2\text{H}_5\text{OH}$ in Solvent		Gms. $\text{KNaC}_4\text{H}_4\text{O}_6 \cdot 4\text{H}_2\text{O}$ per 100 Gms. Solvent	Wt. % $\text{C}_2\text{H}_5\text{OH}$ in Solvent		Gms. $\text{KNaC}_4\text{H}_4\text{O}_6 \cdot 4\text{H}_2\text{O}$ per 100 gms. Sat. Sol.
$d_{25}$ of Sat. Sol.			$d_{25}$ of Sat. Sol.		
0	1.310	53.33	50	0.908	2.40
10	1.216	41.60	60	0.878	0.90
20	1.124	26.20	70	0.857	0.30
30	1.034	13.80	80	0.840	0.06
40	0.961	6	100	0.789	trace

## POTASSIUM Dihydroxy TARTRATES $\text{K}_2\text{C}_4\text{H}_4\text{O}_8 \cdot \text{H}_2\text{O}$ and $\text{KHC}_4\text{H}_4\text{O}_8 \cdot \text{H}_2\text{O}$

100 gms.  $\text{H}_2\text{O}$  dissolve 2.66 gms.  $\text{K}_2\text{C}_4\text{H}_4\text{O}_8 \cdot \text{H}_2\text{O}$  at  $0^\circ$ . (Fenton, 1898)  
 100 gms.  $\text{H}_2\text{O}$  dissolve 2.70 gms.  $\text{KHC}_4\text{H}_4\text{O}_8 \cdot \text{H}_2\text{O}$  at  $0^\circ$ . ( " " )

## POTASSIUM TARTRATE ESTERS

F.-pt. data for mixtures of  $\underline{d}$  and  $\underline{l}$  dimethyl ester of potassium bitartrate and for mixtures of  $\underline{d}$  and  $\underline{l}$  diacetyl dimethylester of potassium bitartrate are given by Adriani (1900).

## CH POTASSIUM ANTIMONY TARTRATE $\text{C}_2\text{H}_2(\text{OH})_2(\text{COOK})(\text{COOSbO}) \cdot \frac{1}{2}\text{H}_2\text{O}$

100 gms. water dissolve 5.9 gms. salt at room temp. (Squire and Caines, 1905)  
 100 gms. water dissolve 6.9 gms. salt at  $25^\circ$ . (S. and S., 1903)  
 100 gms. water dissolve 8 gms. salt at  $21^\circ$ . (Aschan, 1913)

Freezing points of very dilute Potassium Antimony Tartarate solutions are given by Girard and Barboux, 1951.

SOLUBILITY OF ANTIMONY POTASSIUM TARTRATE IN AQ. ALCOHOL  
SOLUTIONS AT 25°  
(Seidell, 1910)

Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. C <sub>4</sub> H <sub>4</sub> O <sub>6</sub> ·KSbO· $\frac{1}{2}$ H <sub>2</sub> O per 100 Gms. Sat. Sol.	Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. C <sub>4</sub> H <sub>4</sub> O <sub>6</sub> ·KSbO· $\frac{1}{2}$ H <sub>2</sub> O per 100 Gms. Sat. Sol.
0	1.052	7.85	40	0.935	0.38
5	1.025	5.50	50	0.913	0.23
10	1.007	3.92	60	0.890	0.12
20	0.980	1.92	70	0.866	0.06
30	0.958	0.84	100	0.788	trace

100 gms. 95% HCOOH dissolve 82.7 gms. salt at 20.8°. (Aschan, 1913)  
100 gms. glycerol dissolve 5.5 gms. salt at 15.5°. ( " " )

POTASSIUM SUCCINATE K<sub>2</sub>C<sub>4</sub>H<sub>4</sub>O<sub>4</sub>·3H<sub>2</sub>O

CH

100 gms. Methyl Alcohol (CH<sub>3</sub>OH) [sat. with anhydrous potassium succinate] dissolve 3.16 gms. K<sub>2</sub>C<sub>4</sub>H<sub>4</sub>O<sub>4</sub> at 15° and 3.75 gms. at 66.6 (b.pt.). (Henstock, 1934.)

POTASSIUM URATE KHC<sub>5</sub>H<sub>4</sub>N<sub>4</sub>O<sub>3</sub>

SOLUBILITY OF POTASSIUM URATE IN WATER  
(Barkan, 1924)

It was previously shown that sodium urate passes from a gelatin like colloidal form to a stable granular condition, and the author desired to learn if the potassium salt behaves likewise. Several different samples of potassium urate were prepared and used for solubility determinations. The solubility of each diminished with time of rotation. In general the diminution was from about 2.38 gms. per liter to 1.9 gms. per liter. The mean of all the determinations was:

2.13 gms. (=  $10.35 \times 10^{-3}$  gms. mols.) potassium urate per liter at 18°.

Several determinations of the solubility of the compound in the fresh colloidal form gave, as the highest value, 6.67 gms. (=  $32.4 \cdot 10^{-3}$  gm. mols.) potassium urate per liter at 18°.

POTASSIUM CITRATE (CH<sub>2</sub>)<sub>2</sub>C(OH)(COOK)<sub>3</sub>·H<sub>2</sub>O

CH

SOLUBILITY IN WATER  
(Average results of Seidell, 1910; Greenish and Smith, 1901; Köhler, 1897)

t°	Gms. (CH <sub>2</sub> ) <sub>2</sub> C(OH)(COOK) <sub>3</sub> ·H <sub>2</sub> O per 100 Gms.	
	Sat. Solution	Water
15	61.8	162
20	63.2	172
25	64.5	182 (d <sub>25</sub> = 1.518)
30	66.0	194

100 gms. H<sub>2</sub>O dissolve 198.3 gms. (CH<sub>2</sub>)<sub>2</sub>COH(COOK)<sub>3</sub> + 303.9 gms. cane sugar at 31.25°. (Köhler, 1897.)

# K KALIUM

## SOLUBILITY OF POTASSIUM CITRATE IN AQUEOUS ETHYL ALCOHOL AT 25° (Seidell, 1910)

When potassium citrate is added to aqueous alcohol of certain concentrations the mixture separates into two liquid layers. A series of determinations made by adding an excess of the salt to 10-15 cc. portions of several aq. alcohol mixtures at 25° gave the following results.

	Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent		$d_{25}$ of Sat. Solution	Wt. % C <sub>2</sub> H <sub>5</sub> OH in sat. Solution	Gms. (CH <sub>2</sub> ) <sub>2</sub> COH(COOK)·H <sub>2</sub> O per 100 Gms. Sat. Solution
CH	8.9	{ a	--	--	--
		{ b	1.4920	0	60.0
	32	{ a	--	--	0.2
		{ b	1.4930	0	61.6
	51	{ a	--	65.1	0.38
		{ b	--	--	62.5
	70.2	{ a	0.8366	81.0	0.10
		{ b	--	--	62.3
	81.4		0.8356	81.4	0.038
	91.6		0.8139	91.6	0.016
	99.9		0.7896	99.5	0.014

a = upper, alcohol rich layer.

b = lower, water rich layer.

A series of determinations was also made by adding just enough potassium citrate to the alcohol solution to cause distinct clouding and then, after bringing to 25°, titrating with the aqueous alcohol mixture to disappearance of the clouding. The results were plotted and the following interpolated values obtained.

Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	$d_{25}$ of Sat. Solution	Gms. (CH <sub>2</sub> ) <sub>2</sub> COH(COOK) <sub>3</sub> ·H <sub>2</sub> O per 100 Gms. Sat. Sol.
0	1.518	64.5
5	1.400	52.5
10	1.310	45.5
20	1.177	31.5
30	1.085	21.5
40	1.005	12.4
50	0.943	5.6
60	0.900	1.6
70	0.868	0.4
80	0.838	0.04

In one determination at 15°, made with alcohol of 59 vol. per cent, 4.51 gms. (CH<sub>2</sub>)<sub>2</sub>COH(COOK)<sub>3</sub>·H<sub>2</sub>O were required to just cause clouding.

100 gms. U.S.P. Glycerol (CH<sub>2</sub>OHCHOHCH<sub>2</sub>OH) saturated with Potassium Citrate contain 28.2 gms. (CH<sub>2</sub>)<sub>2</sub>C(OH)(COOK)<sub>3</sub>·H<sub>2</sub>O at 25°. (Schnellbach and Rosin, 1931.)

POTASSIUM PHENOLATE  $C_6H_5OK$ 

EQUILIBRIUM IN THE SYSTEM POTASSIUM HYDROXIDE, PHENOL, AND WATER AT 25°  
(Van Meurs, 1916)

Mols. per 100 mols. sat. sol.		Solid Phase	Mols. per 100 mols. sat. sol.		Solid Phase
$C_6H_5OH$	KOH		$C_6H_5OH$	KOH	
70.20	0.74	$C_6H_5OH$	25.93	17.15	$C_6H_5OK \cdot 2H_2O$
76.40	4.13	"	22.15	16.92	"
60.16	7.28	$C_6H_5OK \cdot 3C_6H_5OH$	14.95	15.48	"
51.27	8.32	"	8.84	15.39	"
46.38	9.11	"	5.57	15.14	"
33.79	11.18	"	0.92	16.04	"
29.70	17.13	"	0.04	26.04	"
31.69	19.05	" + $C_6H_5OK \cdot 2H_2O$	0.0	27.65	$KOH \cdot 2H_2O$

The two liquid layers which are formed at concentrations of KOH less than about 0.5 mol. % have the following compositions.

Aqueous layer		Phenol layer	
Mol. % $C_6H_5OH$	Mol. % KOH	Mol. % $C_6H_5OH$	Mol. % KOH
1.79	0.0	32.33	0.0
2.48	0.19	21.60	0.37
3.85	0.25	15.85	0.45

POTASSIUM PICRATE  $C_6H_2(NO_2)_3OK$ 

CH

## SOLUBILITY IN WATER

t°	Solubility				Author
20	0.506 gms.	$C_6H_2(NO_2)_3OK$	per 100 cc. sat. sol.		(Moser and Ritschel, 1925)
25	0.645 "	"	"	"	(Fischer, 1914, 1918)
30	0.755 "	"	"	gms. $H_2O$	(Dermer and Dermer, 1939)

SOLUBILITY OF POTASSIUM PICRATE IN AQUEOUS SOLUTIONS OF  
ETHYL ALCOHOL, METHYL ALCOHOL AND OF ACETONE AT 25°  
(Fischer, 1914, 1918)

The composition of the aqueous alcohol and acetone mixtures, which served as solvents was accurately controlled by density determinations. Saturation was secured by constant agitation in a thermostat. The saturated solution was withdrawn by means of a graduated pipet and its dissolved picrate determined by evaporation and weighing the residue, or by a method of titration. The absolute alcohol was prepared by treatment with lime and distillation.

# K KALIUM

## SOLUBILITY OF POTASSIUM PICRATE IN AQUEOUS SOLUTIONS OF ETHYL ALCOHOL, METHYL ALCOHOL AND OF ACETONE AT 25°--Cont.

Vol. % $C_2H_5OH$ in solvent	Gms. $C_6H_2(NO_2)_3OK$ per 100 cc. sat. sol.	Vol. % $C_2H_5OH$ in solvent	Gms. $C_6H_2(NO_2)_3OK$ per 100 cc. sat. sol.
0.0 (= $H_2O$ )	0.645	55	0.598
10	0.559	60	0.574
15	0.475	65	0.546
20	0.450	70	0.485
25	0.453	75	0.410
30	0.472	80	0.326
35	0.484	85	0.227
40	0.533	90	0.174
45	0.560	95	0.100
50	0.582	100	0.184 (?)

Vol. % $CH_3OH$ in solvent	Gms. $C_6H_2(NO_2)_3OK$ per 100 cc. sat. sol.	Vol. % Acetone in solvent	Gms. $C_6H_2(NO_2)_3OK$ per 100 cc. sat. sol.
10	0.542	10	0.726
20	0.470	20	0.876
30	0.444	30	1.140
40	0.422	40	1.155
50	0.411	50	2.106
60	0.410	60	2.615
70	0.396	70	3.090
80	0.332	80	3.340
90	0.254	90	3.084
100	0.274	100	1.080

The distribution coefficient for potassium picrate between di iso-propyl ketone and water at 25° is  $S^0 = 3.3 \times 10^{-2}$  where  $S^0$  = the ratio C-ketone/C-water extrapolated to infinite dilution. (Karpfen and Randles, 1953.)

### CH POTASSIUM CHLOROPICRATE [ $C_6H(NO_2)_3ClO$ ]K

At 30°, 100 gms. of water dissolve 1.82 gms. (6.03 millimoles) of the salt. (Dermer and Dermer, 1939.)

### CH POTASSIUM METHYL PICRATE [ $C_6H(NO_2)_2CH_3O$ ]K

At 30°, 100 gms. of water dissolve 3.78 gms. (13.4 millimoles) of the salt. (Dermer and Dermer, 1939.)

POTASSIUM RESORCINOLATES  $C_6H_4(OH)OK \cdot 2H_2O$ ,  $C_6H_4(OK)_2 \cdot 4H_2O$ 

CH

EQUILIBRIUM IN THE SYSTEM POTASSIUM HYDROXIDE, RESORCINOL  
AND WATER AT 30°  
(Van Meurs, 1916)

Mols. per 100 mols. sat. sol.		
$C_6H_4(OH)_2$ (m)	KOH	Solid Phase
38.81	0.0	$C_6H_4(OH)_2$ (m)
46.80	3.26	"
57.30	6.85	"
69.06	10.13	"
50.27	16.95	$C_6H_4(OH)OK \cdot 2H_2O$
36.85	16.40	"
33.00	16.63	"
26.71	17.62	"
25.64	17.84	" + $C_6H_4(OK)_2 \cdot 4H_2O$
22.40	17.44	$C_6H_4(OK)_2 \cdot 4H_2O$
18.29	16.64	"
16.11	16.07	"
11.58	16.44	"
6.68	17.71	"
1.45	22.71	"
0.71	26.49	"
0.76	26.99	" + KOH(?)
0.74	29.95	"
0.74	30.13	KOH (?)
0.31	29.88	KOH · H <sub>2</sub> O (?)
0.17	29.70	"
0.0	28.80	KOH · H <sub>2</sub> O

POTASSIUM GLUCONATE  $KC_6H_{11}O_7$ 

100 cc. sat. solution of Potassium Gluconate in water contain 50.85  
gms.  $KC_6H_{11}O_7$  at 25°. (May, Weisberg and Herrick, 1929.)

POTASSIUM BENZOATE  $C_6H_5COOK$ 

CH

SOLUBILITY OF POTASSIUM BENZOATE IN WATER  
(Sidgwick and Ewbank, 1922)

t°	Gms. $C_6H_5COOK$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $C_6H_5COOK$ per 100 gms. sat. sol.	Solid Phase
- 0.86	5.04	Ice	33.3	44*	$C_6H_5COOK$
- 2.14	9.70	"	41.0	44.92	"
- 4.29	16.23	"	50	46.6*	"
- 7.31	24.23	"	81.0	50.99	"
+ 8.5	39.89	$C_6H_5COOK$	97.5	53.50	"
13.0	40.60	"	131.0	58.42	"
17.5	41.1*	"	181.0	66.09	"
25	42.4*	"			

\*Pajetta, 1906, 1907.

# K KALIUM

100 gms. Methyl Alcohol ( $\text{CH}_3\text{OH}$ ) dissolve 7.07 gms.  $\text{C}_6\text{H}_5\text{COOK}$  at  $15^\circ$  and 8.33 gms. at  $66^\circ$  (b.pt.). (Henstock, 1934.)

## CH POTASSIUM Hydroxy BENZOATES o, m and p $\text{C}_6\text{H}_4\text{OHCOOK}$

SOLUBILITY OF POTASSIUM ORTHO-HYDROXY BENZOATE  
(= POTASSIUM SALICYLATE) IN WATER  
(Sidgwick and Ewbank, 1922)

Gms. C <sub>6</sub> H <sub>4</sub> OH·COOK(o) per 100 gms. t°      sat. sol.			Solid Phase	Gms. C <sub>6</sub> H <sub>4</sub> OH·COOK(o) per 100 gms. t°      sat. sol.			Solid Phase
-1.82	10.49		Ice	24.0	53.33		C <sub>6</sub> H <sub>4</sub> OHCOOK·H <sub>2</sub> O
-3.47	18.82		"	28.5	55.82		"
-6.52	31.15		"	61.0	61.31		C <sub>6</sub> H <sub>4</sub> OHCOOK
-8.0	35.80		"	103.8	68.97		"
0	44.08		C <sub>6</sub> H <sub>4</sub> OHCOOK·H <sub>2</sub> O	108.5	70.20		"
+9	49.19		"	138.2	74.80		"

SOLUBILITY OF POTASSIUM  
META-HYDROXY BENZOATE IN WATER

Gms.		
$\text{C}_6\text{H}_4\text{OH}\cdot\text{COOK(m)}$		
t°	per 100 gms. sat. sol.	Phase
- 2.41	12.39	Ice
- 5.06	22.25	"
- 8.59	31.34	"
-19.92	49.39	"
+10.0	59.04	$\text{C}_6\text{H}_4\text{OH}\cdot\text{COOK(m)}$
33.5	61.94	"
95.0	69.60	"
136.8	75.02	"

SOLUBILITY OF POTASSIUM  
PARA-HYDROXY BENZOATE IN WATER

	Gms. $\text{C}_6\text{H}_4\text{OH}\cdot\text{COOK}(\text{p})$ per 100 gms. sat. sol.	Solid Phase
t°		
- 1.43	8.04	Ice
- 3.24	15.55	"
+15.8	29.91	(p) $\text{C}_6\text{H}_4\text{OH}\cdot\text{COOK}\cdot 3\text{H}_2\text{O}$
25.8	35.50	"
43.0	45.71	"
64.4	56.70	"
70.5	59.34	"
86.8	63.01	(p) $\text{C}_6\text{H}_4\text{OH}\cdot\text{COOK}$
129.5	64.95	"

## POTASSIUM MANDELATE (Racemic) $\text{C}_6\text{H}_5\cdot\text{CHOH}\cdot\text{COOK}$

EQUILIBRIUM IN THE SYSTEM RACEMIC POTASSIUM MANDELATE,  
RACEMIC MANDELIC ACID AND WATER AT  $25^\circ$   
(Ross and Morrison, 1933)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{C}_8\text{H}_8\text{O}_3$	$\text{C}_8\text{H}_7\text{O}_3\text{K}$		$\text{C}_8\text{H}_8\text{O}_3$	$\text{C}_8\text{H}_7\text{O}_3\text{K}$	
3.3	47.3	$[\text{K}(\text{C}_8\text{H}_7\text{O}_3)_2]\text{H}$	6.0	23.1	$[\text{K}(\text{C}_8\text{H}_7\text{O}_3)_3]\text{H}_2$
4.1	45.2	"	6.5	19.5	"
5.1	37.2	"	8.6	16.2	"
6.4	33.3	"	11.4	14.5	"
7.7	30.8	"	8.4	16.5	"
8.1	29.7	$[\text{K}(\text{C}_8\text{H}_7\text{O}_3)_3]\text{H}_2$	11.0	15.6	$[\text{K}(\text{C}_8\text{H}_7\text{O}_3)_4]\text{H}_3$
6.3	27.7	"	11.6	15.0	"
5.5	24.7	"	12.9	13.7	"

EQUILIBRIUM IN THE SYSTEM RACEMIC POTASSIUM MANDELATE,  
RACEMIC MANDELIC ACID AND WATER AT 25°--Cont.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$C_8H_8O_3$	$C_8H_7O_3K$		$C_8H_8O_3$	$C_8H_7O_3K$	
14.4	12.3	$[K(C_8H_7O_3)_4]H_3$	31.7	8.3	$C_8H_8O_3$
15.8	11.2	"	30.1	7.7	"
20.4	9.8	"	27.1	6.7	"
24.0	9.4	"	25.0	5.5	"
27.1	8.8	"	21.6	3.8	"
30.1	8.5	"	18.6	1.1	"
			16.9	0.0	"

POTASSIUM MANDELATE (Levo)  $C_8H_5CHOH \cdot COOK$ EQUILIBRIUM IN THE SYSTEM (-) POTASSIUM MANDELATE  
(-) MANDELIC ACID AND WATER AT 25°  
(Ross, Morrison and Johnstone, 1937)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$C_8H_8O_3$	$C_8H_7O_3K$		$C_8H_8O_3$	$C_8H_7O_3K$	
9.7	46.4	$[K(C_8H_7O_3)_2]H$	30.9	17.7	$C_8H_8O_3$
34.4	38.5	"	12.1	6.0	"
42.7	37.3	"	10.5	3.2	"
39.8	27.2	" + $C_8H_8O_3$	10.1	1.4	"
			10.1	0.0	"

POTASSIUM PHTHALATE  $C_6H_4(COOK)_2$ 

CH

SOLUBILITY IN WATER  
(Smith, 1931)

t°	0	25	35	60
Gms. $C_6H_4(COOK)_2$ per 100 gms. sat. sol.	60.4	74.8	78.5	78.9

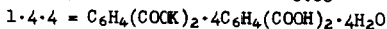
THE SYSTEM POTASSIUM PHTHALATE - PHTHALIC ACID - WATER  
AT SEVERAL TEMPERATURES  
(Smith, 1931)

The transition temperature above which the 1.4.4 double salt does not exist was found to be 36.68° and the composition of the saturated solution at this temperature was 6.14 percent  $C_6H_4(COOH)_2$  and 7.65 percent  $C_6H_4(COOK)_2$ .



## K KALIUM

Gms. per 100 gms. sat. sol.			Solid Phase
$C_6H_4(COOH)_2$	$C_6H_4(COOK)_2$		
Results at 0°			
0.0	60.4	$C_6H_4(COOK)_2$	
0.10	60.4	" + $C_6H_4(COOH)(COOK)$	
0.11	48.89	$C_6H_4(COOH)COOK$	
0.19	33.02	"	
0.40	20.43	"	
1.06	8.33	"	
2.01	4.01	" + 1.4.4	
1.74	2.79	1.4.4	
1.55	2.12	" + $C_6H_4(COOH)_2$	
0.89	1.00	$C_6H_4(COOH)_2$	
0.30	--	"	
CH	Results at 25°		
0.0	74.8	$C_6H_4(COOK)_2$	
0.17	74.7	" + $C_6H_4(COOH)COOK$	
0.27	60.97	$C_6H_4(COOH)COOK$	
0.28	48.16	"	
0.36	39.70	"	
0.54	31.23	"	
0.77	23.33	"	
1.25	16.65	"	
3.07	7.10	"	
4.16	6.11	" + 1.4.4	
3.93	5.41	1.4.4	
3.77	4.80	" + $C_6H_4(COOH)_2$	
3.44	4.12	$C_6H_4(COOH)_2$	
2.61	2.87	"	
1.72	1.47	"	
0.75	0.0	"	
Results at 35°			
0.0	78.5	$C_6H_4(COOK)_2$	
0.28	75.6	" + $C_6H_4(COOH)COOK$	
0.27	68.51	$C_6H_4(COOH)COOK$	
0.33	58.59	"	
0.38	48.67	"	
0.51	37.43	"	
0.89	27.07	"	
1.28	21.03	"	
2.32	13.09	"	
3.23	9.76	"	
5.10	7.43	"	
5.70	7.32	" + 1.4.4	
5.53	6.64	1.4.4 + $C_6H_4(COOH)_2$	
5.29	6.35	$C_6H_4(COOH)_2$	
4.74	5.60	"	
2.38	2.06	"	
0.98	0.0	"	
Results at 60°			
0.0	78.9	$C_6H_4(COOK)_2$	
0.40	79.0	" + $C_6H_4(COOH)COOK$	
0.51	64.17	$C_6H_4(COOH)COOK$	
0.80	49.07	"	
2.15	29.66	"	
4.94	16.57	"	
8.50	12.59	"	
14.14	13.00	" + $C_6H_4(COOH)_2$	
7.68	5.97	$C_6H_4(COOH)_2$	
2.58	0.00	"	



SOLUBILITY OF POTASSIUM PHTHALATE IN ALCOHOLS AT 20°  
(Handy and Hoyt, 1927)

Solvent	Gms. $C_6H_5(COOK)_2$ per 100 cc. solvent
Ethyl Alcohol (Absolute)	0.0161
Ethyl Alcohol (95%)	0.0252
100 vols. Ethyl Alcohol (95%) + 10 vols. $CH_3OH$	0.0728
Methyl Alcohol ( $CH_3OH$ )	0.792

POTASSIUM Hydrogen PHTHALATE  $KHC_8H_4O_8$

CH

100 gms. sat. solution of potassium hydrogen phthalate in water contain 10.23 gms.  $KHC_8H_4O_8$  at 25°, 12.67 gms. at 35° and 36.12 gms. at the b.pt. (Hendrixson, 1920.)

POTASSIUM NITRANILATE  $[C_6H_5H_2O_2]K$

CH

At 30°, 100 gms. of water dissolve 0.567 gms. (1.85 millimoles) of the salt. (Dermer and Dermer, 1939.)

POTASSIUM PICROLONATE  $[C_3N_2(CH_3)(NO_2)(C_6H_4NO_2)O]K$

At 30°, 100 gms. of water dissolve 0.338 gms. (1.12 millimoles) of the salt. (Dermer and Dermer, 1939.)

POTASSIUM DIPICRYLAMINATE  $K[(NO_2)_3C_6H_2HHC_6H_2(NO_2)_3]$

SOLUBILITY IN WATER

t°	Moles per liter	t°	Moles per liter
0	$1.53 \times 10^{-4}$ (1)	30	$3.04 \times 10^{-3}$ (4)*
15	$2.0 \times 10^{-3}$ (2)	35	$3.1 \times 10^{-3}$ (2)
20	$1.22 \times 10^{-3}$ (3)	45	$3.7 \times 10^{-3}$ (2)
25	$1.85 \times 10^{-3}$ (1)		
	$2.5 \times 10^{-3}$ (2)		

\*Moles per 1000 gms.  $H_2O$

(1) Kolthoff and Bendix, 1939

(3) Treadwell and Hepenstrick, 1949

(2) Kielland, 1938

(4) Dermer and Dermer, 1939

POTASSIUM 2, 4 - DINITROPHENATE  $(C_6H_3(NO_2)_2)O)K$  (See note Vol. I, p. 217) CH

At 4° between 1% and 2% dissolve in water.

At 15° between 2% and 4% dissolve in water.- Pastac & Lecrivain, 1948.

POTASSIUM 2, 4 - DINITROCRESYLATE  $(C_6H_2(CH_3)(NO_2)_2)O)K$  (See note Vol. I, p. 217)

At 15° between 2% and 4% dissolve in water.- Pastac & Lecrivain, 1948.

POTASSIUM STYPHNATE  $[C_6H(NO_2)_3(OH)O)K (?)$

At 30°, 100 gms. of water dissolve 1.54 gms. (5.42 millimoles) of the salt. (Dermer and Dermer, 1939.)

# K KALIUM

## POTASSIUM FLAVIANATE (dibasic) $[C_{10}H_4(OH)_2(SO_3)O]K_2 \cdot H_2O$

At 30°, 100 gms. of water dissolve 1.03 gms. (2.5 millimoles) of the salt. (Dermer and Dermer, 1939.)

## POTASSIUM TETRACHLOROPHTHALATE $C_6Cl_4(COOK)_2$

### SOLUBILITY IN WATER (Lawlor, 1947)

t°	Gms. $C_6Cl_4(COOK)_2$ per 100 gms. Sat. Sol.	t°	Gms. $C_6Cl_4(COOK)_2$ per 100 gms. Sat. Sol.
5	28.3	23	29.3
14	28.9	59	34.5
20	29.1	75	37.5

## POTASSIUM PHENYL ACETATE $CH_2C_6H_5COOK$

Fusion-point data for mixtures of Potassium Phenyl acetate and Phenyl acetic acid, showing the formation of the compound  $CH_2C_6H_5COOK \cdot CH_2C_6H_5COOH$  are given by Bakunin and Vitale, 1935.

# CH POTASSIUM BENZENE SULFONATES

### SOLUBILITY OF EACH SEPARATELY IN WATER (Elgersma, 1929)

Compound	Formula	t°	Gms. anhydrous compound per 100 gms. $H_2O$
Potassium <u>o</u> Nitro benzene sulfonate	$K[NO_2 \cdot C_6H_4 \cdot SO_3]$	25	9.63
" <u>m</u> " " "	"	25	3.04
" <u>p</u> " " "	"	25	5.95
" <u>o p</u> Dinitro " "	$K[(NO_2)_2 \cdot C_6H_3 \cdot SO_3] \cdot H_2O$	25	4.70
" <u>2</u> Nitro <u>4</u> Chlor " "	$K[NO_2 \cdot C_6H_3ClSO_3]$	25	0.87
" <u>2</u> " <u>5</u> " " "	"	25	1.59
" <u>3</u> " <u>6</u> " " "	"	25	2.83
" <u>2</u> " <u>4</u> Brom " "	$K[NO_2 \cdot C_6H_3BrSO_3]$	25	1.68
" <u>m</u> -chloro benzene " "	$K[Cl \cdot C_6H_4SO_3]$	18	3.02*
" " " " "	"	98	31.05*
" <u>p</u> " " " "	"	18	0.73*
" " " " "	"	98	28.55*

\*Bollinger, 1928

### SOLUBILITY IN ORGANIC SOLVENTS (Henstock, 1934)

100 gms. Methyl Alcohol sat. with Potassium Benzene Sulfonate contain 2.67 gms.  $C_6H_5SO_3K$  at 15° and 9.67 gms. at 66.1 (b.pt.).

100 gms. acetone dissolve 0.12 gm.  $C_6H_5SO_3K$  at 15°.

POTASSIUM 3-chloro-3-nitro-p-Xylene SULFONATE  $[C_6H(CH_3)_2NO_2(Cl)SO_3]K$  CH

At 30°, 100 gms. of water dissolve 9.21 gms. (30.4 millimoles) of the salt. (Dermer and Dermer, 1939.)

POTASSIUM NAPHTHALENE SULFONATES CH

POTASSIUM NAPHTHYLAMINE SULFONATES

Compound	t°	Gms. anhyd. compound per 100 gms. H <sub>2</sub> O	Author
Potassium Naphthalene Monosulfonate·H <sub>2</sub> O	25	8.48	(Witt, 1915)
" " -2- Sulfonate	18.5	8.12	(Ephraim and Pfister, 1925)
" " 1,4 Chloro Sulfonate	18	0.73	(Ferrero and Bolliger, 1928)
" " 1,5 " "	18	3.12	( " " " )
" Naphthylamine 2,4,7 Sulfonate	20	29.3	(Frisch, 1930)
" " " "	80	66.3	( " " " )
" 2,6,8 naphthylamine Disulfonate	15	106.6	(Braunschweig, 1922)
" 2,5,7 " " "	15	177.0	( " " " )
" 2,6,8 Acid " " "	15	2.53	( " " " )
" 2,5,7 " " "	15	2.65	( " " " )

POTASSIUM ANTHRACENE SULFONATES  $C_{14}H_8S_2O_6K_2$   $C_{14}H_9SO_3K$  CH

SOLUBILITY IN WATER  
(Federov and Lodygin, 1942)

	Gms. Salt per 100 gms. Saturated Solution	
	20°	100°
$\alpha$ - $C_{14}H_9SO_3K$	0.412	5.367
$\beta$ - $C_{14}H_9SO_3K \cdot 2H_2O$	0.156	0.601
1,5- $C_{14}H_8S_2O_6K_2 \cdot 2H_2O$	4.598	14.240
1,8- $C_{14}H_8S_2O_6K_2 \cdot H_2O$	2.320	11.670
2,6- $C_{14}H_8S_2O_6K_2$	1.638	19.410
2,7- $C_{14}H_8S_2O_6K_2$	1.005	10.890

POTASSIUM ANTHRAQUINONE SULFONATES

SOLUBILITY OF EACH SEPARATELY IN WATER  
(Fierz-David, Kröbsen and Anderau, 1927)

Compound	Formula	t°	Gms. Cmpd. per 100 cc. H <sub>2</sub> O
Potassium Anthraquinone 1,5 Disulfonate	$K_2C_{14}H_8O_9(SO_3)_2$	18	0.7
" " " "		100	3.5
" " 1,8 " "	$K_2C_{14}H_8O_9(SO_3)_2 \cdot 2H_2O$	18	0.65
" " " "		100	2.2
" " 1,6 " "	$K_2C_{14}H_8O_9(SO_3)_2 \cdot 1\frac{1}{2}H_2O$	18	1.5
" " " "		100	14.3
" " 1,7 " "	$K_2C_{14}H_8O_9(SO_3)_2 \cdot 2H_2O$	18	4.3
" " " "		100	50.0
" " 1,5 Chloro Sulfonate	$KC_{14}H_8O_9ClSO_3 \cdot 2H_2O$	18	0.4
" " 1,8 " "	$KC_{14}H_8O_9ClSO_3 \cdot 2H_2O$	18	0.42
" " " "		100	5.50
" " 1,6 " "	$KC_{14}H_8O_9ClSO_3$	18	0.17
" " 1,7 " "	$KC_{14}H_8O_9ClSO_3 \cdot 1\frac{1}{2}H_2O$	18	2.0

# K KALIUM

## CH POTASSIUM PHENANTHRENE SULFONATES

Compound		t°	Gms. Anhydrous Cmpd. per 100 Gms. H <sub>2</sub> O	Author
Potassium	2 Phenanthrene Monosulfonate·4H <sub>2</sub> O	20	0.273	(Sandquist, 1912.)
"	3 " " "·OH <sub>2</sub> O	20	0.342	" " "
"	10 " " "·1H <sub>2</sub> O	20	0.84	" " "
"	" 10 Chloro 3 or 8 Sulfonate	20	0.248	( " , 1917.)
"	2 Guaiacol Sulfonate (Thiocol) d. = 1.029	15-20	16.6	(Squire & Caines, 1905)
100 cc. 90 vol. % alcohol dissolve 0.25 gm. thiocol at 15-20°				(Squire & Caines, 1905)

## POTASSIUM CYMENE SULFONATE $\text{CH}_3\text{C}_6\text{H}_4\text{CH}_2\cdot\text{CH}_2\text{CH}_2\cdot\text{SO}_3\text{K}$

SOLUBILITY OF POTASSIUM CYMENE SULFONATE IN WATER  
(Hauslick, 1935)

t°	Gm. Mols. Sulfonate per 100 gms. H <sub>2</sub> O	t°	Gm. Mols. Sulfonate per 100 gms. H <sub>2</sub> O
2.5	0.025	45	0.250
15.0	0.056	68	0.523
31.0	0.133	90	0.994

## POTASSIUM (RARE EARTH) ETHYLENEDIAMINE TETRAACETATES (EDTA)

LANTHANUM  
PRAESEODYMIUM  
NEODYMIUM  
SAMARIUM  
GADOLINIUM  
DYSPROSIUM  
YTTRIUM  
ERBIUM  
YTTERBIUM

SOLUBILITIES IN WATER  
(Marsh, 1955)

t°	Gms. hydrated salt per liter								
	La	Pr	Nd	Sm	Gd	Dy	Y	Er	Yb
0	42.3 <sup>e</sup>	--	--	13.6 <sup>e</sup>	--	--	--	--	--
2	58	19.6	17.6	17.9	26 <sup>a</sup>	86	220	207 <sup>c</sup>	167
25	182	66	53	54	81	273	443	435	--
35	292	--	90	96	126 <sup>b</sup>	403	523	550 <sup>d</sup>	--

<sup>a</sup>Approx. 2.64 g/100 gms. H<sub>2</sub>O

<sup>b</sup>" 13.5 " " "

<sup>c</sup>" 23.2 " " "

<sup>d</sup>" 76.5 " " "

<sup>e</sup>Gms. per 1000 gms. H<sub>2</sub>O (Brunisholz and Cahen, 1958)

THE SYSTEM K[LA-edta] - K[Sm-edta] - H<sub>2</sub>O AT 0°  
(Brunisholz and Cahen, 1958)

Continuous octahydrated solid solutions are formed. At 95% Sm the solid solution is apparently congruently saturated.

Liquid Solution		Solid Solution	Liquid Solution		Solid Solution
Gm. atom % Sm	Gm. moles H <sub>2</sub> O per gm. atom (La + Sm)		Gm. atom % Sm	Gm. moles H <sub>2</sub> O per gm. atom (La + Sm)	
0.0	610.9	0.0	46.7	1367	85.2
1.6	638.8	9.3	66.4	1579	90.8
4.4	692.5	21.6	73.4	1669	93.5
6.3	753.7	35.2	81.7	1740	93.8
13.4	891.2	51.7	92.5	1873	94.6
17.4	941.8	60.2	100.0	1961	100.0
26.2	1094	66.3	100.0	1937	--
39.4	1269	79.6			

POTASSIUM CAMPHORATES C<sub>10</sub>H<sub>14</sub>O<sub>4</sub>K<sub>2</sub>, C<sub>10</sub>H<sub>15</sub>O<sub>4</sub>K

CH

SOLUBILITY IN AQUEOUS SOLUTIONS OF d CAMPHORIC ACID  
AT 13.5-16° AND VICE VERSA  
(Jungfleisch and Landrieu, 1914)

Gms. per 100 Gms. Sat. Sol.		Solid Phase
C <sub>8</sub> H <sub>14</sub> (COOH) <sub>2</sub>	C <sub>10</sub> H <sub>14</sub> O <sub>4</sub> K <sub>2</sub>	
0	66.65	C <sub>10</sub> H <sub>14</sub> O <sub>4</sub> K <sub>2</sub>
0.90	69.69	C <sub>10</sub> H <sub>15</sub> O <sub>4</sub> K
1.00	69.00	"
1.10	66.79	"
0.90	66.65	C <sub>10</sub> H <sub>15</sub> O <sub>4</sub> K·H <sub>2</sub> O
1.50	62.37	"
2.60	59.34	"
3.20	58.37	"
3.20	58.09	"
3.20	52.71	C <sub>10</sub> H <sub>15</sub> O <sub>4</sub> K·C <sub>10</sub> H <sub>16</sub> O <sub>4</sub>
3.20	48.43	"
2.80	47.88	"
2.80	42.36	"
3.00	35.60	"
2.85	34.77	"
2.90	32.84	"
3.20	29.39	"
3.30	28.56	C <sub>10</sub> H <sub>15</sub> O <sub>4</sub> K·3C <sub>10</sub> H <sub>16</sub> O <sub>4</sub>
3.20	27.32	"
3.20	22.77	"
3.10	21.66	"
2.90	12.97	"
2.90	11.73	"
3.10	11.59	dC <sub>8</sub> H <sub>14</sub> (COOH) <sub>2</sub>
2.90	9.66	"
2.80	8.14	"
2.50	6.76	"
2.30	6.07	"
2.00	4.55	"
0.621	0	"

C<sub>10</sub>H<sub>14</sub>O<sub>4</sub>K<sub>2</sub> = Dipotassium d camphorate. C<sub>10</sub>H<sub>15</sub>O<sub>4</sub>K·C<sub>10</sub>H<sub>16</sub>O<sub>4</sub> = Monopotassium d dicamphorate.  
C<sub>10</sub>H<sub>15</sub>O<sub>4</sub>K = Monopotassium d camphorate. C<sub>10</sub>H<sub>15</sub>O<sub>4</sub>K·3C<sub>10</sub>H<sub>16</sub>O<sub>4</sub> = Monopotassium d tetracamphorate.

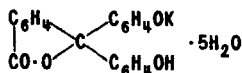
## K KALIUM

POTASSIUM HELIANTHATE  $KC_{14}H_{14}N_3SO_3 \cdot 2H_2O$ 

1000 cc.  $H_2O$  dissolve 4.368 gms.  $KC_{14}H_{14}N_3SO_3 \cdot 2H_2O$  at 20-25°. (Stark and Dehn, 1918.)

## POTASSIUM Salts of PHENOLPHTHALEIN

CH

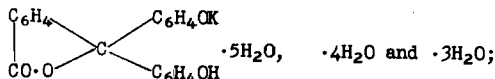


EQUILIBRIUM IN THE SYSTEM POTASSIUM HYDROXIDE, PHENOLPHTHALEIN  
AND WATER AT 25°  
(Bassett and Bagnall, 1924)

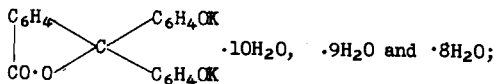
Note.—Saturation was obtained by constant rotation for not less than 3 days of mixtures of phenolphthalein and aqueous potassium hydroxide solutions of various strengths. Such concentrations were chosen that a liquid and a solid phase was obtained in all cases. Both the saturated solution and the solid phase was analyzed. No solid colored salt was obtained. The results are expressed in terms of phenolphthalein anhydride ( $C_{20}H_{12}O_3$ ) potassium oxide ( $K_2O$ ) and water.

Gms. per 100			Gms. per 100			Gms. per 100		
gms. sat. sol.		Solid Phase	gms. sat. sol.		Solid Phase	gms. sat. sol.		Solid Phase
$K_2O$	$C_{20}H_{12}O_3$		$K_2O$	$C_{20}H_{12}O_3$		$K_2O$	$C_{20}H_{12}O_3$	
4.96	13.68	P	17.31	39.01	P·K <sub>2</sub> ·8	29.50	2.03	P·K <sub>3</sub> ·8
7.49	24.20	"	17.15	44.90	P·K <sub>3</sub> ·4	24.74	10.70	P·K <sub>3</sub> ·7
8.25	25.06	P·K·5	16.50	40.74	"	30.90	1.14	"
8.97	27.75	"	16.98	39.22	"	31.65	0.76	"
12.43	38.74	"	16.60	37.06	"	34.32	0.06	"
13.22	39.91	"	17.72	33.24	P·K <sub>3</sub> ·9	36.24	—	"
11.26	33.60	P·K·4	19.84	27.47	"	39.10	—	"
14.14	41.59	"	21.57	22.11	"	39.57	—	P·K <sub>3</sub> ·6
13.19	40.34	P·K·3	17.80	35.67	"	42.14	—	"
15.11	44.31	"	19.68	30.90	"	43.62	—	P·K <sub>3</sub> ·5
15.77	45.76	P·K <sub>2</sub> ·10	22.21	19.47	P·K <sub>3</sub> ·8	45.60	—	"
15.88	44.66	"	24.74	10.70	"	46.49	—	P·K <sub>3</sub> ·4
16.44	43.50	P·K <sub>2</sub> ·9	25.64	8.15	"	47.44	—	"
15.92	43.80	P·K <sub>2</sub> ·8	28.27	3.10	"	45.44	—	" +
16.62	42.62	"	28.98	2.69	"			KOH·2H <sub>2</sub> O

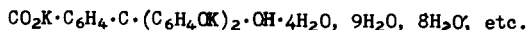
P = Phenolphthalein; P·K·5, P·K·4, P·K·3 = Mono potassium salt:



P·K<sub>2</sub>·10, P·K<sub>2</sub>·9, P·K<sub>2</sub>·8 = Di potassium salt:



P·K<sub>3</sub>·4, P·K<sub>3</sub>·9, ·8, etc. = Tri potassium salt:



# POTASSIUM METHYL ORANGE $(\text{CH}_3)_2\text{NC}_6\text{H}_4\text{N}_2\text{C}_6\text{H}_4\text{SO}_3\text{K}$

The phase diagram for the system potassium methyl orange - water in which liquid crystals are formed is given by Branner, 1939.

# POTASSIUM LAURATE $\text{CH}_3(\text{CH}_2)_{10}\text{COOK}$

CH

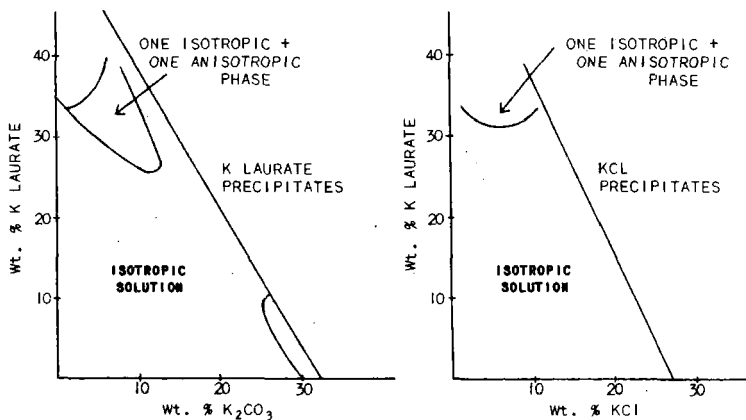
100 gms. Water dissolve approx. 70.0 gms.  $\text{CH}_3(\text{CH}_2)_{10}\text{COOK}$  at  $25^\circ$ .  
 " " Benzene " " 0.005 " " "

Results are also given for the extraction of lauric acid from aqueous solutions of potassium laurate and of sodium laurate by means of benzene. (McBain and Eaton, 1928.)

The phase rule diagrams for equilibrium in the system potassium laurate + lauric acid + water, at temperatures between  $100^\circ$  and  $370^\circ$  are given by McBain and Field, 1933. Due to high viscosity, even at  $90^\circ$ , months may be required for the separation of the liquid phases. The existence of acid soaps is demonstrated by the separation of crystalline sediments from dilute solutions of soluble soap such as potassium laurate. At  $370^\circ$  the three components are almost but not quite soluble in all proportions.

## THE SYSTEMS K LAURATE - KCl - $\text{H}_2\text{O}$ AND K LAURATE - $\text{K}_2\text{CO}_3$ - $\text{H}_2\text{O}$ AT $23^\circ$ (Dervichian, Joly and Titchen, 1952)

250 equilibrium determinations were made in the  $\text{K}_2\text{CO}_3$  system and 200 in the KCl system. The results are presented in the following diagrams.



The solubility of potassium laurate in solutions containing up to 35% potassium silicate ( $\text{SiO}_2/\text{K}_2\text{O}$  by wt. = 2.04) from  $0^\circ$  to  $175^\circ$  is given by Merrill, 1948. The temperatures at which birefringent phases appeared were used to outline the concentration limits of the isotropic solutions.



# K KALIUM

## CH POTASSIUM PALMITATE $\text{CH}_3(\text{CH}_2)_{14}\text{COOK}$

SOLUBILITY IN AQUEOUS ETHANOL AT 18°  
(Scherings, 1932)

Gms. $\text{C}_2\text{H}_5\text{OH}$ per 100 gms. Solvent	Gms. $\text{CH}_3(\text{CH}_2)_{14}\text{COOK}$ per 100 gms. sat. sol.
49	45.0*
66	19.0
79.5	6.5
96	1.4

\*This result uncertain on account of the colloidal character of the solution.

## POTASSIUM STEARATE $\text{CH}_3(\text{CH}_2)_{16}\text{COOK}$

SOLUBILITY IN AQUEOUS ETHYL ALCOHOL  
(Scherings, 1932)

t°	Gms. $\text{C}_2\text{H}_5\text{OH}$ per 100 gms. Solvent	Gms. $\text{CH}_3(\text{CH}_2)_{16}\text{COOK}$ per 100 gms. sat. sol.
18	49	4.4
18	66	2.6
18	79.5	1.8
18	96	0.62
25	91.53 (d = 0.80935)	0.633*

\*Thomas and Yu, 1923.

## CH POTASSIUM OLEATE $\text{C}_8\text{H}_{17}\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOK}$

100 gms. of aq. 91.53 wt. per cent  $\text{C}_2\text{H}_5\text{OH}$  dissolve 41.1 gms.  $\text{C}_{18}\text{H}_{33}\text{O}_2\text{K}$  at 25° and the saturated solution has  $d = 0.80935$ . (Thomas and Yu, 1923.)

Results are given by McBain and Stewart, 1933, for equilibrium in the System Potassium Oleate + Oleic Acid, determined by observing the temperature of disappearance of the last crystal upon heating, and the first appearance of turbidity upon cooling known mixtures of the two components contained in sealed evacuated tubes. An acid soap of the composition,  $\text{C}_8\text{H}_{17}\text{CH}:\text{CH}(\text{CH}_2)_7\text{COOK} \cdot \text{C}_8\text{H}_{17}\text{CH}:\text{CH}(\text{CH}_2)_7\text{COOH}$  exists below its transition temp. of 47°.

The freezing point depressions of potassium oleate solutions containing excess KOH or iso-octane were measured by Johnston and McBain, 1942 over the range 0 - 0.16 molar.

## POTASSIUM $\alpha$ -NITRILE $\alpha, \alpha$ -DIPHENYL $\alpha'$ -ETHYLSUCCINIC ACID



The solubility at 5° is between 80-100 gms./100 cm<sup>3</sup> H<sub>2</sub>O. (Salmon-Legagneur, 1956.)

POTASSIUM LIGNOCERATE  $C_{23}H_{47}COOH$ 

100 gms. aq. 91.53 wt. per cent ethyl alcohol dissolve 0.153 gm. potassium lignocerate at 25° and the solution has  $d = 0.80935$ . (Thomas and Yu, 1923.)

POTASSIUM Salt of CARYOPHYLLIN  $KC_{30}H_{49}O_4 \cdot 1\frac{1}{2}H_2O$ 

100 gms. Ethyl alcohol dissolve 2.78 gms. of the salt at 20°. (Dodge, 1918)  
 " Methyl alcohol " 40.0 " " " " ( " " )

## POTASSIUM CYANIDE KCN

CN

## SOLUBILITY IN WATER

t°	Solubility	Author
25	41.7 gms. per 100 gms. sat. sol.	Corbet, 1926
103.3	55 " " " "	Griffiths

SOLUBILITY OF POTASSIUM CYANIDE IN AQUEOUS SOLUTIONS  
 OF POTASSIUM HYDROXIDE AT 25°  
 (Basset and Corbet, 1924)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
KCN	KOH*	KCN + KOH	KCN	KOH*	KCN + KOH
41.56	0.11	41.67	34.72	7.39	42.11
41.67	0.69	42.36	33.58	8.96	42.54
38.92	3.3	42.22	26.39	16.29	42.68

\*In terms of KCN. These results show that KOH decreases the solubility of KCN in water. Hence accurate results require that KCN free of KOH must be used for solubility determinations.

THE SYSTEM POTASSIUM CYANIDE - NICKEL CYANIDE - WATER AT 25°  
 (Corbet, 1926)

Note.--In the case of this and the following experiments by Basset and Corbet the authors prepared the KCN from pure double salts in order to obtain it free of KOH. In order to prevent oxidation an atmosphere of coal gas previously passed through solutions of lead acetate and sodium hydroxide was maintained in the bottles. Both the liquid and the solid phases were analyzed.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
KCN	Ni(CN) <sub>2</sub>		KCN	Ni(CN) <sub>2</sub>	
39.85	1.00	KCN	23.97	10.82	K <sub>2</sub> Ni(CN) <sub>4</sub> ·H <sub>2</sub> O
38.79	1.88	"	23.14	10.34	"
37.64	4.69	"	16.82	14.29	"
*41.11	6.56	"	16.82	13.94	" + Ni(CN) <sub>2</sub>
39.09	5.95	KCN + K <sub>2</sub> Ni(CN) <sub>4</sub> ·H <sub>2</sub> O	10.58	9.13	Ni(CN) <sub>2</sub>
30.94	7.46	K <sub>2</sub> Ni(CN) <sub>4</sub> ·H <sub>2</sub> O	0.28	0.23	"

\*Unstable equilibrium.

# K KALIUM

## THE SYSTEM POTASSIUM CYANIDE - THALLIUM CYANIDE - WATER AT 25° (Bassett and Corbet, 1924)

	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	KCN	TlCN		KCN	TlCN	
CN	41.7	0.0	KCN	34.36	4.90	TlCN
	40.83	0.71	"	35.09	4.96	"
	39.76	1.65	"	31.25	4.46	"
	37.0	3.17	" + K <sub>2</sub> Tl(CN) <sub>2</sub>	30.21	5.00	"
	37.5	3.11	K <sub>2</sub> Tl(CN) <sub>2</sub>	28.07	4.47	"
	36.47	4.16	"	21.00	4.36	"
	36.52	4.12	"	14.75	5.46	"
	35.93	5.78	"	9.12	7.17	"
	36.00	4.99	TlCN	0.51	16.20	"
	35.27	4.98	"	0.34	16.12	"
	34.45	4.91	"	0.00	16.51	"

## THE SYSTEM POTASSIUM CYANIDE - ZINC CYANIDE - WATER AT 25° (Corbet, 1926)

	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	KCN	Zn(CN) <sub>2</sub>		KCN	Zn(CN) <sub>2</sub>	
	41.7	0.00	KCN	18.22	0.47	K <sub>2</sub> Zn(CN) <sub>4</sub>
	41.15	trace	" + K <sub>2</sub> Zn(CN) <sub>4</sub>	14.17	1.50	"
	39.04	trace	K <sub>2</sub> Zn(CN) <sub>4</sub>	7.65	5.75	"
	37.15	0.12	"	6.64	5.86	"
	34.46	0.17	"	6.77	6.97	" + Zn(CN) <sub>2</sub>
	32.65	0.20	"	3.81	3.33	Zn(CN) <sub>2</sub>
	23.56	0.67	"	2.50	2.30	"

100 gms. abs. ethyl alcohol dissolve 0.87 gms. KCN at 19.5°. (de Bruyn, 1892)  
 100 gms. abs. methyl alcohol dissolve 4.91 gms. KCN at 19.5°. (de Bruyn, 1892)  
 100 gms. glycerol dissolve 32 gms. KCN at 15.5°. (Ossendowski, 1907)  
 100 gms. hydroxylamine dissolve 41 gms. KCN at 17.5°. (de Bruyn, 1892)  
 100 gms. liquid ammonia (NH<sub>3</sub>) dissolve 4.55 gms. KCN at -33.9° and the density of the sat. solution is 0.7034. (Johnson and Krumboltz, 1933)  
 100 gms. liquid sulfur dioxide (SO<sub>2</sub>) dissolve 0.017 gm. KCN at 0°. (Jander and Ruppolt, 1937)  
 One liter of a sat. sol in phosphorus oxychloride (POCl<sub>3</sub>) at 20° contains 0.73 gms. KCN. (Gutmann, 1953)

F.-pt. data for KCN + KCl, KCN + NaCN, KCN + AgCN, KCN + Cu<sub>2</sub>(CN)<sub>2</sub> and for KCN + Zn(CN)<sub>2</sub> are given by Truthe (1912).

POTASSIUM ARGENTOCYANIDE  $KAg(CN)_2$ 

(See also Vol. I, p. 51)

## SOLUBILITY IN DEUTERIUM OXIDE SOLUTIONS AT 5°

(Noonan, 1948)

Mole % $D_2O$	Moles $KAg(CN)_2$ per 100 moles $H_2O + D_2O$
0	1.290
90.86	1.015
100.0	0.974

POTASSIUM CHROMOCYANIDE  $K_3Cr(CN)_6$ 100 gms.  $H_2O$  dissolve 32.33 gms.  $K_3Cr(CN)_6$  at 20°.

(Moissan, 1885; Christensen, 1885)

POTASSIUM FERROCYANIDE  $K_4Fe(CN)_6$ 

CN

## SOLUBILITY IN WATER

The various results are in excellent agreement. The results below are those of Harkins and Pearce, 1916; Fabris 1921, 1931, 1932; Vallance 1922, 1927; Regner and Balej, 1957; Bovalin and Fabris, 1933; Tettamanzi, 1933; Ginnings, Herring and Webb, 1933. The very careful determinations by Vallance, 1927 seem to show a break in the solubility and density curves at 18°, but no change in form of the solid phase was evident. dilatometry also showed a transition at 17.7°.

t°	d. of sat. sol.	Gms. $K_4Fe(CN)_6$ per 100 gms. sat. sol.	Solid Phase
- 0.24	--	1.25	Ice
- 0.62	--	4.0	"
- 1.09	--	8.0	"
- 1.6 Eutec.	--	11.6	" + $K_4Fe(CN)_6 \cdot 3H_2O$
0	--	12.5	$K_4Fe(CN)_6 \cdot 3H_2O$
5	--	15.0	"
10	--	17.36	"
15	--	19.3	"
20	--	22.0	"
25	1.1731	24.0	"
30	--	26.0	"
35	1.2018	27.8	"
50	1.2350	32.6	"
65	1.2635	36.8	"
70	--	38.2	"
80	1.2854	40.1	"
87.3	--	41.34	" + $K_4Fe(CN)_6$
94	--	41.99	$K_4Fe(CN)_6$
99.6	--	42.63	"
104.1	--	44.77	"
88.3	--	41.68*	$K_4Fe(CN)_6 \cdot 3H_2O$
90	--	42.24*	"
94	--	43.91*	"
95.8	--	44.74*	"

\*Metastable

(cont'd.)

# K KALIUM

Results of Vallance, 1927

t°	d of sat. sol.	Gms. $K_4Fe(CN)_6$ per 100 gms. sat. sol.	t°	d of sat. sol.	Gms. $K_4Fe(CN)_6$ per 100 gms. sat. sol.
15	1.1378	19.52	19.0	1.1505	21.08
16	1.1415	20.00	20.0	1.1543	21.9
17	1.1455	21.00	22.5	1.1615	22.7
17.7	1.1471	25.64	25.0	1.1701	23.97

SOLUBILITY OF POTASSIUM FERROCYANIDE IN AQ. POTASSIUM HYDROXIDE  
SOLUTIONS AT 25°  
(Grube, 1914)

## CN

Sovent	Gms. $K_4Fe(CN)_6 \cdot 3H_2O$ per 1000 cc. sat. sol.	Solid Phase
0.09984 <u>n</u> KOH	308.5	$K_4Fe(CN)_6 \cdot 3H_2O$
0.2496 "	283.5	"
0.4963 "	247.1	"
0.7036 "	217.4	"
0.9415 "	184.8	"
1.395 "	132.1	"
1.883 "	86.12	"

SOLUBILITY OF POTASSIUM FERROCYANIDE IN AQUEOUS  
SOLUTIONS OF AMMONIA AT 18°  
(Tettamanzi, 1933)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$NH_3$	$K_4Fe(CN)_6$		$NH_3$	$K_4Fe(CN)_6$	
0.0	21.21	$K_4Fe(CN)_6 \cdot 3H_2O$	20.60	0.872	$K_4Fe(CN)_6 \cdot 3H_2O$
4.51	11.20	"	22.37	0.750	"
9.13	5.65	"	23.62	0.645	"
11.86	3.76	"	25.05	0.497	"
15.19	2.24	"	26.95	0.427	"
16.79	1.53	"	34.09	0.157	"
18.11	1.16	"			

THE SYSTEM POTASSIUM FERRICYANIDE - POTASSIUM SULFATE - WATER  
(Bovalini and Fabris, 1933)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.			Solid Phase
$K_4Fe(CN)_6$	$K_2SO_4$	Solid Phase	$K_4Fe(CN)_6$	$K_2SO_4$	Solid Phase	
At $-1.6^\circ$			At $65^\circ$			
11.58	0.0	Ice + K·3	38.81	0.0	K·3	
			33.645	3.215	" + $K_2SO_4$	
			0.0	16.0	$K_2SO_4$	
At $-2.05^\circ$			At $74^\circ$			
9.07	4.62	" " + $K_2SO_4$				CN
At $0^\circ$			38.75	0.0	K·3	
			36.20	3.295	" + $K_2SO_4$	
9.80	4.83	" "	0.0	16.92	$K_2SO_4$	
12.48	0.0	"				
0.0	6.82	$K_2SO_4$	At $85^\circ$			
At $30^\circ$			40.72	0.0	K·3	
			38.715	2.975	" + $K_2SO_4$	
25.94	0.0	K·3	0.0	18.11	$K_2SO_4$	
24.17	0.902	"	At $86.3^\circ$			
22.97	2.231	"				
22.23	3.902	" + $K_2SO_4$				
16.45	5.535	$K_2SO_4$	39.03	2.80	K·3 + $K_4Fe(CN)_6$ + $K_2SO_4$	
11.08	7.126	"	At $90^\circ$			
8.54	7.818	"				
5.01	9.59	"				
3.03	10.205	"	41.38	0.0	$K_4Fe(CN)_6$	
0.0	11.53	"	40.14	1.030	"	
At $40^\circ$			39.75	1.410	"	
			39.30	2.770	"	
			39.165	2.831	" + $K_2SO_4$	
29.28	0.0	K·3	32.11	4.30	$K_2SO_4$	
28.58	1.288	"	30.36	5.26	"	
27.50	2.468	"	17.20	9.92	"	
25.66	3.982	" + $K_2SO_4$	14.67	11.09	"	
19.63	5.495	$K_2SO_4$	5.46	15.42	"	
15.21	7.031	"	0.0	18.60	"	
10.36	8.557	"	At $104.1$ (b.pt.)			
8.56	8.930	"				
5.88	10.111	"	44.77	0.0	$K_4Fe(CN)_6$	
3.03	11.306	"	At $104.3$ (b.pt.)			
0.0	12.90					
			39.356	3.344	" + $K_2SO_4$	
			At $101.4$ (b.pt.)			
			0	19.50	$K_2SO_4$	

K·3 =  $K_4Fe(CN)_6 \cdot 3H_2O$

## K KALIUM

THE SYSTEM POTASSIUM FERROCYANIDE - POTASSIUM FERRICYANIDE - WATER  
(Regner and Balej, 1957)

	Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
	$K_4Fe(CN)_6$	$K_3Fe(CN)_6$		$K_4Fe(CN)_6$	$K_3Fe(CN)_6$	
	15°C			50°--Cont.		
CN	19.654	--	A	7.868	32.525	A + B
	18.16	1.86	A	5.81	34.40	B
	15.65	4.88	A	5.66	34.53	B
	14.08	7.75	A	2.14	37.19	B
	13.71	7.61	A	--	39.52	B
	12.35	10.08	A			
	10.22	14.10	A			
	10.14	14.16	A		65°	
	9.39	14.78	A	37.00	--	A
	8.51	16.90	A	28.49	9.73	A
	7.27	19.97	A	20.85	18.28	A
	6.95	20.52	A	20.715	18.30	A
	5.72	22.78	A	13.22	28.29	A
	4.636	25.760	A + B	9.37	34.00	A
	2.49	27.77	B	9.22	34.14	A + B
	2.43	27.62	B	4.22	38.45	B
	0	29.69	B	3.21	39.28	B
				2.49	40.49	B
				--	42.19	B
		50°C				
	32.55	--	A		80°	
	30.54	2.82	A	40.05	--	A
	25.21	8.46	A	27.43	13.65	A
	23.85	10.11	A	22.24	20.17	A
	20.88	13.53	A	20.41	22.40	A
	17.32	18.02	A	16.69	26.95	A
	16.70	19.21	A	11.10	35.00	A + B
	14.67	21.69	A	5.74	40.00	B
	11.53	27.14	A	2.75	42.40	B
	10.92	28.46	A	--	45.27	B
	10.45	28.70	A			

A =  $K_4Fe(CN)_6 \cdot 3H_2O$ B =  $K_3Fe(CN)_6$ SOLUBILITY OF MIXTURES OF POTASSIUM FERROCYANIDE AND FERRICYANIDE  
IN WATER AND IN Aq. POTASSIUM HYDROXIDE SOLUTIONS AT 25°  
(Grube, 1914)

Solvent	Gms. per 1000 cc. Sat. Solution		Solid Phase
	$K_3Fe(CN)_6$	$K_4Fe(CN)_6$	
Water	338.1	79.02	$K_3Fe(CN)_6 + K_4Fe(CN)_6 \cdot 3H_2O$
0.4687 n KOH	309	66.64	" "
0.9628 " "	275.3	55.19	" "
1.949 " "	200.8	35.95	" "

THE SYSTEM POTASSIUM FERROCYANIDE - SODIUM FERROCYANIDE - WATER AT 25°  
(Harkins and Pearce, 1916)

Mols. per 1000 Gms. H <sub>2</sub> O		$d_{24}^4$ of Sat. Sol.	Mols. per 1000 Gms. H <sub>2</sub> O		$d_{24}^4$ of Sat. Sol.
Na <sub>4</sub> Fe(CN) <sub>6</sub>	K <sub>4</sub> Fe(CN) <sub>6</sub>		Na <sub>4</sub> Fe(CN) <sub>6</sub>	K <sub>4</sub> Fe(CN) <sub>6</sub>	
0.0	0.89459	1.09081	0.9588	1.0578	1.2267
0.05072	0.88272	1.0990	0.8984	0.6994	1.1830
0.06633	0.88544	1.10039	0.8712	0.6111	1.1581
0.12306	0.88088	1.09350	0.8652	0.5850	1.1567
0.25972	0.89116	1.12796	0.7814	0.3532	1.1243
0.4900	0.91600	1.17241	0.7610	0.2722	1.1113
0.87034	0.99000	1.19700	0.7253	0.2115	1.1006
0.91060	1.01200	1.21190	0.7213	0.1789	1.0792
0.95879	1.05177	1.22673	0.7056	0.1327	1.0199
1.0438	1.1159	1.25789	0.6818	0.0	1.0595

SOLUBILITY OF POTASSIUM FERROCYANIDE IN AQUEOUS SOLUTIONS  
OF ETHYL ALCOHOL AT 20°

(Díaz de Rada and Bermejo, 1929)

Vol. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	Gms. K <sub>4</sub> Fe(CN) <sub>6</sub> per 100 gms. sat. sol.	Vol. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	Gms. K <sub>4</sub> Fe(CN) <sub>6</sub> per 100 gms. sat. sol.
0 (= H <sub>2</sub> O)	22.01	45	0.352
5	16.40	50	0.229
10	10.47	55	0.143
15	6.61	60	0.094
20	3.995	65	0.057
25	2.394	70	0.053
30	1.420	75	0.039
35	0.789	80	0.025
40	0.565	85	none

100 gms. Methyl Alcohol dissolve 0.90 gm. Potassium ferrocyanide at the b. pt. (66°). (Henstock, 1934.)

POTASSIUM FERRICYANIDE K<sub>3</sub>Fe(CN)<sub>6</sub>

CN

SOLUBILITY OF POTASSIUM FERRICYANIDE IN WATER  
(Friend and Smirles, 1928)

The solid phase is K<sub>3</sub>Fe(CN)<sub>6</sub> in all cases and there is no indication of a break in the solubility or density curve. The saturated solutions were prepared by continuous agitation for 6 hours and analyzed by a gravimetric determination of the Fe. The results of Regner and Balej, 1957 (\*) are in reasonable agreement. The previous determinations of Wallace, 1855; Schiff, 1860 and Grube, 1916 are slightly lower than the present results.



# K KALIUM

t°	d of sat. sol.	Gms. $K_3Fe(CN)_6$ per 100 gms.		t°	d of sat. sol.	Gms. $K_3Fe(CN)_6$ per 100 gms.	
		sat. sol.	H <sub>2</sub> O			sat. sol.	H <sub>2</sub> O
0.1	--	23.22	30.24	33.1	1.2045	--	--
4.7	--	25.49	34.21	39.9	1.2115	37.22	59.27
7.8	1.1567	26.96	36.95	49.0	--	39.12	64.25
15	--	29.69*	--	50	--	39.52*	--
15.7	1.1738	30.35	43.58	56.25	--	40.41	67.80
18.7	--	30.96	44.85	58.0	1.2269	41.10	69.78
22.1	1.1872	32.08	47.22	65	--	42.15*	--
25.0	--	32.80	48.80	80	--	45.27*	--
26.3	1.1928	33.66	50.74	81.0	--	44.70	80.82
29.8	--	36.65	53.02	99.0	--	47.60	90.83

## SOLUBILITY OF POTASSIUM FERRICYANIDE IN POTASSIUM HYDROXIDE SOLUTIONS AT 25° (Grube, 1914)

One liter sat. sol. in	0.4687	n KOH contains	342.7 gms. $K_3Fe(CN)_6$
" "	0.9628	" "	302.3 " "
" "	1.949	" "	215.1 " "

## THE SYSTEM POTASSIUM FERRICYANIDE - TERTIARY BUTYL ALCOHOL - WATER AT 25° (Ginnings, Herring and Webb, 1933)

The composition of the homogeneous mixture (plait point) of this system was found to be:

4.3 percent  $K_3Fe(CN)_6$  + 38.0 percent ter.  $(CH_3)_3COH$  + 57.7 percent  $H_2O$ .

The original results for the remaining points on the binodal curve are not given but only the values of a series of arbitrary constants calculated from them by means of empirical equations.

## OTHER SOLVENTS

100 gms. methyl alcohol dissolve 0.31 gm. Potassium ferricyanide at the b. pt. (66°). (Henstock, 1934.)

100 cc. anhy. hydrazine dissolve 2 gms.  $K_3Fe(CN)_6$  at room temp.  
(Welsh and Broderson, 1915)

## CN POTASSIUM Calcium FERROCYANIDE $K_2Ca[Fe(CN)_6]$

The effect of added salts on the solubility of  $K_2Ca[Fe(CN)_6]$  in water was studied by Tananaev and Tikhomirova, 1945.

POTASSIUM PLATINUM CYANIDE  $K_2Pt(CN)_4$ SOLUBILITY IN WATER  
(Terrey and Jolly, 1923)

The transition temperatures (tr. pt.) were determined by the dilatometric method.

t°	Gms. $K_2Pt(CN)_4$ per 100 gms. $H_2O$	Solid Phase
0.1	11.60	$K_2Pt(CN)_4 \cdot 5H_2O$
9.8	19.76	"
14.4	26.53	"
13.35 tr. pt.		" + $K_2Pt(CN)_4 \cdot 3H_2O$
16.38	28.63	$K_2Pt(CN)_4 \cdot 3H_2O$
17.42	29.02	"
20.05	33.83	"
22.65	37.73	"
25.0	41.93	"
35.0	64.16	"
39.75	78.23	"
45.0	95.43	"
49.9	109.20	"
52.4 tr. pt.		" + $K_2Pt(CN)_4 \cdot 2H_2O$
55.4	127.5	$K_2Pt(CN)_4 \cdot 2H_2O$
60.4	139.1	"
67.5	156.9	"
74.5 tr. pt.	175.2	" + $K_2Pt(CN)_4 \cdot H_2O$
78.2	173.2	$K_2Pt(CN)_4 \cdot H_2O$
83.6	178.3	"
87.2	184.0	"
95.0	210.0	"

POTASSIUM ZINC CYANIDE  $K_2Zn(CN)_4$ 

100 cc.  $H_2O$  dissolve 11 gms.  $K_2Zn(CN)_4$  at 20°. (Sharwood, 1903)

## POTASSIUM CYANATE KOCN

## SOLUBILITY IN ALCOHOLIC MIXTURES, etc.

Solvent	Gms. KOCN per Liter Solvent at b.p.-pt.	Author
80% Alcohol + 20% Water	62	(Erdmann, 1893)
80% Alcohol + 20% Methyl Alcohol	76	{ " " }
80% Alcohol + 10% Acetone	82	{ " " }
100 gms. alcohol of $d_{17} = 0.799$ dissolve 0.16 gm. KOCN at 0° and 0.53 gm. at b. pt. (Cranston and Livingstone, 1926.)		
100 gms. alcohol of 80% concentration dissolve 1.9 gms. KOCN at 0° and 6.2 gms. at b.pt. (Cranston and Livingstone, 1926.)		
100 gms. <u>benzene</u> dissolve 0.18 gm. KOCN at b.pt. (Cranston and Livingstone, 1926.)		
100 gms. <u>liquid Ammonia</u> , $NH_3$ , dissolve 1.7 gm. KOCN at 25°. (Hunt, 1932)		
" cc: " " " " " 1.02 " " " ( " " )		
One liter of sat. sol in <u>phosphorus oxychloride</u> at 20° contains 0.80 gms. KOCN. (Gutmann, 1952)		

# K KALIUM

## SCN POTASSIUM THIOCYANATE KSCN

### SOLUBILITY OF POTASSIUM THIOCYANATE IN WATER

Up to 25°, Rudorff, 1869, 1872; Foote, 1903; Wassilijew, 1910, Occleshaw, 1931. At the higher temperatures, Kracek, 1936.

The determinations of Kracek were made by observing the temperature of disappearance of the last crystal in mixtures of KSCN + H<sub>2</sub>O contained in sealed tubes. A polymorphic inversion of KSCN occurs at 140.6°, hence the solubility curve has a break at that point.

Chretien and Hoffer, 1935, by means of the crystallization diagram, found metastable crystalline forms of KSCN having 1/2 and 4/5 mol. of H<sub>2</sub>O at temperatures between the eutectic (-33.2°) and + 6.8°.

t°	Gms. KSCN per 100 gms.		Solid Phase	t°	Gms. KSCN per 100 gms.		Solid Phase
	H <sub>2</sub> O	sat. sol.			H <sub>2</sub> O	sat. sol.	
- 6.5	20.0	16.7	Ice	84.2	526.9	84.05	KSCN II
- 9.55	30.0	23.1	"	99.0	673.6	87.04	"
-31.2	101.0	50.24	" + KSCN	108.4	802.9	88.94	"
0	177	63.9	KSCN II	116.8	956.2	90.53	"
20	217	68.45	"	124.6	1150.2	92.00	"
25	239	70.50	"	130.7	1346.2	93.07	"
		(70.70)*	"	140.6	1825.6	94.82	KSCN I
32.6	265.1	72.61	"	142.7	1957.7	95.13	"
40		(70.70)*	"	149.4	2471.1	96.12	"
47.3	317.05	76.03	"	157.4	3599.6	97.29	"
57.0	358.6	78.18	"	169.2	9342.0	98.93	"
66.7	408.45	80.34	"	176.8	M. pt.		"
74.5	455.9	82.02	"				

\*Bogoyavlenskii and Sukmanskaya, 1953

### SOLUBILITY OF POTASSIUM THIOCYANATE IN DEUTERIUM OXIDE

(Chang and Hsieh, 1949)

The ratio of the molal solubilities (moles/55.51 moles solvent) of KSCN in D<sub>2</sub>O and H<sub>2</sub>O at 25° is  $S_{D_2O}/S_{H_2O} = 0.972$ .

### THE SYSTEM POTASSIUM THIOCYANATE - POTASSIUM NITRATE - WATER AT 25°

(Bogoyavlenskii, 1955)

Sat. sol. wt. %		Solid Phase	Sat. sol. wt. %		Solid Phase
KNO <sub>3</sub>	KSCN		KNO <sub>3</sub>	KSCN	
27.16	0.0	KNO <sub>3</sub>	12.3	38.8	KNO <sub>3</sub>
25.6	2.04	"	11.68	45.49	"
21.7	8.66	"	9.94	57.77	"
18.69	15.13	"	9.45	65.2	KNO <sub>3</sub> + KSCN
16.87	21.73	"	6.35	66.64	KSCN
14.85	29.4	"	0.0	70.7	"

THE SYSTEM POTASSIUM THIOCYANATE - POTASSIUM SULFATE - WATER  
(Bogoyavlenskii and Sukmanskaya, 1953)

Results at 25°

Results at 40°

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
KSCN	K <sub>2</sub> SO <sub>4</sub>	Solid Phase	KSCN	K <sub>2</sub> SO <sub>4</sub>	Solid Phase
0.0	10.76	K <sub>2</sub> SO <sub>4</sub>	0.0	13.10	K <sub>2</sub> SO <sub>4</sub>
1.18	9.71	"	0.48	12.64	"
3.03	8.42	"	2.10	11.87	"
4.94	7.13	"	3.88	9.50	"
6.63	6.20	"	6.42	8.05	"
8.68	5.24	"	8.12	6.41	"
11.80	4.22	"	10.54	5.67	"
15.04	3.05	"	11.94	5.17	"
18.20	2.14	"	14.42	4.13	"
24.07	1.45	"	19.31	3.05	"
32.50	0.60	"	24.46	1.69	"
38.57	0.31	"	25.75	1.28	"
46.16	0.20	"	30.06	1.02	"
52.51	0.10	"	32.83	0.85	"
70.60	0.04	" + KSCN	36.75	0.79	"
70.70	0.0	KSCN	39.63	0.44	"
			46.30	0.22	"
			55.9	0.13	"
			74.24	0.03	" + KSCN
			74.31	0.0	KSCN

THE SYSTEM POTASSIUM THIOCYANATE - AMMONIUM THIOCYANATE - WATER  
(Ravich, Ketkovich, and Rassonskaya, 1949)

At 0°, 30° and 60° two series of solid solutions are formed. The region of immiscibility between the solid solution diminishes with increasing temperature. At 90° a continuous solid solution is formed. The data are also given in mole percent.

Liquid Phase wt. %		Wet Residue wt. %		Extrapolated solid composition wt. %	Solid Phase
NH <sub>4</sub> SCN	KSCN	NH <sub>4</sub> SCN	KSCN	NH <sub>4</sub> SCN	
Results at 0°					
42.9	14.6	68.4	10.3	94.1	Y solid solution
35.7	24.4	62.9	19.5	84.4	Y " "
30.1	34.1	54.0	29.3	74.9	Y " "
29.7	35.5	44.0	43.7	51.8	Y + β " "
25.0	39.2	33.0	54.2	37.5	β " "
19.9	44.1	25.9	62.0	29.0	β " "
10.7	53.8	13.7	73.7	15.4	β " "

## K KALIUM

## THE SYSTEM POTASSIUM THIOCYANATE - AMMONIUM THIOCYANATE - WATER--Cont.

	Liquid Phase		Wet Residue		Extrapolated	Solid Phase
	wt. %		wt. %		solid composition	
	NH <sub>4</sub> SCN	KSCN	NH <sub>4</sub> SCN	KSCN	wt. % NH <sub>4</sub> SCN	
Results at 30°						
SCN	55.4	10.8	75.6	7.1	96.8	γ solid solution
	47.8	19.3	69.2	14.5	90.2	γ " "
	46.7	22.0	65.6	18.2	85.8	γ " "
	41.0	29.3	62.5	24.6	79.0	γ " "
	39.8	31.8	50.1	38.4	57.1	β " "
	29.1	42.1	36.3	51.4	41.7	β " "
	23.2	48.0	28.9	58.7	33.2	β " "
	13.1	57.7	16.0	72.4	17.9	β " "
Results at 60°						
	71.5	5.7	88.0	4.2	96.6	γ " "
	64.4	13.9	83.0	10.4	91.1	γ " "
	61.8	16.9	78.4	13.7	88.2	γ " "
	59.4	19.1	73.6	18.6	81.7	γ + β " "
	59.2	19.8	70.2	22.5	76.1	γ + β " "
	50.6	27.7	55.9	31.0	64.0	β " "
	36.0	41.8	41.4	47.6	46.7	β " "
	23.3	54.6	27.4	64.2	29.9	β " "
	14.0	63.9	16.4	75.5	17.8	β " "
Results at 90°						
	74.6	10.5	80.8	12.2	86.3	β " "
	70.1	14.8	77.7	16.5	82.4	β " "
	61.4	23.8	65.5	25.9	71.2	β " "
	47.0	37.7	50.4	43.6	52.4	β " "
	29.9	55.5	30.8	61.4	31.8	β " "
	15.1	69.4	15.4	77.4	15.7	β " "

THE SYSTEM POTASSIUM THIOCYANATE - TERTIARY BUTYL ALCOHOL - WATER AT 25°  
(Ginnings, Herring and Webb, 1933)

The composition of the homogeneous mixture (plait point) of this system was found to be:

37.9 percent KSCN + 19.3 percent ter. (CH<sub>3</sub>)<sub>3</sub>COH + 42.8 percent H<sub>2</sub>O.

The original results for the remaining points on the binodal curve are not given but only the values of a series of arbitrary constants calculated from them by means of empirical equations.

DISTRIBUTION OF POTASSIUM THIOCYANATE BETWEEN WATER  
AND AMYL ALCOHOL AT 17°  
(Wosnessensky, 1925)

Millimols KSCN per liter of		$C_1$	Millimols KSCN per liter of		$C_1$
H <sub>2</sub> O layer ( $C_1$ )	Alcohol layer ( $C_2$ )	$C_2^{0.7}$	H <sub>2</sub> O layer ( $C_1$ )	Alcohol layer ( $C_2$ )	$C_2^{0.7}$
155.40	2.329	88	640.235	17.379	86
338.82	7.090	86	1075.221	31.506	86
410.753	9.333	86			

SOLUBILITY OF POTASSIUM THIOCYANATE IN ORGANIC SOLVENTS  
(von Laszcynski, 1894)

SCN

In Acetone		In Amyl Alcohol		In Ethyl Acetate	
t°	Gms. KSCN per 100 gms. (CH <sub>3</sub> ) <sub>2</sub> CO	t°	Gms. KSCN per 100 gms. C <sub>5</sub> H <sub>11</sub> OH	t°	Gms. KSCN per 100 gms. CH <sub>3</sub> COOC <sub>2</sub> H <sub>5</sub>
22	20.75	13	0.18	0	0.44
58	20.40	65	1.34	14	0.40
		100	2.14	79	0.20
		133.5	3.15		

100 gms. anhydrous acetonitrile dissolve 11.31 gms. KSCN at 18°.  
(Naumann and Schier, 1914)

SOLUBILITY OF POTASSIUM THIOCYANATE IN PYRIDINE

The data of Wagner and Zerner, 1911 determined by the synthetic method are considerably smaller than those of von Laszcynski, 1894 (in parentheses).

t°	Gms. KSCN per 100 Gms. Mixture	Solid Phase
- 42.	0	C <sub>5</sub> H <sub>5</sub> N
- 42.1	0.5	"
- 42.4	1.33	"
- 42.8	2.4	"
- 43.3 Eutec.	3.1	" + KSCN
0	(6.33)	KSCN
about + 10	2.2	"
20	(5.79)	"
58	(4.73)	"
70-71	1.23	"
97	(3.73)	"
115	(3.11)	"
116-117	0.89	"
172.7	*	"
173.8 m. pt.	100	"

\*At this temperature two liquid layers appear and do not become homogeneous up to 200°.

# K KALIUM

## THE SYSTEMS POTASSIUM THIOCYANATE - IODINE - BENZENE AND POTASSIUM THIOCYANATE - IODINE - TOLUENE AT 6° (Foote and Fleischer, 1940)

	With Benzene		With Toluene (no compound formed)	
	Gms. I <sub>2</sub> per 100 gms. Sat. Sol.	Solid Phase	Gms. I <sub>2</sub> per 100 gms. Sat. Sol.	Solid Phase
SCH	7.34	KSCN	10.21	KSCN + I <sub>2</sub>
	8.15	KSCN + KSCN·6I·4C <sub>6</sub> H <sub>6</sub>	10.29	"
	7.93	"	10.18	"
	8.11	"		
	7.91	"		
	8.30	KSCN·6I·4C <sub>6</sub> H <sub>6</sub>		
	8.45	"		
	8.59	"		
	8.70	KSCN·6I·4C <sub>6</sub> H <sub>6</sub> + I <sub>2</sub>		
	8.69	"		

83.0 gms. KSCN dissolve in 100 gms. of ethylenediamine at 25°. (Isbin and Kobe, 1945)  
1 liter sat. sol. in phosphorus oxychloride contains 0.76 gms. KSCN at 20°. (Gutmann, 1952)  
100 gms. liquid Sulfur Dioxide, SO<sub>2</sub>, dissolve 4.87 gms. KSCN at 0°. (Jander and Ruppolt, 1937)

Melting point data are given for:

KSCN + NaSCN (Wrzesnewsky, 1912; Sokolov and Pochtakova, 1958)  
" + RbSCN ( " " )  
" + NH<sub>4</sub>SCN (Ravich, Ketkovich, and Rassonskaya, 1949)  
" + KNO<sub>3</sub> (Palkina, 1945)  
KSCN + Na formate ⇌ K formate + NaSCN (Sokolov and Pochtakova, 1958b)  
KSCN + K formate ( " " " " )  
KSCN + Na Butyrate ⇌ K butyrate + NaSCN ( " " " 1958a)  
KSCN + K butyrate ( " " " " )  
KSCN + KBr, KI, KCl, NiBr<sub>2</sub>, CdI<sub>2</sub>,  
ZnI<sub>2</sub>, CoCl<sub>2</sub> (up to 0.1 M in  
molten KSCN) (Kordes, Bergmann, and Vogel, 1951)

## POTASSIUM CHROMITHIOCYANATE K<sub>2</sub>Cr(SCN)<sub>6</sub>·4H<sub>2</sub>O

100 gms. H<sub>2</sub>O dissolve 139 gms. salt. (Karsten, 1864-5.)

POTASSIUM CARBONATE  $K_2CO_3$ 

CO

## SOLUBILITY OF POTASSIUM CARBONATE IN WATER

(Mulder, 1864; de Copet, 1872; Meyerhoffer, 1905; Kremann and Zitek, 1909; de Waal, 1910; Osaka, 1910-12; Bain, 1927; Hill and Miller, Jr., 1927; Hill, 1930, 1930(a); Lang and Sukava, 1958)

Other determinations not in good agreement with these are given by Engel, 1888; Köhler, 1897; Greenish and Smith, 1901; Rubitzov, 1918; Blasdale, 1923; Iljinski, 1924; Starkowa, 1931; and Appleby and Lefshman, 1932. The results of Takahashi, 1927 are slightly higher.

Determinations of the equilibrium in aqueous solutions of potassium carbonate and bicarbonate in concentrations up to 2.5 gm. mol. per liter, in relation to the partial pressure of  $CO_2$  in the gas phase in contact with the solution, are given by Walker, Bray & Johnston, 1927.

I = ICE				K6 = K <sub>2</sub> CO <sub>3</sub> ·6H <sub>2</sub> O				K1.5 = K <sub>2</sub> CO <sub>3</sub> ·1½H <sub>2</sub> O			
t°	Gms. K <sub>2</sub> CO <sub>3</sub> per 100 gms. sat. sol.	density	Solid Phase	t°	Gms. K <sub>2</sub> CO <sub>3</sub> per 100 gms. sat. sol.	density	Solid Phase				
-10	21.3	--	I	30	53.2	1.557	K1.5				
-20	31.0	--	I	40	53.9	--	"				
-30	36.9	--	I	50	54.8	1.570	"				
-36.5	39.6	--	I + K6	60	55.9	--	"				
-20	44.62	--	K6	70	57.1	1.590	"				
-10	50.65	--	K6	80	58.3	--	"				
- 6.2	50.9	--	K6 + K1.5	90	59.6	--	"				
0	51.25	1.546	K1.5	100	60.9	--	"				
+10	51.9	1.549	"	110	62.5	--	"				
20	52.5	--	"	120	64.4	--	"				
25	52.85	1.559	"	130	66.2	--	"				

SOLUBILITY OF POTASSIUM CARBONATE AND OF BICARBONATE IN WATER IN CONTACT  
WITH ATMOSPHERES CONTAINING VARYING PERCENTAGES OF CARBON DIOXIDE  
(Takahashi, 1927)

## Results at 50°

Percent $CO_2$ in Atmospheres	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
		$K_2O$	$CO_2$	
0	1.570	38.00	17.78	$K_2CO_3 \cdot 2H_2O$
16	1.569	37.90	18.07	"
18	1.570	37.43	17.90	" + $KHCO_3$
20	1.512	35.81	17.27	$KHCO_3$
22	1.494	31.79	15.80	"
50	1.401	27.25	14.60	"
60	1.352	23.32	14.20	"
80	1.282	19.54	14.10	"
99.5	1.241	16.95	14.62	"

## Results at 70°

0	1.590	39.65	18.48	$K_2CO_3 \cdot 2H_2O$
22	1.588	39.34	19.41	" + $KHCO_3$
26	1.575	39.02	19.16	" "
50	1.550	36.36	18.44	$KHCO_3$
55	1.430	29.47	16.85	"
60	1.315	25.99	16.37	"
80	1.335	22.65	16.18	"
99.5	1.301	20.45	16.87	"



K KAL IUM

THE SYSTEM POTASSIUM CARBONATE - POTASSIUM HYDROXIDE - WATER  
(Hostalek and Kasparova, 1956 (20° to 100°); Lang and Sukava, 1958  
(-60° to +25°); de Waal, 1910 (30°))

$$I = ICE \quad C6 = K_2CO_3 \cdot 6H_2O \quad C1.5 = K_2CO_3 \cdot 1.5H_2O \quad O4 = KOH \cdot 4H_2O \quad O2 = KOH \cdot 2H_2O$$

	Sat. sol. wt. %		Solid Phase	Sat. sol. wt. %		Solid Phase	Sat. sol. wt. %		Solid Phase
	KOH	K <sub>2</sub> CO <sub>3</sub>		KOH	K <sub>2</sub> CO <sub>3</sub>		KOH	K <sub>2</sub> CO <sub>3</sub>	
	At -60°			At -10°			At 20°		
C0	30.1	0	I	12.1	0	I	2.5	49.9	C1.5
	29.22	1.30	"	11.05	1.72	"	4.4	47.8	--
	28.50	2.48	"	9.61	4.67	"	13.6	36.9	--
	26.75	5.43	"	5.68	11.80	"	16.3	33.4	--
	24	10	I + O4	0	23.60	"	16.8	33.1	--
	27.50	5.83	O4	0	49.40	C6	16.9	32.8	C1.5
	29.42	3.35	"	0	49.37	"	24.8	23.5	--
	31.36	1.23	"	3.88	45.16	"	27.8	19.9	--
	32.8	0	"	6.90	41.90	"	32.2	15.3	--
		At -40°			6.9	41.9	C6 + C1.5	38.7	9.1
			0	50.50	C1.5	42.2	6.0	C1.5	
			0	50.80	"	44.7	4.6	--	
	25.5	0	I	5.09	44.21	"	50.7	1.3	--
	24.84	1.22	"	13.45	33.60	"			
	22.04	5.40	"	16.40	29.72	"			
	18.71	10.65	"	20.00	25.45	"			
	15.12	17.16	"	21.75	23.50	"	0	52.80	C1.5
	9.62	25.65	"	36.70	7.32	"	10.77	39.45	"
	7.99	28.62	I + C6	42.92	3.33	"	14.41	34.84	"
	9.88	26.60	C6	45.58	2.01	C1.5 + O2	22.83	24.87	"
	13.12	22.95	"	45.70	1.90	" + "	28.83	18.05	"
	20.68	15.15	"	46.40	0.92	O2	37.02	11.10	"
	28.26	11.30	"	47.0	0	"	46.33	4.28	"
	30.5	11.0	C6 + O4				50.41	2.91	"
	31.75	8.87	O4		At 0°		52.46	2.41	C1.5 + O2
	33.40	5.92	"				52.50	2.36	" + "
	35.50	1.78	"	0	51.25	C1.5	54.0	0	O2
	36.6	0	"	6.94	42.50	"			
				13.20	34.30	"			
				18.20	28.45	"			
				23.10	22.47	"			
				29.60	15.13	"	0	53.27	C1.5
	18.0	0	I	35.43	9.04	"	53.77	2.50	"
	17.39	1.14	"	44.04	3.24	"	55.14	2.05	C1.5 + O2
	13.68	7.63	"	47.51	2.09	C1.5 + O2	55.75	0	O2
	6.84	19.85	"	47.45	2.11	" + "			
	0	32.52	"	49.2	0	O2			
	0	44.62	C6						
	7.47	36.24	"				4.8	48.5	--
	14.68	29.50	"		At 10°		16.2	35.1	--
	17.52	27.41	C6 + C1.5				23.8	26.5	--
	22.80	21.83	C1.5	0	51.9	C1.5	27.2	22.2	C1.5
	30.40	12.86	"	9.76	39.15	"	32.9	16.5	--
	40.54	4.09	"	20.08	26.93	"	36.1	13.1	--
	44.60	1.73	C1.5 + O2	29.51	16.40	"	39.7	9.9	C1.5
	44.90	1.42	O2	35.82	10.05	"	44.2	6.8	--
	46.3	0	"	42.55	5.10	"	56.9	1.2	C1.5 + O2
				48.92	2.18	C1.5 + O2			
				49.03	2.20	" + "			
				50.7	0	O2			

Sat. sol. wt. %			Sat. sol. wt. %			Sat. sol. wt. %		
KOH	K <sub>2</sub> CO <sub>3</sub>	Solid Phase	KOH	K <sub>2</sub> CO <sub>3</sub>	Solid Phase	KOH	K <sub>2</sub> CO <sub>3</sub>	Solid Phase
At 60°			At 80° (Cont.)			At 100° (Cont.)		
6.8	48.1	--	15.0	41.8	Cl.5	4.8	56.0	--
15.6	38.1	--	22.0	33.8	--	5.3	55.4	--
22.6	29.7	--	25.8	29.7	--	9.0	51.4	Cl.5
30.3	21.1	--	29.7	25.3	Cl.5	12.8	47.0	--
36.8	14.5	Cl.5	33.6	21.1	--	22.0	39.9	--
43.5	9.1	--	39.4	15.2	--	26.1	32.6	--
51.9	4.8	--	46.8	9.3	--	31.5	26.8	--
58.4	2.8	Cl.5	56.8	5.0	Cl.5	35.6	22.1	Cl.5
At 80°			At 100°			37.4	20.7	--
						38.4	19.7	--
						44.7	13.5	--
						47.3	11.6	--
3.2	55.0	--	0.9	60.0	--	53.6	8.8	Cl.5
11.7	45.5	--	3.0	58.0	Cl.5	55.9	7.7	--

THE SYSTEM POTASSIUM CARBONATE - AMMONIA - WATER  
(Applebey and Leishman, 1932)

Two liquid layers are formed at concentrations of ammonia above 2.5 percent. The concentrations are expressed in gms. per 100 gms. sat. solution.

Experiments indicate that the upper critical solution temperature is probably above 155°. It was also found that the vapor pressure of the two liquid layers in contact with K<sub>2</sub>CO<sub>3</sub>·2H<sub>2</sub>O becomes greater than atmospheric at about 22.5°.

The data of Guyen, Bieler and Orelli, (p. 84) are in disagreement.

t°	Aqueous Layer			Ammoniacal Layer			Solid Phase
	d. of sat. sol.	NH <sub>3</sub>	K <sub>2</sub> CO <sub>3</sub>	d. of sat. sol.	NH <sub>3</sub>	K <sub>2</sub> CO <sub>3</sub>	
0	1.539	9.0	50.69	--	--	--	K <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O
	1.517	1.06	49.37	--	--	--	"
	1.507	1.57	48.84	--	--	--	"
	1.483	2.51	47.42	--	--	--	"
	1.475	2.52	47.13	0.901	32.07	2.72	"
	1.421	3.26	42.54	0.921	27.41	2.99	
	1.371	3.70	39.44	0.946	24.59	3.73	
	1.340	4.41	35.95	0.968	22.02	5.84	
	1.240	6.91	28.92	1.038	16.17	12.44	
	1.109	12.09	18.51	1.109	12.09	18.51	(Crit. solution)
	--	--	--	--	42.9	2.3	K <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O
18.05	1.550	0.0	51.72	--	--	--	"
	1.455	2.88	46.50	0.894	30.48	4.76	"
	1.407	2.75	43.6	0.917	27.24	5.98	
	1.404	2.83	42.78	0.919	26.75	6.15	
	1.351	4.14	39.31	0.950	23.08	8.87	
	1.104	12.74	21.05	1.104	12.74	21.05	(crit. solution)
	--	--	--	--	61.95	2.10	K <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O

(Cont.)

## K KALIUM

## THE SYSTEM POTASSIUM CARBONATE - AMMONIA - WATER--Cont.

t°	Aqueous Layer			Ammoniacal Layer			Solid Phase
	d. of sat. sol.	NH <sub>3</sub>	K <sub>2</sub> CO <sub>3</sub>	d. of sat. sol.	NH <sub>3</sub>	K <sub>2</sub> CO <sub>3</sub>	
CO	25.06	1.556	0.0	51.47	--	--	K <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O
	--	--	0.550	50.91	--	--	"
	--	--	1.004	50.91	--	--	"
	--	--	1.286	50.30	--	--	"
	--	--	1.842	49.77	--	--	"
	--	--	2.885	48.79	--	--	"
	--	--	3.450	47.00	--	30.85 4.83	"
	--	--	4.79	40.69	--	25.81 7.48	"
	--	--	6.04	36.36	--	21.98 10.85	"
	--	--	8.19	30.94	--	8.19 30.94	(crit. solution)

SOLUBILITY OF POTASSIUM CARBONATE IN AMMONIA SOLUTIONS  
(Guyer, Bieler, and Orelli, 1940)

The data below were read from curves given by the authors and are in grams of K<sub>2</sub>CO<sub>3</sub> per 100 grams of solvent. These results do not agree with those of Appleby and Leishman, above.

% NH <sub>3</sub> in Solvent	-30°	-10°	0°	19°
3	--	34	52	50.5
5	--	28	51	49
10	--	--	45	--
20	3	--	--	8
30	2	3	4	5
40	1	2	--	--
60	1	--	3	4
80	1	2	3	3

THE SYSTEM POTASSIUM CARBONATE - HYDRAZINE - WATER AT 50°  
(Penneman and Audrieth, 1949)

Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
N <sub>2</sub> H <sub>4</sub>	K <sub>2</sub> CO <sub>3</sub>		K <sub>2</sub> H <sub>4</sub>	K <sub>2</sub> CO <sub>3</sub>	
97.0	0.6	K <sub>2</sub> CO <sub>3</sub> ·3/2H <sub>2</sub> O	28.7	25.0	K <sub>2</sub> CO <sub>3</sub> ·3/2H <sub>2</sub> O
69.8	2.7	"	16.2	38.5	"
53.4	6.0	"	7.6	47.9	"
40.5	14.3	"			

A study of the liquid phase separations in the system K<sub>2</sub>CO<sub>3</sub> - K laurate - H<sub>2</sub>O at 23° and 36.5° was made by Dervichian, Titchen and van der Berg, 1950.

THE SYSTEM POTASSIUM CARBONATE - POTASSIUM BICARBONATE - WATER  
(Hill, 1930(a); Luzhnaya and Kosyachkova, 1955)

Results for the 42° isotherm for this system are given by Starkowa, 1931, but the author failed to find the double salt  $K_2CO_3 \cdot 2KHCO_3 \cdot 1\frac{1}{2}H_2O$ . The earlier results of Engel, 1888, at 0°, for this system are also probably inaccurate since his value for  $K_2CO_3$  in water varies so greatly from that of all other investigators.

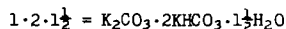
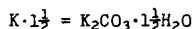
The data at 50° are those of Luzhnaya and Kosyachkova; Hill's results agree.

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	CO
	K <sub>2</sub> CO <sub>3</sub>	KHCO <sub>3</sub>			K <sub>2</sub> CO <sub>3</sub>	KHCO <sub>3</sub>		
Results at 5° (H.)				Results at 35° (H.)				
1.543	51.53	0.0	K·1½	1.560	53.56	0.0	K·1½	
1.555	50.59	1.72	" + 1·2·1½	1.573	51.68	3.26	" + 1·2·1½	
--	50.03	1.77	1·2·1½	1.563	50.99	3.48	1·2·1½	
1.543	49.91	1.90	"	1.564	50.58	3.62	"	
1.542	49.65	1.96	" + KHCO <sub>3</sub>	1.556	50.00	3.92	"	
1.509	46.38	2.55	KHCO <sub>3</sub>	1.556	49.51	4.27	" + KHCO <sub>3</sub>	
1.137	0.0	20.15	"	1.548	48.93	4.27	KHCO <sub>3</sub>	
Results at 25° (H.)				1.441	37.73	7.50	"	
1.559	52.77	0.0	K·1½	1.329	23.04	14.21	"	
1.563	51.23	2.64	" + 1·2·1½	1.252	10.04	22.10	"	
1.562	50.77	2.85	1·2·1½	1.208	0.97	28.82	"	
1.554	50.28	3.02	"	1.200	0.0	29.60	"	
1.549	49.77	3.22	"	Results at 50° (L. and K.)				
1.545	49.48	3.33	" + KHCO <sub>3</sub>	1.5938	54.50	0.0	K·1½	
1.538	48.14	3.56	KHCO <sub>3</sub>	1.5802	52.30	4.60	" + 1·2·1½	
1.485	42.82	4.67	"	(1.584	52.85	3.83	" + "	)*
1.402	34.71	7.35	"	--	52.03	5.04	1·2·1½	
1.316	23.36	12.19	"	1.5798	51.04	5.07	"	
1.272	16.98	15.45	"	1.5790	50.20	6.30	"	
1.228	10.00	19.31	"	1.5784	49.50	7.10	" + KHCO <sub>3</sub>	
1.187	0.0	26.78	"	(1.565	49.65	5.77	" + "	)*
				--	45.50	7.80	KHCO <sub>3</sub>	
				1.5314	43.50	8.50	"	
				1.4892	42.70	9.44	"	
				--	40.00	11.00	"	
				1.4004	31.14	16.34	"	
				1.3062	14.40	25.16	"	
				1.2643	4.60	31.10	"	
				1.2612	2.90	31.60	"	
				1.2471	1.93	34.00	"	
				1.2420	0.0	34.50	"	

K·1½ = K<sub>2</sub>CO<sub>3</sub>·1½H<sub>2</sub>O

1·2·1½ = K<sub>2</sub>CO<sub>3</sub>·2KHCO<sub>3</sub>·1½H<sub>2</sub>O

\* Hill, 1930a



\* Hill, 1930a

## K KALIUM

THE SYSTEM  $K_2CO_3 + KHCO_3 + K_2SO_4 + H_2O$  AT  $50^\circ$   
(Luzhnaya and Kosyachkova, 1955)

Gms. per 100 gms. sat. sol.			
$K_2CO_3$	$K_2SO_4$	$KHCO_3$	Solid Phase
54.10	0.08	0.0	$C3/2 + S$
52.50	0.08	3.00	"
53.00	0.06	5.00	$C \cdot 3/2 + 2H \cdot C \cdot 3/2 + S$
52.90	0.07	5.01	"
53.08	0.06	4.98	"
52.30	0.0	4.60	$C \cdot 3/2 + 2H \cdot C \cdot 3/2$
49.50	0.0	7.10	$H + 2H \cdot C \cdot 3/2$
51.90	0.15	5.26	$H + 2H \cdot C \cdot 3/2 + S$
CO 51.88	0.14	5.29	"
0.0	2.30	33.48	$H + S$
8.00	1.10	28.78	"
22.90	0.80	17.90	"
30.20	0.48	12.60	"
37.46	0.40	10.80	"
36.80	0.30	10.10	"
38.50	0.20	9.40	"
41.40	0.16	8.80	"
42.50	0.15	8.20	"
46.89	0.15	6.53	"
51.90	0.13	5.05	$2H \cdot C \cdot 3/2 + S$

 $C3/2 = K_2CO_3 \cdot 3/2H_2O$  $S = K_2SO_4$  $2H \cdot C \cdot 3/2 = 2KHCO_3 \cdot K_2CO_3 \cdot 3/2H_2O$  $H = KHCO_3$ 

## THE SYSTEM POTASSIUM CARBONATE - POTASSIUM CHLORIDE - WATER

Results of de Waal, 1910 at  $30^\circ$ 

Gms. per 100 Gms. Sat. Sol.		
$K_2CO_3$	KCl	Solid Phase
53.27	0	$K_2CO_3 \cdot 1\frac{1}{2}H_2O$
52.22	1.03	" + KCl
51.66	1.07	KCl
1.64	26.22	"
0	28.01	"

Solution saturated with both salts:  
(Berg and Nikolajev, 1937)

t°	Gms. per 100 gms. sat. sol.		Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
	$K_2CO_3$	KCl	$K_2CO_3$	KCl	
20	51.9	0.8	109.7	1.7	$K_2CO_3 \cdot 1\frac{1}{2}H_2O + KCl$
30	52.22	1.03	111.7	2.2	"
50	53.63	1.40	119.8	3.1	"
70	56.06	2.00	133.7	4.8	"
84	57.16	2.21	140.8	5.45	"
100	59.44	2.48	155.0	6.5	"
124.5	65.33	2.68	180.7	7.7	"
133.5	Constant boiling solution.				

THE SYSTEM  $K_2CO_3 - KCl - K_2SO_4 - H_2O$   
(Teeple, 1929)

Cl = KCl			S = K <sub>2</sub> SO <sub>4</sub>	C = K <sub>2</sub> CO <sub>3</sub> · ½H <sub>2</sub> O			
Gms. per 100 gms. H <sub>2</sub> O			Solid Phase	Gms. per 100 gms. H <sub>2</sub> O			Solid Phase
KCl	K <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> CO <sub>3</sub>		KCl	K <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> CO <sub>3</sub>	
Results at 35°				Results at 50° (Cont.)			
39.0	--	--	Cl	3.6	--	121.3	C + Cl
--	14.1	--	S	--	trace	121.2	C + S
--	--	115.1	C	3.6	"	121.2	C + S + Cl
38.4	1.7	--	Cl + S				
3.1	--	114.1	Cl + S + C				
--	trace	112.5	C + S	Results at 75°			
2.9	"	112.7	C + Cl	49.7	--	--	Cl
				--	20.6	--	S
				--	--	136.4	C
Results at 50°				48.5	1.9	--	Cl + S
43.1	--	--	Cl	5.2	--	134.9	C + Cl
--	17.1	--	S	--	trace	135.8	C + S
--	--	121.2	C	5.2	"	133.5	C + S + Cl
42.2	1.8	--	S + Cl				

THE SYSTEM POTASSIUM CARBONATE - POTASSIUM CHLORATE - WATER  
(Iljinsky, 1924)

NOTE.--Saturation was secured by active shaking at constant temperature. The attainment of equilibrium was controlled by successive density determinations and by analyses. In most cases the time required was 3 to 5 hours. For the triple points and those corresponding to double salts, several days were required. The solid phases were identified by analysis.

d. of sat. sol.	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	d. of sat. sol.	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
	KClO <sub>3</sub>	K <sub>2</sub> CO <sub>3</sub>			KClO <sub>3</sub>	K <sub>2</sub> CO <sub>3</sub>	
Results at 24.2°				Results at 24.2°			
1.550	0.0	112.6	K <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O	--	2.90	23.4	KClO <sub>3</sub>
--	0.35	111.6	" + KClO <sub>3</sub>	1.180	3.00	22.3	"
--	0.5	97.5	KClO <sub>3</sub>	1.100	4.50	10.1	"
--	0.35	96.8	"	1.045	8.10	0.0	"
1.500	0.55	95.2	"	Results at 40°			
1.362	1.10	58.3	"	1.558	0.0	119.3	K <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O
1.362	1.15	56.5	--	1.539	2.2	109.8	" + KClO <sub>3</sub>
1.302	1.60	44.7	"	1.316	2.1	42.2	KClO <sub>3</sub>
1.220	2.20	31.3	"	1.195	5.5	24.4	"
1.218	2.40	29.3	"	1.073	14.2	0.0	"

# K KALIUM

THE SYSTEM  $K_2CO_3 + 2NaClO_3 \rightleftharpoons 2KClO_3 + Na_2CO_3$  IN  $H_2O$  AT  $24.2^\circ$   
(Iljinski, 1924)

See note p. 87.

d. of sat. sol.	Gms. per 100 gms. $H_2O$				Solid Phase
	$K_2CO_3$	$KClO_3$	$Na_2CO_3$	$NaClO_3$	
--	0.0	1.5	22.0	68.9	$NaClO_3 + Na_2CO_3 \cdot 7H_2O$
--	0.0	2.6	22.2	66.9	" + $KClO_3$
1.383	0.0	0.0	24.6	46.2	$Na_2CO_3 \cdot 10H_2O + Na_2CO_3 \cdot 7H_2O$
--	0.0	2.5	24.5	45.0	" + $KClO_3$
1.398	27.7	0.7	33.6	0.0	" + $Na_2CO_3 \cdot K_2CO_3 \cdot 6H_2O + KClO_3$
1.516	89.9	0.6	7.7	0.0	$K_2CO_3 \cdot 2H_2O + Na_2CO_3 \cdot K_2CO_3 \cdot 6H_2O + KClO_3$
CO 1.510	90.7	0.5	6.7	0.0	" + $KClO_3$
1.530	92.8	0.4	6.0	0.0	" + "
1.528	100.7	0.8	1.3	0.0	" + "
1.552	111.6	0.3	0.0	0.0	" + "
--	0.0	2.6	22.2	66.9	$NaClO_3$ + " + $Na_2CO_3 \cdot 7H_2O$
1.442	0.0	5.1	6.6	88.2	" + "
1.389	0.0	5.9	3.8	90.6	" + "
1.443	0.0	5.1	1.5	95.7	" + "
1.450	0.0	4.6	1.4	96.0	" + "
1.432	0.0	4.2	0.0	96.6	" + "
--	0.0	2.5	24.5	45.0	$Na_2CO_3 \cdot 10H_2O + KClO_3 + Na_2CO_3 \cdot 7H_2O$
1.332	0.0	3.2	26.0	29.1	" + "
--	0.0	7.2	30.7	0.0	" + "
1.398	27.7	0.7	33.6	0.0	" + " + $Na_2CO_3 \cdot K_2CO_3 \cdot 6H_2O$
1.433	54.1	0.6	15.2	0.0	" + "
1.516	89.9	0.6	7.7	0.0	$K_2CO_3 \cdot 2H_2O$ + " + "
--	0.0	2.6	22.2	66.9	$NaClO_3$ + " + $Na_2CO_3 \cdot 7H_2O$
--	0.0	2.5	24.5	45.0	$Na_2CO_3 \cdot 10H_2O$ + " + "

## THE SYSTEM $K_2CO_3 - KNO_3 - H_2O$

100 gms.  $H_2O$  dissolve 10.76 gms.  $K_2CO_3$  + 2.66 gms.  $KNO_3$  at  $10^\circ$  when both salts are present in excess.  
(Kremann and Zitek, 1909)

Data for aqueous solutions of  $K_2CO_3 + KNO_3 + Na_2CO_3 + NaNO_3$ , simultaneously saturated with two or more of the salts at  $10^\circ$  and at  $25^\circ$ , are also given by Kremann and Zitek (1909).

## THE SYSTEM POTASSIUM CARBONATE - LITHIUM CARBONATE - WATER AT $25^\circ$ (Urazov and Lifatova, 1944)

The data are also given in mole % and moles per 100 gms. of  $H_2O$ .

Gms. $Li_2CO_3$ per 100 gms. Sat. Sol.	Gms. $K_2CO_3$ per 100 gms. Sat. sol.	Solid Phase
0.0	52.97	$K_2CO_3 \cdot 2H_2O$
0.276		"
0.378	52.93	"
0.403	51.73	"
0.476	52.85	"
0.553	52.71	$Li_2CO_3 + K_2CO_3 \cdot 2H_2O$

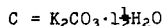
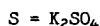
(Cont.)

Gms. $\text{Li}_2\text{CO}_3$ per 100 gms. Sat. Sol.	Gms. $\text{K}_2\text{CO}_3$ per 100 gms. Sat. Sol.	Solid Phase
0.810	39.57	$\text{Li}_2\text{CO}_3$
0.913	34.06	"
0.879	29.69	"
1.068	19.62	"
1.123	10.96	"
1.239	0.0	"

Data for the system  $\text{K}_2\text{CO}_3\text{-KMnO}_4\text{-H}_2\text{O}$  at 25° are given by Filippco and Voskresenskaya, 1940.

## THE SYSTEM POTASSIUM CARBONATE - POTASSIUM SULFATE - WATER

CO



Density Sat. Sol.	Sat. Sol. Wt. %		Solid Phase	Density Sat. Sol.	Sat. Sol. Wt. %		Solid Phase
	$\text{K}_2\text{SO}_4$	$\text{K}_2\text{CO}_3$			$\text{K}_2\text{SO}_4$	$\text{K}_2\text{CO}_3$	

Results at 25°  
(Hill and Moskowitz, 1929)

1.083	10.7	0.0	S	1.348	0.3	35.0	S
1.103	6.5	5.5	S	1.465	0.08	45.1	S
1.122	4.9	9.4	S	1.506	0.03	48.0	S
1.170	2.8	16.4	S	1.557	0.03	52.8	S + C
1.230	1.5	23.2	S	1.557	0.0	52.8	C

Results at 50°  
(Luzhnaya and Kosyachkova, 1954)

1.1145	14.25	0.0	S	1.4712	0.50	44.94	S
1.1863	6.74	11.12	S	1.5900	0.08	54.12	S + C
1.2192	4.50	16.70	S	1.5908	0.08	54.09	S + C
1.2516	2.96	21.09	S	--	0.06	54.21	C
1.2790	2.50	23.90	S	1.5925	0.03	54.52	C
1.4116	1.08	39.40	S	1.5938	0.0	54.82	C

Results at 150°  
(Itkina and Kokhova, 1955)

--	21.8	0.0	S	--	0.2	62.9	S
--	9.6	18.6	S	--	0.2	68.6	S + C
--	3.4	32.5	S	--	0.0	70.7	C

## THE SYSTEM POTASSIUM CARBONATE - SODIUM CARBONATE - WATER

The system has been studied in considerable detail. Earlier workers (Kreman and Zitek, 1909; Osaka, 1910-11; Iljinsky, 1924; Bain, 1927) report the formation of a hydrated double carbonate of potassium and sodium. The later very careful determinations of Hill and Miller, Jr., 1927, show that at no temperature between 20° and 50° is a hydrated double carbonate formed, but that the material which exists in contact with the saturated solutions is a hydrated solid solution, the composition of which can vary over a considerable range. Due to the slowness with which equilibrium



# K KALIUM

is reached, in all cases in which solid solution is formed, the authors found it necessary to prepare the mixtures in a special manner which would reduce the length of time required for attainment of the internal equilibrium of the solid solution or anhydrous double compound. The saturated solutions were analyzed by evaporation to dryness and estimation of the  $H_2O$  by loss in weight. The total carbonates were determined by titration and from this result and the known weight of the mixed carbonates the percentage of each was calculated. The results are re-recorded in percentage of  $H_2O$  and  $Na_2CO_3$ . In the following table the  $K_2CO_3$  values have been obtained by subtracting the sum of  $H_2O + Na_2SO_4$  from 100. Results for the quintuple points are also given.

The data at  $-6^\circ$  and  $+10^\circ$  are from Iljinsky, 1924; those at  $40^\circ$  are from Bain, 1927. Bain determined combined potassium and sodium by weighing as chlorides. The potassium was determined as perchlorate. CO The existence of  $Na_2CO_3 \cdot 3H_2O$  was demonstrated and its transition point to  $Na_2CO_3 \cdot H_2O$  found to be  $39.8^\circ$ .

Above  $100^\circ$ , the data of Ervin, Giorgi and McCarthy, 1944 and Ravich, Itkina and Kokhova, 1954 are in excellent agreement. The earlier work of Makarov and Shulgina, which seemed to indicate the disappearance of the anhydrous double salt with increasing temperature, is incorrect. R. I. and K. found both  $Na_2CO_3 \cdot H_2O$  and  $Na_2CO_3$  stable at  $100^\circ$ .

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	K <sub>2</sub> CO <sub>3</sub>	Na <sub>2</sub> CO <sub>3</sub>			K <sub>2</sub> CO <sub>3</sub>	Na <sub>2</sub> CO <sub>3</sub>	
Results at -6° (I)				Results at 25° (H. and M.)			
--	45.8	0.0	K·x	--	52.8	0.0	K·1½
--	33.6	4.3	" + KN·24	1.561	51.5	2.8	"
--	26.3	4.6	KN·24	1.555	48.4	5.0	" + S
--	18.5	8.5	" + N·10	1.551	47.5	4.9	S
Results at +10° (I)				1.552	45.7	5.3	"
--	52.0	0.0	K·2	--	39.4	6.4	"
--	49.9	2.9	KN·6	1.471	37.1	7.2	"
--	31.1	6.7	"	1.471	29.5	11.6	"
--	23.1	11.5	N·10	1.471	26.5	13.6	"
--	0.0	10.7	N·10	1.406	26.2	13.7	"
Results at 20° (H. and M.)				1.404	21.0	17.9	"
--	52.6	0.0	K·1½	1.399	16.4	22.1	"
--	49.9	3.0	" + S	1.395	15.8	22.7	" + N·7
1.545	49.0	3.6	S	--	14.1	23.2	N·7
1.541	48.2	3.6	"	1.404	12.6	23.3	"
1.417	43.6	7.6	"	1.368	12.5	23.3	" + N·10
1.373	17.4	19.0	"	1.368	10.1	24.3*	N·7
1.375	15.3	21.1*	"	1.369	9.3	24.3*	"
1.372	13.9	22.5*	"	1.335	4.4	26.1*	"
1.371	17.2	19.2	" + N·10	1.317	10.8	22.9	N·10
1.352	16.0	18.7	N·10	--	6.1	22.0	"
--	0.0	17.8	"	1.263	2.6	22.4	"
				--	0.0	22.5	" (Cont.)

K·x =  $K_2CO_3 \cdot xH_2O$ ; KN·24 =  $K_2CO_3 \cdot Na_2CO_3 \cdot 24H_2O$ ; K·2 =  $K_2CO_3 \cdot 2H_2O$ ;  
 $K \cdot \frac{1}{2}$  =  $K_2CO_3 \cdot \frac{1}{2}H_2O$ ; S = Solid Solution ( $Na_2 \cdot K_2$ ) $CO_3 \cdot 6H_2O$ , the mol.  
 ratio  $K_2CO_3 : Na_2CO_3$  varies from 1:0.88 to 1:2.07; N·10 =  $Na_2CO_3 \cdot 10H_2O$ ;  
 N·7 =  $Na_2CO_3 \cdot 7H_2O$ ; N·3 =  $Na_2CO_3 \cdot 3H_2O$ ; N·1 =  $Na_2CO_3 \cdot H_2O$ ; N =  $Na_2CO_3$ ;  
 KN =  $K_2CO_3 \cdot Na_2CO_3$ ; KN·6 =  $K_2CO_3 \cdot Na_2CO_3 \cdot 6H_2O$ . \*metastable

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	K <sub>2</sub> CO <sub>3</sub>	Na <sub>2</sub> CO <sub>3</sub>			K <sub>2</sub> CO <sub>3</sub>	Na <sub>2</sub> CO <sub>3</sub>	
Results at 30° (H. and M.)				Results at 36° (H. and M.)-Cont.			
--	53.2	0.0	K·1½	1.532	45.4	7.2	KN + N·1
1.561	50.2	3.5	"	1.503	39.5	9.6	N·1
1.561	49.9	4.0	" + KN	1.461	32.4	12.9	"
1.554	49.0	4.7	KN	1.421	23.4	18.2	"
1.558	48.0	5.4	"	1.392	17.6	21.5	"
1.553	47.9	5.3	"	--	0.0	33.2	"
1.551	46.2	6.6	"				
1.547	45.8	6.8	" + N·1	Results at 40° (Bain)			
1.545	45.1	7.3	N·1				
1.543	44.85	7.3	N·1 + S	--	53.9	0.0	K·1½
1.530	44.1	7.3	S	1.582	51.9	2.7	"
1.451	33.4	11.1	"	1.581	50.7	3.8	" + KN
1.422	23.0	18.5	"	1.586	48.1	5.6	KN
1.419	22.1	19.1	" + N·1	1.563	45.8	6.8	"
1.414	21.2	19.6	N·1	1.562	44.4	7.2	" + N·1
1.398	16.2	22.6	"	1.550	42.8	7.2	N·1
1.390	13.5	24.5	"	1.508	37.1	9.5	"
1.378	10.2	26.6	" + N·7	1.496	31.1	13.6	"
1.354	6.7	27.8	N·7	1.451	27.1	15.5	"
1.330	4.0	28.6	" + N·10	1.424	24.3	16.7	"
--	0.0	28.0	N·10	1.447	21.6	17.8	"
Results at 33° (H. and M.)				1.387	12.9	24.0	" + N·3
--	53.2	0.0	K·1½	1.374	9.1	26.6*	N·1
--	49.8	4.3	" + KN	1.366	6.2	28.5*	"
1.555	47.5	5.7	KN	1.341	12.2	21.6	N·3
--	45.1	6.7	" + N·1	1.441	8.4	19.0	"
1.510	40.7	8.9	N·1	1.290	7.4	21.6	"
1.498	38.0	10.0	"	1.291	6.6	22.5	"
1.479	37.0	10.6	" + S	1.272	4.8	22.1	"
1.454	35.5	11.5	S	1.292	3.7	25.8	"
1.455	34.2	12.0	"	1.328	2.3	30.0	"
1.454	32.9	12.8	" + N·1	1.326	1.8	31.1	"
1.457	30.6	14.0	N·1	--	0.0	32.8	"
1.440	27.8	15.6	"	Results at 50° (H. and M.)			
1.377	13.8	24.0	"	--	54.8	0.0	K·1½
1.354	4.7	29.9	" + N·7	1.574	52.3	3.3	" + KN
--	0.0	31.6	N·7	1.530	44.5	8.0	KN + N·1
Results at 36° (H. and M.)				1.523	42.6	8.5	N·1
--	53.6	0.0	K·1½	--	0.0	32.2	"
--	50.9	3.5	"	Results at 100° (R. I. and K.)			
1.545	50.4	4.0	" + KN	--	61.2	0.0	K·1½
1.552	48.7	4.9	KN	--	59.9	1.7	"
--	46.5	5.7	"	--	59.3	1.9	" + KN

K·x = K<sub>2</sub>CO<sub>3</sub>·xH<sub>2</sub>O; KN·24 = K<sub>2</sub>CO<sub>3</sub>·Na<sub>2</sub>CO<sub>3</sub>·24H<sub>2</sub>O; K·2 = K<sub>2</sub>CO<sub>3</sub>·2H<sub>2</sub>O;  
 K·1½ = K<sub>2</sub>CO<sub>3</sub>·1½H<sub>2</sub>O; S = Solid Solution (Na<sub>2</sub>·K<sub>2</sub>)CO<sub>3</sub>·6H<sub>2</sub>O, the mol.  
 ratio K<sub>2</sub>CO<sub>3</sub>:Na<sub>2</sub>CO<sub>3</sub> varies from 1:0.88 to 1:2.07; N·10 = Na<sub>2</sub>CO<sub>3</sub>·10H<sub>2</sub>O;  
 N·7 = Na<sub>2</sub>CO<sub>3</sub>·7H<sub>2</sub>O; N·3 = Na<sub>2</sub>CO<sub>3</sub>·3H<sub>2</sub>O; N·1 = Na<sub>2</sub>CO<sub>3</sub>·H<sub>2</sub>O; N = Na<sub>2</sub>CO<sub>3</sub>;  
 KN = K<sub>2</sub>CO<sub>3</sub>·Na<sub>2</sub>CO<sub>3</sub>; KN·6 = K<sub>2</sub>CO<sub>3</sub>·Na<sub>2</sub>CO<sub>3</sub>·6H<sub>2</sub>O. \*metastable

# K KALIUM

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	
	K <sub>2</sub> CO <sub>3</sub>	Na <sub>2</sub> CO <sub>3</sub>			K <sub>2</sub> CO <sub>3</sub>	Na <sub>2</sub> CO <sub>3</sub>		
Results at 100° (R.I. and K.)-Cont. (E.G. and M.)†				Results at 150° (E.G. and M.) (R.I. and K.)†				
CO	--	(59.2)	(1.5)†	K·1½ + KN	--	71.0	0.0	K·1½
	--	53.9	3.8	KN	--	68.2	1.0	"
	--	51.3	4.7	"	--	67.5	1.8	" + KN
	--	51.2	4.9	"	--	(67.5)	(1.6)†	" + "
	--	50.5	5.2	"	--	64.4	1.6	KN
	--	46.6	7.3	"	--	63.3	2.0	"
	--	45.4	8.2	"	--	58.7	2.7	"
	--	44.9	8.8	KN + N	--	55.0	4.2	"
	--	(44.0)	(8.6)†	" + "	--	52.7	5.7	"
	--	44.1	9.1	N	--	50.2	6.6	"
	--	38.0	11.2	"	--	47.5	8.4	"
	--	37.1	12.0	"	--	46.4	8.6	KN + Na
	--	36.4	12.0	"	--	(47.0)	(8.8)†	" + "
	--	31.9	14.1	"	--	44.3	9.2	Na
	--	25.6	16.7	N + N·1	--	29.6	14.8	"
	--	22.4	19.0	N·1	--	16.1	20.1	"
	--	21.8	19.4	"	--	00.0	27.7	"
	--	18.8	20.4	"				
	--	13.4	23.7	"				
	--	0.0	30.9	"				

K·x = K<sub>2</sub>CO<sub>3</sub>·xH<sub>2</sub>O; KN·24 = K<sub>2</sub>CO<sub>3</sub>·Na<sub>2</sub>CO<sub>3</sub>·24H<sub>2</sub>O; K·2 = K<sub>2</sub>CO<sub>3</sub>·2H<sub>2</sub>O;  
 K·1½ = K<sub>2</sub>CO<sub>3</sub>·1½H<sub>2</sub>O; S = Solid Solution (Na<sub>2</sub>·K<sub>2</sub>)CO<sub>3</sub>·6H<sub>2</sub>O, the mol.  
 ratio K<sub>2</sub>CO<sub>3</sub>:Na<sub>2</sub>CO<sub>3</sub> varies from 1:0.88 to 1:2.07; N·10 = Na<sub>2</sub>CO<sub>3</sub>·10H<sub>2</sub>O;  
 N·7 = Na<sub>2</sub>CO<sub>3</sub>·7H<sub>2</sub>O; N·3 = Na<sub>2</sub>CO<sub>3</sub>·3H<sub>2</sub>O; N·1 = Na<sub>2</sub>CO<sub>3</sub>·H<sub>2</sub>O; N = Na<sub>2</sub>CO<sub>3</sub>;  
 KN = K<sub>2</sub>CO<sub>3</sub>·Na<sub>2</sub>CO<sub>3</sub>; KN·6 = K<sub>2</sub>CO<sub>3</sub>·Na<sub>2</sub>CO<sub>3</sub>·6H<sub>2</sub>O.

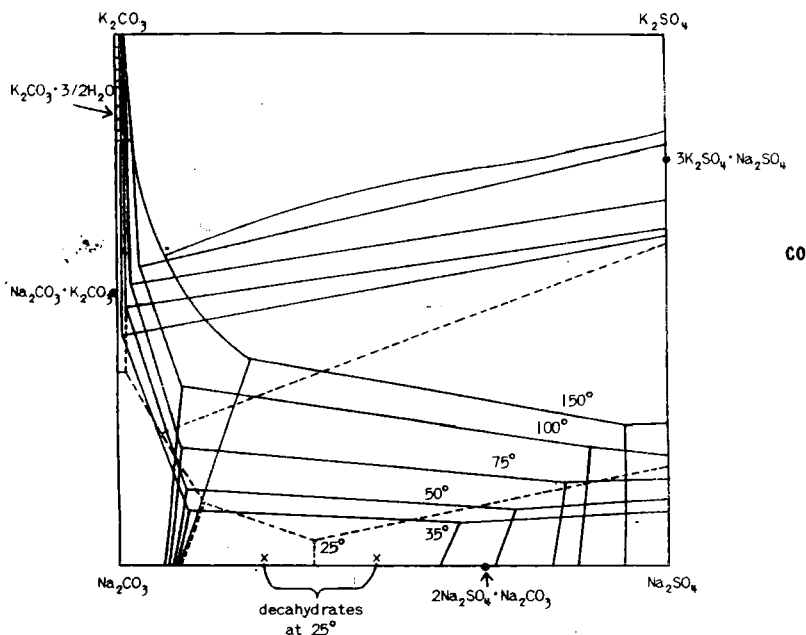
THE RECIPROCAL SYSTEM K<sub>2</sub>CO<sub>3</sub> + Na<sub>2</sub>SO<sub>4</sub> ⇌ K<sub>2</sub>SO<sub>4</sub> + Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O

The results are summarized in the diagram on p. 93.

25° - Blasdale, 1923; 35°, 50°, 75° - Teeple, 1929; 100° - Boryachek, Drozin, Zubakhina and Kutsyna, 1955; 150° - Itkina and Kokhova, 1956.  
 The data at room temperature are given in the following table.

Gms. per 100 gms. H <sub>2</sub> O				Solid Phase
K <sub>2</sub> CO <sub>3</sub>	Na <sub>2</sub> CO <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	
0.0	27.44	0.0	24.06	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
0.0	0.0	9.34	30.98	K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub> + "
0.0	0.0	13.31	6.86	" + K <sub>2</sub> SO <sub>4</sub>
3.58	26.09	0.0	25.46	" + Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
7.37	33.74	6.30	0.0	" + " + K <sub>2</sub> SO <sub>4</sub>
18.50	35.63	1.45	0.0	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O + " + "
27.07	35.35	0.0	1.01	" + KNaCO <sub>3</sub> ·6H <sub>2</sub> O + "
103.72	10.83	1.36	0.0	K <sub>2</sub> CO <sub>3</sub> ·3/2H <sub>2</sub> O + " + "
35.71	27.38	0.97	0.0	KNaCO <sub>3</sub> ·6H <sub>2</sub> O + K <sub>2</sub> SO <sub>4</sub>
0.0	41.65	9.40	3.31	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O + K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub>

## DIAGRAM OF RECIPROCAL SYSTEM



Data for equilibrium in the system,  $K_2CO_3 + 2NaHCO_3 \rightleftharpoons 2KHCO_3 + Na_2CO_3$  in water at 25°, are given by Hill and Smith, 1929.

The authors first give the previously determined data for the four 3 component systems;  $K_2CO_3 + Na_2CO_3 + H_2O$ ,  $K_2CO_3 + KHCO_3 + H_2O$ ,  $KHCO_3 + NaHCO_3 + H_2O$  and  $Na_2CO_3 + NaHCO_3 + H_2O$ , calculated to gram mols. per 1000 gm. mols.  $H_2O$ . They then report their results for saturated solutions each composed of water and three of the above four compounds and in contact with two or three of the several solid phases which exist at 25°. The results show the location of 14 curves representing the solubility equilibrium existing with two solid phases, and of seven isothermal invariant points at which the solution is in equilibrium with 3 solid phases. A new tetragene salt was found, having the formula  $K_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$  and not occurring in any of the 3 component systems.

In a later paper Hill, 1930 gives results for double salt formation among the carbonates and bicarbonates of potassium and sodium at 25° and at 35°. The partial isotherms show that the double salt  $K_2CO_3 \cdot 2KHCO_3 \cdot 1\frac{1}{2}H_2O$  and the tetragene salt  $K_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$  both exist at these two temperatures.

# K KALIUM

THE SYSTEM  $K_2CO_3 + 2NaCl \rightleftharpoons 2KCl + Na_2CO_3 + H_2O$  AT 25°  
(Blasdale, 1923; See Teeple, 1929 for data at 35°, 50°, 75°)

Gms. per 100 gms. H <sub>2</sub> O					Solid Phase
K <sub>2</sub> CO <sub>3</sub>	K <sub>2</sub> Cl <sub>3</sub>	Na <sub>2</sub> CO <sub>3</sub>	Na <sub>2</sub> Cl <sub>3</sub>		
113.57	0.0	0.0	0.0		K <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O
104.18	0.0	10.89	0.0		" + NaKCO <sub>3</sub> ·6H <sub>2</sub> O
30.48	0.0	35.57	0.0		Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O + "
18.96	0.0	35.63	0.0		" + Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O
0.0	0.0	25.67	23.51		NaCl + "
0.0	16.29	0.0	29.88		" + KCl
110.68	2.07	0.0	0.0		K <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O + "
0.0	13.78	27.45	15.81		Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O + " + NaCl
CO 25.79	0.0	27.04	10.59		" + " + Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O
29.78	0.0	27.86	8.55		NaKCO <sub>3</sub> ·6H <sub>2</sub> O + " + "
102.50	1.83	11.02	0.0		" + " + K <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O
36.29	0.0	27.82	0.0		"
33.64	9.78	25.79	0.0		" + KCl
0.0	22.08	38.65	0.0		Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O + "

Data for the aqueous system  $KCl + NaCl + Na_2SO_4 + K_2SO_4 + Na_2CO_3 + K_2CO_3$  at 20°, 35°, 50°, 75°, 100° are given by Teeple, 1929.

Data for equilibrium in the system composed of  $K_2CO_3 + PbCrO_4 \rightleftharpoons K_2CrO_4 + PbCO_3 (+ H_2O)$  at 25° are given by Goldblum and Stoffella, 1910.

Data for the reciprocal salt pair  $K_2CO_3 + BaSO_4 \rightleftharpoons K_2SO_4 + BaCO_3$  at 25°, 80° and 100° are given by Meyerhoffer (1905). An aqueous solution, simultaneously saturated with  $K_2CO_3 \cdot 2H_2O$ ,  $K_2SO_4$  and  $BaCO_3$ , contains 53.1 gms.  $K_2CO_3 + 0.023$  gm.  $K_2SO_4$  at 25°.

## THE SYSTEM POTASSIUM CARBONATE - METHYL ALCOHOL - WATER AT 23°-26° (Frankforter and Frary, 1913)

The authors give the data for the binodal curve and the quadruple points, but tie lines, other than for the quadruple points, were not determined.

Gms. per 100 Gms. Homogeneous Liquid			Gms. per 100 Gms. Homogeneous Liquid		
K <sub>2</sub> CO <sub>3</sub>	CH <sub>3</sub> OH	H <sub>2</sub> O	K <sub>2</sub> CO <sub>3</sub>	CH <sub>3</sub> OH	H <sub>2</sub> O
6.32	75.85	17.83*	21.61	33.43	44.96
6.91	63.13	29.97	23.15	31.26	45.60
8.07	59.26	32.67	28.25	23.82	47.94
10.17	52.64	35.33	30.72	20.57	48.71
12.03	49.97	37.99	32.92	17.27	49.80
14.24	45.74	40.02	40.65	9.26	50.09
16.48	41.76	41.76	43.95	6.96	49.09
18.89	37.76	43.36	45.89	6.42	47.69
			49.05	6.10	44.88†

\*Upper quad. point.

†Lower quad. point.

(Cont.)

The following results for the solubility of  $K_2CO_3$  in concentrations of aq.  $CH_3OH$  above and below those yielding liquid layers are also given.

Gms. per 100 Gms. Sat. Sol.		Gms. per 100 Gms. Sat. Sol.	
$CH_3OH$	$K_2CO_3$	$CH_3OH$	$K_2CO_3$
1.03	51.39	85.0	2.05
2.22	50.33	89.2	11.56
6.1	49.05 (Lower quad. pt.)	91.0	1.98
Two Liquid Layers Formed Here.		93.6	2.72
75.85	6.32 (Upper quad. pt.)	94.3	5.70 (Abs. $CH_3OH$ )

Data for the binodal curves for this system at 17° and at 35° are given by de Bruyn (1900).

CO

COMPOSITION OF CONJUGATE LIQUIDS IN EQUILIBRIUM WITH  $K_2CO_3$   
AT VARIOUS TEMPERATURES  
(de Bruyn, 1900)

t°	Gms. per 100 Gms. Upper Layer			Gms. per 100 Gms. Lower Layer		
	$K_2CO_3$	$CH_3OH$	$H_2O$	$K_2CO_3$	$CH_3OH$	$H_2O$
-30	21.7	42.2	36.1	--	--	--
-20	13.8	52.1	34.1	--	--	--
-20	12.4	--	--	44.2	8.2	47.6
0	7.6	66.3	26.1	46.3	6.7	47.0
0	7.4	--	--	46.6	6.6	46.8
+17	6.2	69.6	24.2	48.3	5.7	46.0
35	5.0	72.9	22.1	51.0	4.3	44.7

THE SYSTEM POTASSIUM CARBONATE - ETHYL ALCOHOL - WATER AT 23°-26°  
(Frankforter and Frary, 1913; Koblyanski, 1936)

NOTE.--The binodal curve for the system was very carefully determined and tie lines were located by estimations of  $K_2CO_3$  in specially prepared conjugated liquids. The original results have been plotted and the following data for the conjugated layers read from the curve:

Alcohol Rich Layer (Upper)			Water Rich Layer (Lower)		
Gms. per 100 Gms. Solution			Gms. per 100 Gms. Solution		
$K_2CO_3$	$C_2H_5OH$	$H_2O$	$K_2CO_3$	$C_2H_5$	$H_2O$
0.095	90.65	9.255†	53.6	0.28	46.12†
0.241	72.7	27.059	39.11	1.0	59.89
1.72	53.5	44.78	29.62	4.0	66.38
4.03	42.6	53.37	25.7	6.4	67.90
6.30	35.5	58.20	21.08	11.0	67.92
8.29	31.0	60.71	19.15	13.2	67.65
10.35	27.0	62.65	18.18	14.7	67.12
14.2	20.5	65.3	14.2	20.5	65.3*

\*Plait point.

†Quad. point.

The authors give a complete summary of previous investigations of this system by de Bruyn (1899, 1900); Bell (1905); Cuno (1908-09).

(Cont.)

# K KALIUM

RESULTS OF NIKOL'SKAYA, 1946 AT 25°  
(Results at 50° and 75° are nearly the same)

Lower Layer Wt. %		Upper Layer Wt. %	
Ethanol	K <sub>2</sub> CO <sub>3</sub>	Ethanol	K <sub>2</sub> CO <sub>3</sub>
15.23	17.73	27.70	10.07
5.60	26.80	47.87	2.86
1.13	39.90	72.81	0.53
0.29	52.80	90.50	0.17

COMPOSITION OF THE CONJUGATED LIQUIDS IN EQUILIBRIUM WITH  
SOLID POTASSIUM CARBONATE (QUADRUPLE POINTS) AT VARIOUS TEMPERATURES  
CO (de Bruyn, 1900) (See Cuno, 1908 for 20, 40, 60°)

t°	Gms. per 100 Gms. Upper Layer			Gms. per 100 Gms. Lower Layer		
	K <sub>2</sub> CO <sub>3</sub>	C <sub>2</sub> H <sub>5</sub> OH	H <sub>2</sub> O	K <sub>2</sub> CO <sub>3</sub>	C <sub>2</sub> H <sub>5</sub> CH	H <sub>2</sub> O
-18	0.03	90.3	9.7	51.2	0.2	48.6
0	0.04	91.9	8.1	51.3	0.2	48.5
+17	0.06	91.5	8.4	52.1	0.2	47.7
35	0.07	90.9	9.0	53.4	0.2	46.4
50	0.09	91.8	8.1	55.3	0.2	44.5
75	0.12	91.4	8.5	57.9	0.2	41.9

THE SYSTEM POTASSIUM CARBONATE - NORMAL PROPYL  
ALCOHOL - WATER AT 22°-26°  
(Frankforter and Frary, 1913)

The authors give the data for the binodal curve and the quadruple points but tie lines were not located.

Gms. per 100 Gms. Homogeneous Liquid			Gms. per 100 Gms. Homogeneous Liquid		
K <sub>2</sub> CO <sub>3</sub>	C <sub>3</sub> H <sub>7</sub> OH	H <sub>2</sub> O	K <sub>2</sub> CO <sub>3</sub>	C <sub>3</sub> H <sub>7</sub> OH	H <sub>2</sub> O
52.90	0.02	47.08*	7.45	9.30	83.25
46.98	0.12	52.91	5.97	11.07	82.96
39.00	0.20	60.80	4.73	12.71	82.56
34.58	0.20	65.15	3.86	14.60	81.54
30.43	0.45	69.12	3.11	17.17	79.71
26.51	0.78	72.71	2.42	24.71	72.87
22.81	1.32	75.87	1.91	34.90	63.19
19.08	2.31	78.62	1.71	39.00	59.29
16.35	3.24	80.41	1.33	45.57	53.09
13.47	4.41	82.12	0.948	51.56	47.49
10.99	6.24	82.77	0.387	64.20	35.41
8.55	8.31	83.14	0.017	95.83	4.153†

\*Lower quad. point.

†Upper quad. point.

## THE SYSTEM POTASSIUM CARBONATE - ISOPROPYL ALCOHOL - WATER

Results at 20°  
(Frankforter and Temple, 1915)

Gms. per 100 Gms. Solvent (Alcohol + Water)			Gms. per 100 Gms. Solvent (Alcohol + Water)		
K <sub>2</sub> CO <sub>3</sub>	Alcohol	Water	K <sub>2</sub> CO <sub>3</sub>	Alcohol	Water
44.844	2.911	97.089	15.021	19.445	80.555
36.137	4.783	95.217	13.244	23.919	76.081
28.879	7.349	92.651	6.065	45.397	54.603
24.152	9.159	90.841	3.933	53.265	46.735
17.665	14.395	85.605	2.954	57.294	42.706

Results at 25°  
(Ginnings and Chen, 1931)

CO

The binodal curve, a tie line and the plait point were carefully determined.

Gms. per 100 gms. of the three constituents		Gms. per 100 gms. of the three constituents	
K <sub>2</sub> CO <sub>3</sub>	CH <sub>3</sub> CHOHCH <sub>3</sub>	K <sub>2</sub> CO <sub>3</sub>	CH <sub>3</sub> CHOHCH <sub>3</sub>
0.10	69.60*	13.86	10.10
2.80	42.20	19.83	4.42
6.04	28.40	25.50	1.93
6.2	27.8 PP	33.20	0.65
9.65	17.25	52.67	0.23*

\*Tie line which shows the composition of each of two liquid layers in contact with each other. The one being the upper, rich in isopropyl alcohol and the other, the lower, rich in K<sub>2</sub>CO<sub>3</sub>.

PP is the plait point which shows the composition at that point on the binodal curve where the two layers merge into a homogeneous liquid.

THE SYSTEM POTASSIUM CARBONATE - TERTIARY BUTYL  
ALCOHOL - WATER AT 30°  
(Ginnings and Robbins, 1930)

The points on the binodal curve were determined by observing the appearance or disappearance of clouding in a mixture of weighed amounts of salt and one of the liquids, upon addition of a weighed amount of the other. The conjugated points were found by preparing mixtures which yielded two liquid layers and analyzing each for salt content. The plait point, P.P., was found by plotting. The following results are those given in the authors' table under the column heading K<sub>2</sub>SO<sub>4</sub> which was evidently intended for K<sub>2</sub>CO<sub>3</sub>.



## K KALIUM

THE SYSTEM POTASSIUM CARBONATE - TERTIARY BUTYL  
ALCOHOL - WATER AT 30°--Cont.

				Conjugation Point Data	
Gms. per 100 gms. $K_2CO_3 + (CH_3)_3COH + H_2O$		Gms. per 100 gms. $K_2CO_3 + (CH_3)_3COH + H_2O$		Wt. percent $(CH_3)_3COH$ in butanol rich phase	Wt. percent $K_2CO_3$ in salt rich phase
$K_2CO_3$	$(CH_3)_3COH$	$K_2CO_3$	$(CH_3)_3COH$		
0.7	57.8	9.8	9.1	69	34.2
1.8	39.3	11.4	7.5	62	24.4
3.1	26.9	13.3	5.9	53	14.8
4.8	18.9	15.4	4.5	27	3.2 P.P.*
5.1	17.7	17.0	3.5		
CO 5.8	16.1	26.7	0.9		
7.2	12.8	34.2	0.4		

\*In a later paper by Ginnings, Herring and Webb, 1933, the values given for the plait point, P.P., are respectively, 2.3 percent  $K_2CO_3$  and 36.3 percent  $(CH_3)_3COH$  instead of 3.2 and 27 as shown above.

THE SYSTEM POTASSIUM CARBONATE - ALLYL ALCOHOL - WATER AT 20°  
(Frankforter and Temple, 1915)

Gms. per 100 Gms. Solvent (Alcohol + Water)			Gms. per 100 Gms. Solvent (Alcohol + Water)		
$K_2CO_3$	Alcohol	Water	$K_2CO_3$	Alcohol	Water
47.746	2.103	97.897	8.239	30.677	69.323
33.200	5.267	94.733	5.521	39.337	60.663
23.486	9.309	90.691	2.020	54.487	45.513
16.354	15.037	84.963	1.015	62.610	37.390
11.331	22.454	77.546	0.0853	81.228	18.772

The binodal curve for this system at 25° has also been determined by Ginnings and Dees, 1935, but the authors do not give their experimental results but only a series of arbitrary constants calculated from them by means of an empirical equation. From these the conclusion is drawn that allyl alcohol seems to be more difficult to salt out than either iso propyl or normal propyl alcohol.

THE SYSTEM POTASSIUM CARBONATE - ACETONE - WATER AT 20°  
(Frankforter and Cohen, 1914)

The binodal curve was very carefully determined and, in addition, data for the quadruple points (solid  $K_2CO_3$ ) and give tie lines were located. These data were plotted and the following interpolated values for the conjugated liquids read from the curve.

Gms. per 100 Gms. Upper Layer			Gms. per 100 Gms. Lower Layer		
$K_2CO_3$	$(CH_3)_2CO$	$H_2O$	$K_2CO_3$	$(CH_3)_2CO$	$H_2O$
0.0024	96.4	3.5+†	52.4	trace	47.6†
0.039	64.0	35.96	32.63	1.2	66.17
0.712	55.3	43.99	24.4	3.7	71.9
1.36	48.5	50.15	22.91	4.7	72.39
4.57	34.0	61.43	16.92	10.2	72.88
6.97	27.5	65.53	14.77	13.0	72.23
10.5	20.0	69.5*	10.5	20.0	69.5

\*Plait point.

†Quad. points.

(Cont.)

Additional results for the binodal curve at 24\*-25°, agreeing satisfactorily with the above, are given by Leaming, 1925(?). This author mentions that the effect of temperature upon the results is slight.

The binodal curve and plait point of the system  $K_2CO_3$  + Pyridine +  $H_2O$  at 25° has been determined by Ginnings, Webb and Hinohara, 1933, but the authors do not give their experimental results but only the values of a series of constants calculated from them by means of empirical equations.

THE SYSTEM POTASSIUM CARBONATE - POTASSIUM DIPROPYL  
MALONATE - WATER AT 25°  
(M'David, 1909-10)

A series of mixtures of  $K_2CO_3$  +  $K_{11}H_{19}O_4$  +  $H_2O$  were prepared and thoroughly mixed. They were placed in a thermostat at 25° and the two layers which separated in each case were analyzed. CO

Gms. per 100 Gms. Upper Layer			Gms. per 100 Gms. Lower Layer		
$K_2CO_3$	$K_{11}H_{19}O_4$	$H_2O$	$K_2CO_3$	$K_{11}H_{19}O_4$	$H_2O$
4.05	65.1	30.85	42.6	0.4	57.0
4.9	59.8	35.3	40.7	0.4	58.9
5.6	53.5	40.9	35.0	0.5	64.5
7.2	50.5	42.3	33.5	0.9	65.6
8.7	39.2	52.1	28.9	0.7	70.4
11.0	34.6	54.4	26.8	0.8	72.4
14.5	23.5	62.0	24.8	3.0	72.2
17.0	18.6	64.4	23.1	6.05	70.85
18.6	15.0	66.4	21.7	8.7	69.6

Several determinations at 2° and at 56° are also given.

THE SYSTEM POTASSIUM CARBONATE - ETHYLENE GLYCOL - WATER  
(Kobe and Strong, 1940).

This system does not form 2 liquid layers.

At 25°

At 40°

Gms. per 100 Gms. Sat. Sol.		Gms. per 100 Gms. Sat. Sol.	
Ethylene Glycol	$K_2CO_3$	Ethylene Glycol	$K_2CO_3$
0.0	52.8	0.0	53.9
5.5	50.0	5.4	50.9
11.8	46.2	17.8	44.7
18.4	43.0	33.6	36.3
26.1	38.7	41.7	33.5
33.9	35.7	51.5	28.8
42.5	32.1	67.7	25.4
51.5	28.8	73.5	26.5
60.4	26.2		
68.2	24.8		
74.4	25.6		

# K KALIUM

## THE SYSTEM POTASSIUM CARBONATE - DIOXANE - WATER (Kobe and Strong, 1940)

Two liquid layers are formed.

	At 0°		At 25°		At 40°	
	Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
	Dioxane	K <sub>2</sub> CO <sub>3</sub>	Dioxane	K <sub>2</sub> CO <sub>3</sub>	Dioxane	K <sub>2</sub> CO <sub>3</sub>
CO	0.0	51.7	0.0	52.8	0.0	53.9
	0.56	40.64	0.9	39.0	1.0	39.7
	1.06	37.6	1.7	33.7	2.5	30.0
	2.1	32.0	3.7	27.5	4.1	25.3
	5.0	25.7	6.2	22.9	5.7	22.6
	8.8	21.0	10.9	17.6	9.1	19.0
	11.0	18.9	13.9	15.5	14.2	15.1
	16.5	14.5	22.5	10.8	22.6	10.6
	20.2	12.3	31.0	6.8	26.4	8.7
	23.3	10.6	41.12	3.22	32.67	5.96
	25.0	9.8	48.38	1.66	44.12	2.54
	27.9	8.3	58.44	0.31	58.44	0.31
	35.8	4.8	67.59	0.21	67.59	0.21
	100.0	0.0	100.0	0.0	100.0	0.0

## SOLUBILITY OF K<sub>2</sub>CO<sub>3</sub> IN AQ. GLYCEROL (Holm, 1921-22)

100 gms. Aq. 86.5% Glycerol (d = 1.2326) dissolve 40.5 gms. K<sub>2</sub>CO<sub>3</sub> at 20°.  
 " 98.5% " (d = 1.2645) " 39.4 " "

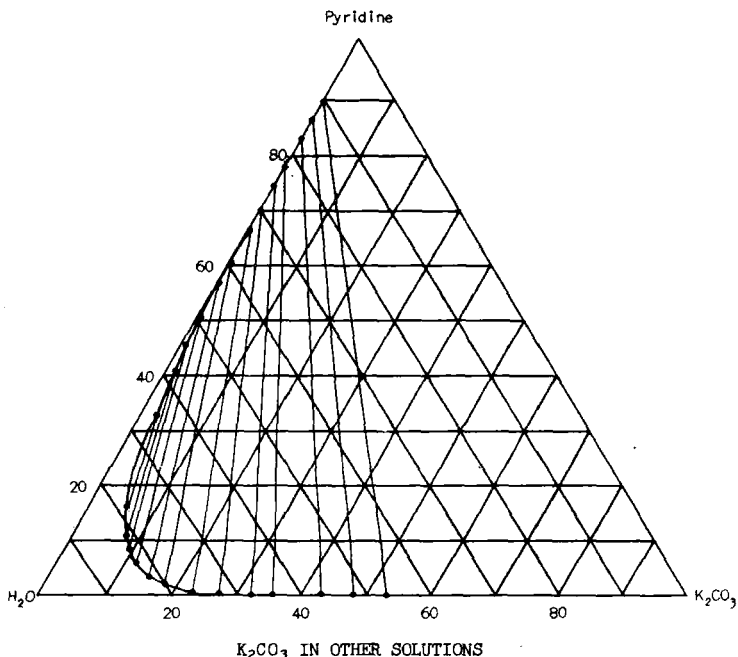
## THE SYSTEMS POTASSIUM CARBONATE - ALIPHATIC AMINES - WATER AT 30° (Arakawa and Kawaguchi, 1958; Arakawa, Kawaguchi and Kato, 1958)

The systems form two liquid layers. The data were read from graphs given by the authors.

Mole fraction of amine in upper layer (X 10 <sup>2</sup> )	Mole fraction K <sub>2</sub> CO <sub>3</sub> in lower layer (X 10 <sup>2</sup> )						
	Propyl Amine	Butyl Amine	Amyl Amine	Hexyl Amine	Heptyl Amine	Pyridine*	2-methyl- Pyridine
5	--	--	--	--	0.3	--	--
10	--	1.7	0.7	--	0.5	--	--
15	4.0	2.5	1.7	0.7	0.7	1.3	0.6
20	4.9	3.2	2.6	1.7	1.1	1.9	1.0
30	7.1	5.6	4.9	4.0	3.4	3.5	3.0
40	9.6	8.0	7.3	6.4	5.8	5.9	5.4
50	11.9	10.4	9.7	8.9	8.1	8.1	7.6
60	--	12.8	12.0	11.1	10.4	10.4	10.0
70	--	--	--	--	12.8	12.3	--

\*Diagram for the K<sub>2</sub>CO<sub>3</sub> - pyridine - water system. See page 101.

Diagram for the  $K_2CO_3$  - pyridine - water system.



Cl

100 cc. anhydrous hydrazine dissolve 1 gm.  $K_2CO_3$  at room temperature.  
(Welsh and Broderson, 1915)

100 gms. aqueous solution simultaneously sat. with  $K_2CO_3$  and cane sugar at  $31.25^\circ$  contain 22.24 gms.  $K_2CO_3$  and 56 gms. sugar. (Kohler, 1897)

Melting point data are given for:

$K_2CO_3 + KCl$  (Sackur, 1911-12)  
 " +  $2NaCl \rightleftharpoons 2KCl + Na_2CO_3$  (Sackur, 1911-12; Volkov and Bergman, 1942; Nyankovskaya, 1952)  
 " +  $K_2SO_4$  (LeChatelier, 1894; Amadori, 1912)  
 " +  $Na_2CO_3$  (LeChatelier, 1894; Makarov and Shulgina, 1940a)  
 " +  $Nb_2O_5$  (Reisman and Holtzberg, 1955)  
 " +  $V_2O_5$  (Holtzberg, Reisman, Berry and Berkenblit, 1956)  
 " +  $2NaOH \rightleftharpoons 2KOH + Na_2CO_3$  (Khitrov, 1954)  
 " +  $K_2CrO_4$  (Gromakov, 1951)  
 " +  $KI$  (Nyankovskaya, 1952, 1953)  
 " +  $2NaI \rightleftharpoons 2KI + Na_2CO_3$  (Nyankovskaya, 1952, 1953)  
 " +  $KF + K_2SO_4$  (Bergman and Rubleva, 1957)  
 " +  $2LiF \rightleftharpoons 2KF + Li_2CO_3$  (Volkov and Shvab, 1953)  
 " +  $NaF + Na_2SO_4$  (Bergman and Rubleva, 1957a)  
 " +  $NaF + K_2SO_4$  (Bergman and Rubleva, 1957a)  
 $K^+, Na^+ \parallel F^-, SO_4^{2-}, CO_3^{2-}$  (Bergman and Rubleva, 1957a)  
 $K_2CO_3 + 2NaF \rightleftharpoons 2KF + Na_2CO_3$  (Volkov and Bergman, 1942)  
 $K_2CO_3 + K_2SO_4 + NaCl$  (Bergman and Sementsova, 1958)

# K KALIUM

## CO POTASSIUM MAGNESIUM CARBONATE $K_2Mg(CO_3)_2 \cdot 4H_2O$

SOLUBILITY IN AQUEOUS KCl SOLUTIONS AT 17°  
(Halla, 1936)

Gm. Mols. per 1000 gms. H <sub>2</sub> O		Solid Phase
KCl	$K_2Mg(CO_3)_2$	
0.274	0.0381	$K_2Mg(CO_3)_2 \cdot 4H_2O$
0.790	0.0352	"
1.490	0.0268	"
2.365	0.0191	"
3.38	0.0139	"

## POTASSIUM URANYL CARBONATE $2K_2CO_3 \cdot (UO_2)CO_3$

100 gms. H<sub>2</sub>O dissolve 7.4 gms. salt at 15°. (Ebelmen, 1852)

This salt is only about 1/50 as soluble as the La and Ce uranyl carbonates.  
(Yakolov and Gorbenko-Germanov, 1956)

## HCO POTASSIUM BICARBONATE $KHCO_3$

SOLUBILITY OF POTASSIUM BICARBONATE IN WATER

(Diblets, 1874; Engel, 1888; Greenish and Smith, 1901; de Forcrand, 1909; Foerster, Brosche and Norberg-Schulz, 1924; Hill and Hill, 1927; Oglesby, 1929; Hill, 1930(a); Starkowa, 1931 and Paris and Mondain-Monval, 1938; Luzbnaya and Kosyachkova, 1955)

The results of the above named investigators varied very slightly from the smoothed curve from which the following values were read.

t°	d. of sat. sol.	Gms. $KHCO_3$ per 100 gms. sat. sol.	Solid Phase
- 0.70	--	2.17	Ice
- 2.16	--	5.77	"
- 3.21	--	9.98	"
- 3.90	--	12.60	"
- 5.43 Eutec.	--	16.95	" + $KHCO_3$
0	1.130	18.6	$KHCO_3$
+10	1.154	21.8	"
20	1.178	25.0	"
25	1.188	26.6	"
30	1.199	28.1	"
40	1.217	31.3	"
50	--	34.2	"
60	--	37.5	"
70	--	40.6	"

The following results of Takahashi, 1927 were obtained under 1 atm. pressure of CO<sub>2</sub> and differ only slightly from the averages above.

t°	d. of sat. sol.	Gms. $KHCO_3$ per 100 gms. sat. sol.	t°	d. of sat. sol.	Gms. $KHCO_3$ per 100 gms. sat. sol.
0	1.1329	18.41	40	1.2196	32.24
10	1.1544	21.53	50	1.2439	36.04
20.5	1.1772	25.23	60	1.2711	39.65
30	1.2004	28.52	70	1.3005	43.37

THE SYSTEM POTASSIUM BICARBONATE - POTASSIUM CHLORIDE - WATER  
(Paris and Mondain-Monval, 1938)

In order to have an excess of  $\text{CO}_2$  present, the authors used, for preparing the saturated solutions, water previously saturated at about  $2^\circ$  with  $\text{CO}_2$ , instead of pure water. Saturation was thus affected under 1 to 2 atmospheres pressure of  $\text{CO}_2$ .

d. of sat. sol.	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	d. of sat. sol.	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
	KCl	KHCO <sub>3</sub>			KCl	KHCO <sub>3</sub>	
Results at 10°				Results at 20°—Cont.			
1.154	0.0	27.78	KHCO <sub>3</sub>	1.218	29.69	15.22	KHCO <sub>3</sub> + KCl
1.164	9.08	20.87	"	1.204	31.11	10.08	KCl
1.175	15.08	17.82	"	1.180	32.00	5.12	"
1.195	23.93	13.75	"	1.174	34.35	0.0	"
1.204	27.45	12.55	" + KCl	Results at 29.85°			
1.181	29.54	5.17	KCl	1.197	0.0	39.23	KHCO <sub>3</sub>
1.164	31.12	0.0	"	1.234	31.30	18.24	" + KCl
Results at 20°				1.181	37.08	0.0	KCl
1.177	0.0	33.19	KHCO <sub>3</sub>	Results at 40°			
1.184	10.05	25.34	"	1.217	0.0	45.51	KHCO <sub>3</sub>
1.180	15.33	22.03	"	1.249	33.03	22.00	" + KCl
1.198	20.14	19.35	"	1.189	40.15	0.0	KCl
1.207	24.31	17.33	"				

THE SYSTEM POTASSIUM BICARBONATE - POTASSIUM SULFATE - WATER AT  $50^\circ$   
(Luzhnaya and Kosyachkova, 1954)

$\text{CO}_2$  was present to prevent hydrolysis.

Sat. Sol. wt. %			Solid Phase	Sat. Sol. wt. %			Solid Phase
$\text{K}_2\text{SO}_4$	$\text{KHCO}_3$	density		$\text{K}_2\text{SO}_4$	$\text{KHCO}_3$	density	
14.25	--	1.1145	$\text{K}_2\text{SO}_4$	6.02	17.91	1.1660	$\text{K}_2\text{SO}_4$
13.00	2.41	1.1189	"	4.50	24.50	1.1820	"
11.61	4.92	1.1245	"	3.20	31.50	1.2195	"
9.53	11.31	1.1425	"	2.27	33.48	1.2339	$\text{K}_2\text{SO}_4 + \text{KHCO}_3$
7.52	14.51	1.1516	"	0.70	34.00	1.2390	$\text{KHCO}_3$
6.42	18.81	1.1621	"	--	34.50	1.2420	"

THE SYSTEM POTASSIUM BICARBONATE - SODIUM BICARBONATE - WATER  
(Oglesby, 1929; Luzhnaya and Kosyachkova, 1956 ( $50^\circ$ ))

Carbon dioxide was bubbled through the solutions prior to the period of saturation and afterwards an atmosphere of  $\text{CO}_2$  was maintained above the surface of the solutions. The analyses were made by titrating the total alkali with HCl and determining the K by the perchloric acid method. Results at  $0^\circ$  are given by Kratom, 1935. Results at  $35^\circ$  which do not agree well with the others are listed by Teeple, 1929.

## K KALIUM

## THE SYSTEM POTASSIUM BICARBONATE - SODIUM BICARBONATE - WATER--Cont.

d. of sat. sol.	Gms. per 100 gms. sat. sol.			d. of sat. sol.	Gms. per 100 gms. sat. sol.		
	NaHCO <sub>3</sub>	KHCO <sub>3</sub>	Solid Phase		NaHCO <sub>3</sub>	KHCO <sub>3</sub>	Solid Phase
Results at 20°				Results at 25°--Cont.			
1.1777	0.00	24.98	KHCO <sub>3</sub>	1.0857	8.20	4.23	NaHCO <sub>3</sub>
1.1830	1.38	24.32	"	1.0648	9.34	0.00	"
1.1897	2.84	23.58	"				
1.1966	4.37	22.89	" + NaHCO <sub>3</sub>				
1.1803	4.58	20.48	NaHCO <sub>3</sub>	Results at 30°			
1.1637	4.88	17.98	"	1.1988	0.0	28.52	KHCO <sub>3</sub>
1.1519	5.16	16.15	"	1.2077	2.06	27.43	"
1.1309	5.73	12.72	"	1.2145	3.58	26.66	"
1.0954	7.05	6.45	"	1.2189	4.83	26.01	" + NaHCO <sub>3</sub>
1.0625	8.72	0.00	"	1.1887	5.47	21.40	NaHCO <sub>3</sub>
				1.1543	6.23	16.08	"
				1.1196	7.34	10.22	"
				1.0973	8.22	6.18	"
				1.0673	9.95	0.0	"
Results at 25°				Results at 50°			
1.1882	0.00	26.78	KHCO <sub>3</sub>				
1.1927	1.12	26.13	"				
1.1977	2.39	25.56	"				
1.1998	2.72	25.27	"	1.2420	0.0	34.50	KHCO <sub>3</sub>
1.2042	3.74	24.93	"	--	1.50	33.40	"
1.2087	4.63	24.46	" + NaHCO <sub>3</sub>	1.2642	4.60	33.00	"
1.1903	4.94	21.89	NaHCO <sub>3</sub>	1.2762	7.59	32.50	" + NaHCO <sub>3</sub>
1.1732	5.14	19.39	"	1.2612	7.81	27.86	NaHCO <sub>3</sub>
1.1547	5.62	16.46	"	1.1868	7.93	19.10	"
1.1282	6.38	12.10	"	1.1393	9.01	11.01	"
1.1035	7.41	7.63	"	1.0835	12.64	0.0	"

THE SYSTEM  $2\text{KHCO}_3 + \text{Na}_2\text{SO}_4 = \text{K}_2\text{SO}_4 + 2\text{NaHSO}_4 + \text{H}_2\text{O}$  AT 50°  
(Iuzhnaya and Kosyachkova, 1956)

Compositions of the invariant points (also given on a mole basis):

Saturated Solution Wt. %				Solid Phase
Na <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	KHCO <sub>3</sub>	NaHCO <sub>3</sub>	
5.80	13.99	--	--	K <sub>2</sub> SO <sub>4</sub> + NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
--	2.28	33.45	--	KHCO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>
--	--	32.44	7.56	KHCO <sub>3</sub> + NaHCO <sub>3</sub>
30.45	5.68	--	--	Na <sub>2</sub> SO <sub>4</sub> + NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
29.69	--	--	4.02	NaHCO <sub>3</sub> + Na <sub>2</sub> SO <sub>4</sub>
--	3.54	29.97	7.50	NaHCO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub> + KHCO <sub>3</sub>
10.65	10.90	--	9.68	Na <sub>2</sub> SO <sub>4</sub> + NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub> + NaHCO <sub>3</sub>
3.16	2.95	22.19	5.34	NaHCO <sub>3</sub> + NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub> + K <sub>2</sub> SO <sub>4</sub>

THE SYSTEM  $2\text{KHCO}_3 + \text{MgCl}_2 \rightleftharpoons 2\text{KCl} + [\text{Mg}(\text{HCO}_3)_2] + \text{H}_2\text{O}$  AT  $25^\circ$   
(Bayliss and Koch, 1952)

The total pressure of  $\text{H}_2\text{O} + \text{CO}_2$  over the solutions was 1 atm. Some data at  $18^\circ$  are also given.

Moles per 1000 moles $\text{H}_2\text{O}$				Solid Phase
K <sub>2</sub>	Mg	Cl <sub>2</sub>	( $\text{HCO}_3$ ) <sub>2</sub>	
32.8	--	--	32.8	$\text{KHCO}_3$ , d.s.*
52.1	--	37.0	15.1	" , " , KCl
52.4	--	37.0	15.4	" , KCl
34.1	11.9	44.2	1.76	d.s., KCl
28.7	19.3	46.3	1.72	" , " , "
25.0	24.4	47.6	1.79	" , " , $\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$
25.3	24.2	47.7	1.81	" , " , "
22.7	28.6	49.6	1.71	KCl, $\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$
19.6	33.1	51.3	1.39	" , "
4.48	74.2	78.2	0.48	KCl, basic carbonate, C.*
4.52	74.2	78.2	0.52	" , " , "
22.2	21.9	42.3	1.87	d.s., $\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$
18.4	19.8	36.4	1.80	" , "
16.9	18.5	33.3	2.15	" , "
16.6	19.1	33.5	2.11	" , "
12.9	16.3	26.7	2.50	" , "
8.31	10.01	15.25	3.07	" , "
2.88	2.62	--	5.50	" , "
2.85	2.65	--	5.51	" , "
--	3.84	--	3.84	$\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$
43.5	--	43.5	--	KCl

\*d.s. =  $\text{KHCO}_3 \cdot \text{MgCO}_3 \cdot 4\text{H}_2\text{O}$ ; C = carnallite =  $\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$

THE SYSTEM  $\text{K}^+, \text{Na}^+, \text{NH}_4^+ || \text{Cl}^-, \text{HCO}_3^- + \text{H}_2\text{O}$  AT  $20^\circ$

The diagram for the system  $\text{K}^+, \text{Na}^+, \text{NH}_4^+, \text{Cl}^-, \text{HCO}_3^- - \text{H}_2\text{O}$  at  $20^\circ$  is given by Schutze, Piechowicz, and Pustelnik, 1943. Their data for the invariant solutions are:

Moles per 1000 moles $\text{H}_2\text{O}$					Solid Phases
K	$\text{NH}_4$	Na	Cl	$\text{HCO}_3$	
53.5	34.3	--	--	87.8	$\text{KHCO}_3 + \text{NH}_4\text{HCO}_3$
51.9	34.4	11.1	--	97.4	$\text{KHCO}_3 + \text{NH}_4\text{HCO}_3 + \text{NaHCO}_3$
84.4	48.1	--	88.3	44.2	$\text{KCl} + \text{KHCO}_3 + \text{NH}_4\text{HCO}_3$
47.3	117.2	--	143.5	21.0	$\text{KCl} + \text{NH}_4\text{Cl} + \text{NH}_4\text{HCO}_3$
72.4	--	27.1	69.1	30.4	$\text{KCl} + \text{KHCO}_3 + \text{NaHCO}_3$
36.0	--	93.0	126.6	2.4	$\text{KCl} + \text{NaCl} + \text{NaHCO}_3$
27.0	70.3	74.8	167.1	5.0	$\text{KCl} + \text{NH}_4\text{Cl} + \text{NaCl} + \text{NaHCO}_3$
45.8	106.9	19.6	148.6	23.7	$\text{KCl} + \text{NH}_4\text{Cl} + \text{NH}_4\text{HCO}_3 + \text{NaHCO}_3$
76.5	50.7	12.8	92.9	47.1	$\text{KCl} + \text{KHCO}_3 + \text{NH}_4\text{HCO}_3 + \text{NaHCO}_3$



## K KALIUM

COO POTASSIUM OXALATE  $K_2C_2O_4$ 

## SOLUBILITY IN WATER

The data of Woskressenskaya, 1926 and of Koppel and Cahn, 1908 agree at about 25°. Below 25° Koppel and Cahn are consistently higher, and above 25° lower, than Woskressenskaya. Several other determinations also agree at 25°. The 50° value of Rivett and O'Connor, 1919 agrees with Woskressenskaya. The data above the boiling point are from Benrath, 1942. The solid phase is  $K_2C_2O_4 \cdot H_2O$  above the eutectic.

t°	Wt. % $K_2C_2O_4$ in sat. sol.		t°	Wt. % $K_2C_2O_4$ in sat. sol.	
	W.	K.&C.		W.	K.&C.
Solid Phase ICE:			Solid Phase $K_2C_2O_4 \cdot H_2O$		
- 0.446	1.271 <sup>a</sup>	--	0	20.28 (b)	20.35
- 0.6	2.4	--	+10	23.20	24.17
- 1.066	4.177 <sup>a</sup>	--	16	24.81	--
- 1.4	5.14	--	20	25.95	26.68
- 2.088	8.355 <sup>a</sup>	--	25	27.40 (c)	--
- 3.0	10.47	--	30	28.70	28.50
- 4.0	14.10	--	40	31.2	30.44
- 5.05	17.12	--	50	33.5 (d)	32.60
- 5.75	18.83	--	60	35.6	34.72
- 5.88 (Eutec.)	--	19.43	70	37.8	36.75
- 6.34 ( " )	20.00	--	80	40.2	38.88
			90	42.0	40.90
			100	44.5	--
			107 b. pt.	45.9	44.19
			130	50	--
			150	55	--
			177	60	--
			219	65	--
			239	68	--
			290	75	--
			330	80	--

<sup>a</sup>Klein and Svanberg, 1920.

(b) 20.62, d = 1.161 (Engel, 1888).

(c) d = 1.215 Rivett and O'Connor, 1919.

(d) d = 1.252 Rivett and O'Connor, 1919.

## THE SYSTEM POTASSIUM OXALATE - OXALIC ACID - WATER

Data at 0°, 30°, and 60° are by Koppel and Cahn, 1908. At 25° the data of Hartley, Drugman, Vlieland and Bourdillon, 1913, were used at lower concentrations (up to 6%  $K_2O$ ) and those of Foote and Andrew, 1905, for the higher concentrations. The two sets of data are in good agreement on the invariant points.

## THE SYSTEM POTASSIUM OXALATE - OXALIC ACID - WATER--Cont.

Results at 0°		Results at 25°		Results at 30°		Results at 60°		Solid Phase	
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.			
C <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O	C <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O	C <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O	C <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O		
2.72	--	8.29	--	9.97	--	24.75	---	A	
2.91	0.226*	--	--	10.15	0.10	--	--	A	
2.985	0.342*	--	--	--	--	--	--	A	
2.827	0.125	8.27	0.02	10.23	0.34	25.70	0.46	A, B	
2.346	0.145	8.278	0.045	--	--	--	--	A, B	
1.471	0.195	7.412	0.064	7.28	0.33	25.80	0.54	B	
0.823	0.240	2.827	0.238	4	0.41	22.06	0.58	B	
0.799	0.454	2.007	0.346	3.08	0.50	20.17	0.67	B	COO
1.173	0.785	1.734	0.567	2.38	1.002	14.25	0.90	B	
1.381	0.962	2.675	1.714	2.98	1.79	9.82	1.48	B	
1.545	1.155	3.079	2.052	--	--	6.95	2.244	B	
1.666	1.273	3.450	2.360	4.24	2.76	9.17	5.60	B, C	
1.754	1.479	5.91	6.52	4.26	3.38	8.81	6.37	C	
2.627	2.858	8.13	9.59	5.44	5.43	10.17	10.00	C	
3.772	4.422	--	--	6.66	7.27	12.36	13.40	C	
4.292	5.161	--	--	8.64	10.05	14.10	16.00	C	
4.975	6.088	--	--	10.03	12.01	15.35	17.80	C	
5.652	7.00	9.82	11.95	10.80	12.94	16.07	18.89	C, D	
6.27	7.87	9.96	12.19	11.47	14.13	16.51	19.59	D	
7.63	9.72	10.71	13.32	12.16	15.11	16.80	20.10	D	
8.66	11.14	11.24	14.10	12.32	15.37	16.95	20.34	D	
9.055	11.58	12.31	15.66	12.90	16.23	17.14	20.70	D, E	
8.826	11.52	11.87	15.52	12.36	16.14	16.71	20.41	E	
5.215	12.33			8.52	15.03	15.94	20.11	E	
2.23	14.80			4.53	15.55	15.06	19.66	E	
1.245	16.82			1.87	18.17	8.82	19.25	E	
0.871	18.40			0.74	22.32	2.04	23.09	E	
0.511	20.91			--	--	0.434	29.00	E	
0.325	23.30			--	--	0.365	31.40	E	
0	41.3†			0	46.79	0	51.34	F	

\*Supersaturated.

†About

A = H<sub>2</sub>C<sub>2</sub>O<sub>4</sub>·2H<sub>2</sub>O    B = KH<sub>3</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>2</sub>·2H<sub>2</sub>O    C = KHC<sub>2</sub>O<sub>4</sub>  
D = (K<sub>2</sub>C<sub>2</sub>O<sub>4</sub>)<sub>2</sub>H<sub>2</sub>C<sub>2</sub>O<sub>4</sub>·2H<sub>2</sub>O    E = K<sub>2</sub>C<sub>2</sub>O<sub>4</sub>·H<sub>2</sub>O    F = KOH·H<sub>2</sub>O

SOLUBILITIES IN THE SYSTEM POTASSIUM OXALATE - OXALIC ACID - WATER  
AT THE CRYOHYDRIC POINTS

(Koppel and Cahn, 1908)

(Temp. of Equilibrium of Solution with Ice)

t° of Ice Separation	Gms. per 100 Gms. Sat. Sol.		Solid Phase in addition to ice
	C <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O	
- 0.95	2.641	--	H <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·2H <sub>2</sub> O
- 0.90	2.720	0.0466	" + KH <sub>3</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O
- 0.52	1.672	0.0602	KH <sub>3</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O
- 0.25	0.643	0.210	"
- 0.58	1.229	0.823	"
- 0.78	1.648	1.234	" + KHC <sub>2</sub> O <sub>4</sub>

(Cont.)

# K KALIUM

## SOLUBILITIES IN THE SYSTEM POTASSIUM OXALATE - OXALIC ACID - WATER AT THE CRYOHYDRIC POINTS--Cent.

t° of Ice Separation	Gms. per 100 Gms. Sat. Sol.		Solid Phase in addition to ice
	C <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O	
- 1.50	2.707	2.950	KHC <sub>2</sub> O <sub>4</sub>
- 2.10	3.687	4.363	"
- 2.78	4.576	5.50	"
- 3.45	5.681	7.05	" + (K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub> ·H <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·2H <sub>2</sub> O
- 4.45	6.902	8.820	(K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub> ·H <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·2H <sub>2</sub> O
- 5.20	7.616	9.74	"
- 5.32	7.696	9.84	"
- 5.97	8.51	11.01	" + K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O
- 6.55	6.742	10.45	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O
- 8.10	4.999	10.86	"
-10.30	3.358	11.76	"
-13.60	1.854	13.08	"
-17.40	1.200	14.55	"
-23.80	0.606	16.89	"

## SOLUBILITIES IN THE SYSTEM POTASSIUM OXALATE - OXALIC ACID - WATER AT THE BOILING POINTS (Koppel and Cahn, 1908)

t° of B. pt.	Gms. per 100 Gms. sat. sol.		Solid Phase
	C <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O	
105.5	39.84	5.25	KH <sub>3</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O
104.9	36.95	5.83	"
104.3	32.75	5.97	"
103.4	27.64	9.12	"
102.9	27.46	11.43	" + KHC <sub>2</sub> O <sub>4</sub>
102.5	23.36	10.50	KHC <sub>2</sub> O <sub>4</sub>
102.4	18.81	12.29	"
102.8	19.10	18.25	"
103.25	21.11	21.71	"
107.7	25.19	27.91	" + K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O
106.35	22.04	26.45	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O
106.25	19.17	25.02	"
108.25	12.73	27.69	"
101.8	5.35	30.40	"

### COO Mono POTASSIUM OXALATE KHC<sub>2</sub>O<sub>4</sub>

### POTASSIUM TETRAOXALATE KHC<sub>2</sub>O<sub>4</sub>·H<sub>2</sub>C<sub>2</sub>O<sub>4</sub>

## SOLUBILITY OF MONO POTASSIUM OXALATE, KHC<sub>2</sub>O<sub>4</sub>, IN WATER (Koppel and Cahn, 1908)

t°	Gms. per 100 Gms. Sat. Sol.		Solid Phase
	C <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O	
60	8.75	6.50	KHC <sub>2</sub> O <sub>4</sub>
102.4 b. pt.	18.81	12.29	"

The KHC<sub>2</sub>O<sub>4</sub> is decomposed to the less soluble tetroxalate at temperatures below 50°.

(Cont.)

SOLUBILITY ABOVE 100°  
(Benrath, 1942)

Temperature°	116	131	143	150
Gms. $\text{KHC}_2\text{O}_4$ per 100 gms. Sat. Sol.	40	45	50	53.2

SOLUBILITY OF  $\text{KHC}_2\text{O}_4$  IN ORGANIC SOLVENTS

100 gms. methyl alcohol dissolve 2.07 gms.  $\text{KH}_3(\text{C}_2\text{O}_4)_2$  at 15° and 1.55 gms. at the b. pt., 66.4°.

100 gms. acetone dissolve 2.44 gms.  $\text{KH}(\text{C}_2\text{O}_4)_2$  at 15°. (Henstock, 1934.)

SOLUBILITY OF POTASSIUM TETROXALATE,  $\text{KH}_3(\text{C}_2\text{O}_4)_2 \cdot 2\text{H}_2\text{O}$ , IN WATER  
(Koppel and Cahn, 1908)

t°	Gms. $\text{KH}_3(\text{C}_2\text{O}_4)_2$ per 100 Gms. $\text{H}_2\text{O}$	Solid Phase
- 0.25 cryohydrate	0.99	$\text{KH}_3(\text{C}_2\text{O}_4)_2 \cdot 2\text{H}_2\text{O}$
0	1.27	"
21	2.46 (*)	"
30	4.30	"
60	11.95	"
103.5 b. pt.	72.17	"

\*Suetsuma, 1950

POTASSIUM COBALT OXALATES, levo

$\text{K}_3[\text{Co}(\text{C}_2\text{O}_4)_3] \cdot \text{H}_2\text{O}$  and racemic  $\text{K}_3[\text{Co}(\text{C}_2\text{O}_4)_3] \cdot 3\frac{1}{2} \text{H}_2\text{O}$

COO

SOLUBILITY OF EACH SEPARATELY IN WATER  
(Jaeger and Thomas, 1918, 1919)

t*	Gms. racemic salt per 100 gms. $\text{H}_2\text{O}$	t°	Gms. levo salt per 100 gms. $\text{H}_2\text{O}$
0	34.50	20	37.40
14	36.84	22	37.60

By plotting these results the transition temperature is found to be 13.2°.

SOLUBILITY OF MIXTURES OF POTASSIUM OXALATE AND OTHER POTASSIUM SALTS IN WATER  
(Colani, 1916)

Results at 15°		Results at 50°		Solid Phase in Each Case
Gms. per 100	Gms. Sat. Sol.	Gms. per 100	Gms. Sat. Sol.	
10.03	$\text{K}_2\text{C}_2\text{O}_4 + 19.19 \text{ KCl}$	15.18	$\text{K}_2\text{C}_2\text{O}_4 + 20.26 \text{ KCl}$	$\text{K}_2\text{C}_2\text{O}_4 \cdot \text{H}_2\text{O} + \text{KCl}$
23.55	" + 1.82 $\text{K}_2\text{SO}_4$	31.06	" + 1.99 $\text{K}_2\text{SO}_4$	" + $\text{K}_2\text{SO}_4$
20.39	" + 11.60 $\text{KNO}_3$ (19°)	19.63	" + 28.29 $\text{KNO}_3$	" + $\text{KNO}_3$

## K KALIUM

THE SYSTEM POTASSIUM OXALATE - AMMONIUM OXALATE - WATER  
(Rivett and O'Connor, 1919)

## Results at 25°

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$K_2C_2O_4$	$(NH_4)_2C_2O_4$	
1.021	0.00	5.01	$(NH_4)_2C_2O_4 \cdot H_2O$
1.040	2.67	4.72	
1.068	6.51	4.38	
1.108	12.10	4.01	Solid Soln. I
1.128	15.37	3.68	
1.166	19.39	3.32	
1.204	24.3	2.90	
1.217	25.9	2.75	(I) + (II)
1.216	26.3	1.83	Solid Soln. II
1.216	26.8	0.85	
1.215	27.2	0.0	

## Results at 50°

1.034	0.0	9.63	$(NH_4)_2C_2O_4 \cdot H_2O$
1.080	7.99	8.40	Solid Soln. I
1.136	16.20	7.10	
1.154	17.99	6.79	
1.187	22.4	6.10	
1.203	24.4	5.75	(I) + (II)
1.254	30.4	4.78	
1.251	31.0	3.34	
1.252	31.5	2.64	
1.252	33.1	0.0	$K_2C_2O_4 \cdot H_2O$

THE SYSTEM POTASSIUM OXALATE - SODIUM OXALATE - WATER AT 25°  
(Rivett and O'Connor, 1919)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$K_2C_2O_4$	$Na_2C_2O_4$	
1.215	27.3	0.0	$K_2C_2O_4 \cdot H_2O$
1.218	26.8	0.77	"
1.223	26.3	1.71	"
1.226	26.2	2.17	"
1.228	26.1	2.50	" + $Na_2C_2O_4$
--	(26.15)	(2.44) *	" + "
1.178	19.6	3.21	$Na_2C_2O_4$
1.135	14.4	3.21	"
1.084	8.10	3.40	"
1.057	3.99	3.71	"
1.026	0.00	3.71	"

\*(Foote and Andrew, 1950)

THE SYSTEM POTASSIUM OXALATE, NICKEL OXALATE AND WATER AT 30°  
(Vosburg, Israel and Birch, 1936)

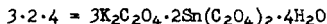
The period of rotation was a week or more and special precautions were necessary to insure that the right solid phase was present. The oxalate content of the samples was determined by permanganate titration and the nickel content either by dimethyl glyoxime or cyanide titration.

SS = Solid solutions of potassium and nickel oxalates. Analyses showed that water of crystallization in the double compound was most probably 4H<sub>2</sub>O.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
K <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	NiC <sub>2</sub> O <sub>4</sub>		K <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	NiC <sub>2</sub> O <sub>4</sub>	
2.26	0.08	SS	23.24	4.55	K <sub>2</sub> Ni <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub> ·xH <sub>2</sub> O
3.77	0.55	"	25.82	4.67	"
5.67	0.57	"	26.83	4.93	"
8.40	1.38	"	26.94	5.13	"
11.08	2.55	"	27.11	5.20	"
12.44	3.53	" + K <sub>2</sub> Ni(C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub> ·xH <sub>2</sub> O	30.55	5.85	"
14.22	3.80	K <sub>2</sub> Ni <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub> ·xH <sub>2</sub> O	34.08	7.39	"
16.74	3.28	"	33.03	6.64	" + K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O
18.77	3.48	"	33.31	6.81	"
19.95	3.84	"	33.57	6.37	"
20.62	3.87	"	31.07	3.34	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O
22.12	4.02	"	32.51	5.56	"

THE SYSTEM POTASSIUM OXALATE - STANNIC OXALATE - WATER AT 25°  
(Willard and Toribara, 1942)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
K <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	Sn(C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub>		K <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	Sn(C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub>	
1.90	5.54	3·2·4 + ?	22.37	0.79	3·2·4
1.80	2.14	3·2·4	27.25	2.81	3·2·4 + K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O
4.11	0.79	"	27.80	1.25	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O
7.44	0.72	"	27.21	0.54	"
13.64	1.41	"	27.12	0.0	"



POTASSIUM Telluric Acid OXALATE K<sub>2</sub>[H<sub>6</sub>TeO<sub>6</sub>·C<sub>2</sub>O<sub>4</sub>]

C00

SOLUBILITY IN WATER  
(Rosenheim and Weinheber, 1910-11)

t°	0°	20°	30°	40°	50°
Gms. K <sub>2</sub> [H <sub>6</sub> TeO <sub>6</sub> ·C <sub>2</sub> O <sub>4</sub> ] per 100 gms. H <sub>2</sub> O	2.67	5.36	6.82	9.07	12.35

## K KALIUM

## THE SYSTEM POTASSIUM OXALATE - ZINC OXALATE - WATER

Results at 25°  
(Metler and Vosburgh, 1933)Results at 35°  
(Metler, 1934)

	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	ZnC <sub>2</sub> O <sub>4</sub>		K <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	ZnC <sub>2</sub> O <sub>4</sub>	
COO	34.09	11.11	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O + 1·1·7	35.96	12.66	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O + 1·1
	29.07	9.70	1·1·7	35.66	12.78	1·1
	23.74	8.36	"	34.56	12.77	"
	21.17	7.63	"	32.54	13.02	"
	16.71	6.46	"	30.07	13.17	"
	15.64	6.20	"	28.33	13.41	"
	15.19	6.06	" + ZnC <sub>2</sub> O <sub>4</sub> ·2H <sub>2</sub> O	26.91	13.68	"
	14.26	5.80*	"	25.28	13.70	" + ZnC <sub>2</sub> O <sub>4</sub> ·2H <sub>2</sub> O
	10.28	4.42*	"	23.99	12.65	ZnC <sub>2</sub> O <sub>4</sub> ·2H <sub>2</sub> O
	13.71	4.86	ZnC <sub>2</sub> O <sub>4</sub> ·2H <sub>2</sub> O	21.48	10.69	"
	11.73	3.85	"	19.11	8.94	"
	10.45	3.11	"	17.72	7.84	"
	9.44	2.59	"	13.13	4.82	"
	7.73	1.76	"	10.62	3.32	"
	5.72	1.01	"	8.14	2.08	"
	4.57	0.69	"	5.38	0.96	"
	3.80	0.38	"	2.14	0.17	"
	3.31	0.29	"			

\* = Metastable

1·1 = K<sub>2</sub>Zn(C<sub>2</sub>O<sub>4</sub>)<sub>2</sub>1·1·7 = K<sub>2</sub>Zn(C<sub>2</sub>O<sub>4</sub>)<sub>2</sub>·7H<sub>2</sub>O

Evidence was also obtained for the metastable existence of the compound K<sub>2</sub>Zn<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub>·12H<sub>2</sub>O and the composition of several metastable solutions in contact with this compound are given.

THE SYSTEM POTASSIUM OXALATE - ZIRCONYL OXALATE - WATER AT 35°  
(Boulanger, 1936)

Tabular results are given for the temperatures 19°, 35° and 52°. Those at 19° yield a very irregular curve. Those at 35° and 52° although giving somewhat better curves probably do not represent equilibrium conditions. The following values taken from the 35° curve indicate roughly the general nature of the system.

	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. Sat. sol.		Solid Phase
	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	ZrOC <sub>2</sub> O <sub>4</sub>		K <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	ZrOC <sub>2</sub> O <sub>4</sub>	
	12.0	trace	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O	2.9	1.10	1·1·1·4(?)
	8.0	0.06	"	2.8	1.24	"
	7.0	0.25	"	2.5	1.20	"
	6.5	0.30	1·1·1·4 (?)	2.0	0.92	ZrC <sub>2</sub> O <sub>4</sub> ·4H <sub>2</sub> O
	5.0	0.28	"	1.5	0.72	"
	4.0	0.34	"	1.0	0.60	"
	3.5	0.42	"	0.5	0.48	"
	3.0	0.80	"			

1·1·1·4 = K<sub>2</sub>C<sub>2</sub>O<sub>4</sub>·ZrOC<sub>2</sub>O<sub>4</sub>·H<sub>2</sub>C<sub>2</sub>O<sub>4</sub>·4H<sub>2</sub>O(?)

## POTASSIUM COLUMBATES

Cbo

SOLUBILITY IN WATER AT 25°  
(Windmaisser, 1942)

Salt	Gms. Anhydrous Salt per 100 gms. Sat. Sol.
$4K_2O \cdot 3Cb_2O_5 \cdot 16H_2O$	56
$*7K_2O \cdot 6Cb_2O_5 \cdot (H_2O)$	55.08
$KCbO_2 \cdot 2H_2O$	59.53

\*The equilibrium diagram of the system  $4K_2O \cdot 3Cb_2O_5 \cdot 16H_2O + K_2CO_3 + H_2O$  at 25° is also given. The 4:3 salt is converted to the 7:6 in solutions containing over 1%  $K_2CO_3$ . The previous 8:7 salt was shown actually to be 7:6.

## POTASSIUM CHLORIDE KCl

Cl

## THE SYSTEM POTASSIUM CHLORIDE - WATER

A very large number of determinations have been made, with generally good agreement between older and recent values. The data below were read from average curves drawn through the various results. The freezing points are by Klein and Svanberg (1920), Rodebush (1918), Barnes and Maass (1930), and Shulgina, Karchuk, and Yanat'eva (1955). Above 100° the average of determinations by Keevil (1942), Cornec and Krombach (1932), Achumow and Wassilijew (1932), and Benrath, Gjedebø, Schiffrers and Wunderlich (1937) is given. Further high temperature results are given by Ravich and Borovaya, 1950. The other data are from Meusser (1905), Kohler (1897), Andrae (1884), Gerardin (1865), de Coppet (1883), Etard (1894), Mulder (1864), Anosov and Byzova (1947), Foote (1927), Wright (1927), Scott and Frazier (1927), Malquori, (1927, 1928a), Flottmann (1928), Cornec and Krombach (1923), Lannung (1934), Hering (1936), and Nallet, 1955. A monohydrate was first reported by Fialkov and Chernogorenko, 1955, and Chernogorenko, 1958. Later very careful determinations by Shul'gina, Kharchuk, and Yanat'eva, 1955 confirmed its presence, but these authors were uncertain of its composition. It may contain 1 - 1½ moles of water. The data from the eutectic to 0° are those of S.K. and Y.

t°	Gms. KCl per 100 gms. sat. sol.	t°	Gms. KCl per 100 gms. sat. sol.
Solid Phase ICE		KCl·nH <sub>2</sub> O	
- 1.00	2.31	- 9.5	19.99
- 2.00	4.48	- 9.0	20.05
- 3.00	6.49	- 8.2	20.10
- 4.00	8.50	- 8.0	20.20
- 5.00	10.36	- 7.6	20.29
- 6.00	12.28	- 7.2	20.44
- 7.00	13.98	- 7.0	20.50
- 8.00	15.64	- 6.9	20.60
- 9.00	17.19		
- 10.00	18.62*		KCl·nH <sub>2</sub> O + KCl
	ICE + KCl	- 6.6	20.68
- 10.8	19.87*		KCl
	ICE + KCl·nH <sub>2</sub> O	- 6.0	20.80
		- 5.4	20.98
- 10.6	19.70	- 2.8	21.30
		- 1.0	21.70

\*metastable

(Cont.)



# K KALIUM

## THE SYSTEM POTASSIUM CHLORIDE - WATER--Cont.

	d. of			d. of		
	t°	sat. sol.	Gms. KCl per 100 gms. sat. sol.	t°	sat. sol.	Gms. KCl per 100 gms. sat. sol.
	0	1.154	21.92	120	--	37.5
	+ 5	--	22.9	130	1.235	38.4
	10	--	23.8	140	--	39.3
	15	--	24.7	150	1.254	40.2
	20	1.174	25.5	160	--	41.1
	25	1.1778	26.4	170	1.276	42.0
	30	1.182	27.1	180	--	43.0
	40	1.189	28.6	200	1.317	44.6
	50	1.194	30.0	225	--	46.8
	60	1.199	31.4	250	--	49.0
Cl	70	1.203	32.7	275	--	51.4
	80	1.205	33.9	300	--	53.8
	90	--	35.0	350	--	58.4
	100	1.210	36.0	400	--	63.4
				454	--	69.0

## THE SOLUBILITY OF POTASSIUM CHLORIDE IN DEUTERIUM OXIDE AND IN ORDINARY WATER (Shearman and Menzies, 1937)

The deuterium water had a content of 98.2% D<sub>2</sub>O and a density relative to that of ordinary water, of 1.1059. The results are reported in moles of KCl per 1000 gms. of water (= 55.51 moles H<sub>2</sub>O) and in 1111.7 gms. of deuterium water (= 55.51 moles D<sub>2</sub>O). The same 0.4086 gm. of KCl was employed in both solvents and the amount of deuterium water was 1.39 gm. The actual measurements were graphed and the following values for round temperatures obtained.

t°	Moles KCl per 55.51 moles:		t°	Moles KCl per 55.51 moles:	
	H <sub>2</sub> O	D <sub>2</sub> O		H <sub>2</sub> O	D <sub>2</sub> O
0	3.78	3.16	80	6.80	6.52
10	4.20	3.68	100	7.51	7.25
20	4.61	4.16	120	8.21	7.97
25	4.80	4.38	140	8.89	8.67
30	5.00	4.59	160	9.57	9.36
40	5.37	5.01	180	10.24	10.06
60	6.09	5.79			

## SOLUBILITY OF KCl IN STEAM (Spillner, 1940; Jasmund, 1952; Ellis and Fyfe, 1957)

For data on the critical temperature of 0.03-0.06 M KCl solutions, see Schroer, 1927.

Pressure Kg/cm <sup>2</sup>	Wt. % KCl in the condensate at			
	400°	407° (S.)	450°	500°
100	0.00052	0.0009	0.00043	0.00030
150	--	.0031	0.0018	--
200	--	.0076	--	0.0046
250	--	.0220	--	--
300	--	.0640	--	--

Data for equilibrium in the system potassium chloride + potassium oxalate + water at 20° are given by Trifnov, 1924-1925.

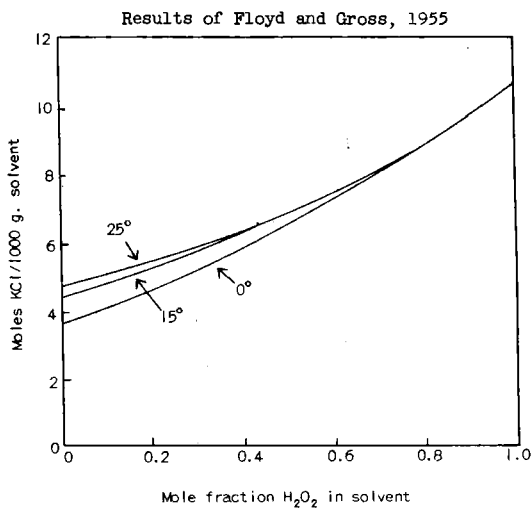
# SOLUBILITY OF POTASSIUM CHLORIDE IN AQUEOUS SOLUTIONS OF HYDROGEN PEROXIDE

The numerical data of Akerlof and Turck, 1935 at 25° are given below. Floyd and Gross, 1955 present their results in graphical form. They are in good agreement with A. and T. and also with the early work of Tilden and Shenstone 1883.

Data of Akerlof and Turck, 1935 at 25°

C1

Composition of aq. solvent in:		Gm. Mols. KCl dissolved per 1000 gms. solvent
Wt. percent H <sub>2</sub> O <sub>2</sub>	Mol. Fraction H <sub>2</sub> O <sub>2</sub>	
0.0	0.0	4.826
5.30	0.0288	4.835
10.73	0.0599	4.974
15.72	0.0899	5.093
21.19	0.1270	5.263
26.24	0.1585	5.362
31.43	0.1955	5.534



# K KALIUM

## SOLUBILITY OF POTASSIUM CHLORIDE IN HYDROCHLORIC ACID SOLUTIONS

Jeannel, 1886; Engel, 1888; Armstrong, Eyre, Hussey and Paddinson, 1907; Armstrong and Eyre, 1910; Seidel and Fischer, 1941 at 0°. Only the data of Seidel and Fischer were used for HCl concentrations over 20%; the older points are low and very scattered.

Armstrong, Eyre, Hussey and Paddinson, 1907; Armstrong and Eyre, 1910; Herz 1911; Ingham, 1928; Malquori, 1928(c) at 25°.

Results at 0°		Results at 25°	
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
Cl	<div>HCl                      KCl</div>		<div>HCl                      KCl</div>
	0	0	26.4
	2	2	23.2
	4	4	20.0
	6	6	16.6
	8	8	13.7
	10	10	11.4
	12	12	9.3
	14	14	7.4
	16	16	5.8
	18	18	4.6
	20	20	3.6
	22	22	2.9
	24	24	2.4
	26	26	2.0
	28	28	1.7
	30	30	1.5
	32	32	1.4
	34	34	1.3
	36	36	1.4
	38	38	1.5
	40		
	42		
	44		

F.-pt. data for mixtures of KCl and HCl are given by Dernby (1918).

## SOLUBILITY OF POTASSIUM CHLORIDE IN HBr SOLUTIONS AT 25° (Herz 1911-12)

Gms. HBr per liter	0	53.5	276.4
Gms. KCl per liter	318.5	281.9	146

SOLUBILITY OF POTASSIUM CHLORIDE IN AQUEOUS SOLUTIONS OF  
POTASSIUM HYDROXIDE AT VARIOUS TEMPERATURES

von Antropoff, 1924; also Akerloff and Short 1937 at 25°. Bronsted, 1920s (at 20°) averages about 1/2% higher than von Antropoff. See the table following for the compositions of invariant solutions. The figures in parentheses are the densities of the saturated solutions.

Gms. KOH per 100 gms. sat. sol.	Gms. KCl per 100 gms. sat. solution at							
	-21.3°	-11.1°	0°	10°	20°	25°	30°	
5	--	15.4 (1.180)	17.6 (1.185)	19.2 (1.184)	20.8 (1.180)	22.0	22.2 (1.182)	Cl
10	--	11.7 (1.189)	13.5 (1.194)	15.0 (1.203)	16.4 (1.201)	17.1	17.9 (1.204)	
15	7.9 (1.204)	8.8 (1.206)	9.9 (1.219)	11.3 (1.227)	12.3 (1.226)	13.0	13.6 (1.230)	
20	5.6 (1.239)	6.3 (1.238)	7.2 (1.249)	8.0 (1.256)	8.8 (1.252)	9.7	10.2 (1.258)	
25	3.6 (1.280)	4.2 (1.278)	4.9 (1.283)	5.4 (1.285)	6.2 (1.283)	7.1	7.4 (1.289)	
30	2.2 (1.326)	2.6 (1.323)	3.0 (1.322)	3.6 (1.324)	4.2 (1.318)	5.1	5.0 (1.323)	
35	1.2 (1.376)	1.5 (1.372)	1.8 (1.370)	2.2 (1.366)	2.6 (1.362)	3.5	3.2 (1.364)	
40	0.7 (1.430)	0.9 (1.425)	1.0 (1.419)	1.3 (1.415)	1.5 (1.411)	2.3	1.8 (1.409)	
45	0.4 (1.486)	0.5 (1.478)	0.6 (1.471)	0.7 (1.469)	0.9 (1.465)	1.3	1.1 (1.460)	
50	--	--	--	0.5 (1.525)	0.6 (1.521)	0.7	0.8 (1.515)	
55	--	--	--	--	--	--	0.5 (1.571)	

Gms. KOH per 100 gms. sat. sol.	Gms. KCl per 100 gms. sat. solution at					
	50°	70°	90°	120°	150°	180°
5	24.7(1.186)	27.3(1.196)	29.7(1.214)	33.0	36.0	38.3
10	20.2(1.208)	22.7(1.220)	24.8(1.231)	27.9	30.8	33.1
15	16.0(1.236)	18.4(1.243)	20.0(1.250)	22.9	25.8	28.1
20	12.3(1.263)	14.4(1.270)	15.9(1.272)	18.0	21.2	23.5
25	9.1(1.293)	10.8(1.299)	12.1(1.298)	14.5	17.0	19.1
30	6.3(1.324)	7.7(1.330)	9.1(1.330)	11.3	13.8	15.3
35	4.1(1.358)	5.3(1.364)	6.6(1.367)	8.8	10.5	12.1
40	2.5(1.404)	3.7(1.404)	4.5(1.408)	6.7	8.0	9.3
45	1.6(1.458)	2.5(1.451)	3.1(1.451)	5.0	6.0	7.1
50	1.1(1.511)	1.7(1.505)	2.2(1.500)	3.3	4.4	5.5
55	0.9(1.568)	1.1(1.566)	1.8(1.556)	2.5	3.4	4.7
60	--	--	1.4(1.618)	2.0	2.7	4.0
65	--	--	--	1.7	2.5	3.9
70	--	--	--	--	2.7	--

## K KALIUM

Compositions of KCl - KOH Solutions  
Saturated with two solid phases

(von Antropoff, 1924)

Gms. per  
100 gms.  
sat. sol.

temp.	KOH	KCl	Solid Phase
-21.30	11.23	9.69	KCl + Ice
-17.35	10.62	10.24	"
-11.0	--	19.74	"
-67.2	30.73	0.23	KOH·4H <sub>2</sub> O(?) + Ice
-65.2	30.83	--	" "
-65.6	29.62	--	" "
-64.3	30.59	0.43	" "+KCl
-21.3	46.6	0.38	KOH·2H <sub>2</sub> O + KCl
-11.1	47.45	0.38	" "
0	48.93	0.44	" "
10	50.69	0.45	" "
20	52.83	0.55	" "
30	55.28	0.47	" "
50	58.09	0.67	KOH·H <sub>2</sub> O + "
70	59.63	0.91	" "
90	61.75	1.25	" "
120	65.31	1.70	" "
150	73.57	2.87	KOH + KCl

Solubility of KCl in KOH  
Solutions at the Boiling Points

(von Antropoff, 1924)

Gms. per  
100 gms.  
sat. sol.

B.pt.	d. of sat. sol.	KOH	KCl
108.5	---	0.0	36.5
109.2	1.227	5.0	31.9
110	1.245	10.0	27.4
111.5	1.266	15.0	22.9
113.5	1.292	20.0	18.7
116.5	1.320	25.0	14.9
120.7	1.351	30.0	11.9
125.7	1.382	35.0	9.6
131.5	1.415	40.0	7.7
139.3	1.448	45.0	6.4
151.5	1.8	50.0	5.4
166.3	--	55.0	4.7

## SOLUBILITY OF POTASSIUM CHLORIDE IN AMMONIA SOLUTIONS

(Alexandrov, 1941)\*

Gms. NH<sub>3</sub> per  
100 gms. H<sub>2</sub>O  
in Sat. Sol.Gms. KCl per 100 gms. H<sub>2</sub>O in Sat. Sol.

	-20°	-10°	0°	10°	20°	30°	40°	50°
0	--	25.0	28.5	31.5	34.5	37.3	40.1	42.9
10	--	18.3	22.1	23.8	26.6	29.3	32.0	34.8
20	11.5	14.0	16.5	19.0	21.4	23.8	26.3	28.8
25	10.2	12.5	15.0	17.3	19.7	22.0	24.2	26.7
30	9.1	11.3	13.7	15.9	18.1	20.3	22.5	24.8
40	7.4	9.7	11.7	13.9	16.2	18.2	20.4	22.8

Data in more concentrated solutions of NH<sub>3</sub> are given by Guyer, Bieler and Schmid, 1934. These were read from curves drawn by the authors. Note different units.

Results at -15°

Gms. per 100  
gms. sat. sol.

NH <sub>3</sub>	KCl
55	4.0
60	3.1
70	1.7
80	0.8
90	0.35
100	0.2

Solid  
PhaseKCl  
"  
"  
"  
"  
"

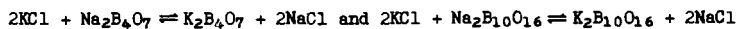
Results at +25°

Gms. per 100  
gms. sat. sol.

NH <sub>3</sub>	KCl
62	4.0
70	2.4
80	1.3
90	0.5
100	0.1

Solid  
PhaseKCl  
"  
"  
"  
"

Data for the aqueous reciprocal systems:



at 35° are given by Teeple, 1929.

THE SYSTEM POTASSIUM CHLORIDE - POTASSIUM CHLORATE - WATER  
(Fleck, 1937; Donald, 1937; Benrath and Braun, 1940; Nallet, 1955;  
Nallet and Paris, 1956.)

The results of DiCapua and Scaletti, 1927 and Winteler, 1900 at 20° are apparently incorrect. Additional data at 25° are given by Holluta and Peter, 1929. See also p. 173, this volume.

At the temperatures where they can be compared (30, 50°) Nallet's data are generally somewhat higher than those of Fleck. Cl

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	KCl	KClO <sub>3</sub>			KCl	KClO <sub>3</sub>	
The Ternary Eutectic:				Results at 20° (F.)			
1.139	19.40	0.424	KCl + KClO <sub>3</sub> + Ice	1.176	25.70	0.0	KCl
	(N.)			1.183	25.17	0.89	"
--	19.8	0.42	" " "	1.184	24.60	1.55	" + KClO <sub>3</sub>
	(B.&B.)			1.177	25.0 *	1.56	" "
Results at -9.8° (N.)				1.153	20.26	1.75	KClO <sub>3</sub>
				1.106	13.47	2.44	"
1.140	19.77	0.0	KCl	1.070	7.44	3.74	"
1.142	19.73	0.414	"	1.051	2.84	5.18	"
1.143	19.69	0.448	" + KClO <sub>3</sub>	1.044	0.0	6.78	"
1.129	17.98	0.461	KClO <sub>3</sub> + Ice	Results at 30° (F.)			
1.124	17.32	0.467	KClO <sub>3</sub> + Ice	1.182	27.30	0.0	KCl
1.128	18.23	0.0	Ice	1.190	26.64	0.87	"
Results at 0° (F.)				1.198	25.81	2.29	" + KClO <sub>3</sub>
				1.140	17.86	3.12	KClO <sub>3</sub>
1.153	21.90	0.0	KCl	1.108	13.06	3.82	"
1.157	21.16	0.71	" + KClO <sub>3</sub>	1.097	11.03	4.38	"
1.121	16.21	0.82	KClO <sub>3</sub>	1.088	9.45	4.82	"
1.068	8.47	1.09	"	--	4.67	6.62	"
1.022	0.0	3.05	"	1.058	0.0	9.24	"
Results at 10° (N.)				Results at 30° (N.)			
				1.181	27.18	0.0	KCl
1.165	23.8	0.0	KCl	--	26.93	0.706	"
1.168	23.59	0.718	"	1.189	26.69	1.401	"
1.171	23.54	1.088	" + KClO <sub>3</sub>	1.194	26.41	2.289	" + KClO <sub>3</sub>
1.124	16.89	1.331	KClO <sub>3</sub>	1.160	21.49	2.728	KClO <sub>3</sub>
1.071	8.73	1.922	"	1.125	15.95	3.412	"
1.037	2.334	3.341	"	1.092	10.01	4.585	"
1.031	0.563	4.256	"	1.071	6.04	5.82	"
1.030	0.0	4.64	"	1.063	3.523	6.94	"
				1.060	2.205	7.69	"
				1.057	0.889	8.54	"
				1.055	0.0	9.24	"

\*Donald, 1937

(Cont.)

## K KALIUM

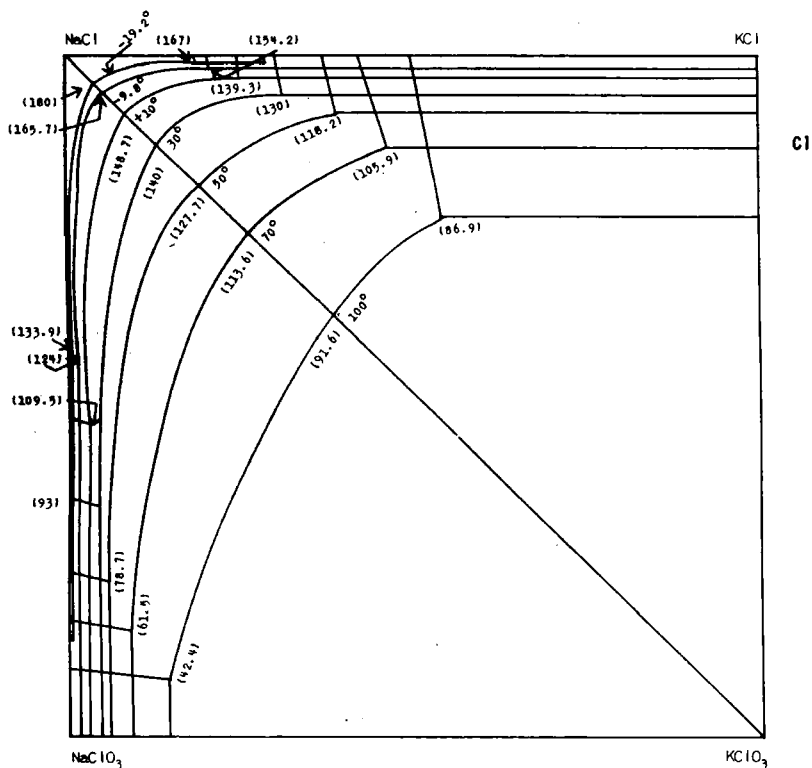
## THE SYSTEM POTASSIUM CHLORIDE - POTASSIUM CHLORATE - WATER--Cont.

d. of sat. sol.	Gms. per 100 gms. sat. sol.			Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.			Solid Phase
	KCl	KClO <sub>3</sub>				KCl	KClO <sub>3</sub>		
Results at 40° (F.)					Results at 70° (N.)--Cont.				
Cl	1.188	28.75	0.0	KCl	1.159	13.17	13.84	KClO <sub>3</sub>	
	1.196	27.74	1.54	"	1.147	8.79	16.52	"	
	1.206	26.49	3.15	" + KClO <sub>3</sub>	1.138	5.17	19.10	"	
	1.165	20.66	3.88	KClO <sub>3</sub>	1.134	2.295	21.39	"	
	1.148	18.43	4.30	"	1.134	0.0	23.49	"	
	1.116	13.16	5.44	"					
	1.106	10.76	6.39	"	Results at 100° (N.)				
	1.098	8.71	7.25	"	1.211	35.72	0.0	KCl	
	1.092	7.66	7.64	"	1.241	32.18	7.81	"	
	1.084	4.60	9.20	"	1.280	29.14	14.57	" + KClO <sub>3</sub>	
1.074	0.0	11.65	"	1.250	21.21	18.71	KClO <sub>3</sub>		
Results at 50° (F.)					1.213	8.40	28.21	"	
1.194	30.18	0.0	KCl	1.215	0.0	26.04	"		
1.207	28.24	3.27	"	Results at 150° (B.&B.)					
1.214	27.45	4.46	" + KClO <sub>3</sub>		34.7	10.40	KCl		
1.211	28.3*	4.32	"		34.4	10.88	"		
1.155	18.53	5.76	KClO <sub>3</sub>		31.7	17.80	"		
1.147	17.55	6.01	"		28.5	23.7	"		
1.105	8.51	9.66	"		26.0	29.5	"		
1.088	0.0	14.76	"		18.22	37.9	KClO <sub>3</sub>		
Results at 50° (N.)						16.90	38.9	"	
1.193	30.06	0.0	KCl		4.97	50.6	"		
1.202	29.45	1.701	"	Results at 175° (B.&B.)					
1.210	28.91	3.173	"		35.5	13.14	KCl		
1.215	28.44	4.275	" + KClO <sub>3</sub>		32.3	19.95	"		
1.184	23.65	5.10	KClO <sub>3</sub>		26.6	32.0	"		
1.157	19.02	6.13	"		20.5	44.9	KCl + KClO <sub>3</sub>		
1.131	13.84	7.92	"		20.4	46.0	"		
1.107	7.65	10.45	"		20.0	46.3	"		
1.095	3.31	13.11	"		9.28	55.9	KClO <sub>3</sub>		
1.091	1.595	14.37	"	Results at 200° (B.&B.)					
1.089	0.0	15.70	"		38.5	12.3	KCl		
Results at 70° (N.)						35.6	16.8	"	
1.201	32.51	0.0	KCl		25.2	36.8	"		
1.213	31.39	2.73	"		21.6	45.9	"		
1.227	30.34	5.30	"		14.55	58.0	"		
1.240	29.41	7.35	" + KClO <sub>3</sub>		51.76	66.6	KCl + KClO <sub>3</sub>		
1.214	25.05	8.61	KClO <sub>3</sub>		3.29	69.4	KClO <sub>3</sub>		
1.193	21.27	9.97	"						
1.175	17.41	11.6	"						

\*Donald, 1937.

THE SYSTEM  $\text{KCl} + \text{NaClO}_3 \rightleftharpoons \text{KClO}_3 + \text{NaCl} (+ \text{H}_2\text{O})$   
(Nallet, 1955; Nallet and Paris, 1956)

Other data for the invariants ( $0^\circ$ ,  $40^\circ$ ) are given by Munter and Brown, 1943. The results of DiCapua and Scaletti, 1927 are in error. Densities were also determined. The figures in parenthesis are grams of  $\text{H}_2\text{O}$  per mole of dissolved salts.





# K KALIUM

## THE SYSTEM POTASSIUM CHLORIDE - POTASSIUM PERCHLORATE - WATER (Benrath and Braun, 1940; Benrath 1943)

### Results of Benrath and Braun, 1940

	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	KCl	KClO <sub>4</sub>		KCl	KClO <sub>4</sub>	
	Results at 150°			Results at 200°-(Cont.)		
Cl	39.6	3.46	KCl	23.9	31.6	KClO <sub>4</sub>
	39.1	5.17	"	22.0	33.6	"
	35.0	11.2	KCl + KClO <sub>4</sub>	11.6	42.8	"
	35.3	11.6	" "	11.1	44.3	"
	33.0	12.3	KClO <sub>4</sub>			
	25.3	17.08	"	Results at 225°		
	23.1	17.7	"			
	16.0	23.7	"	38.7	15.4	KCl
	11.62	26.5	"	29.8	31.8	"
				28.4	34.7	"
	Results at 175°			26.6	38.0	KCl + KClO <sub>4</sub>
	38.6	5.96	KCl	26.4	39.2	" "
	39.1	7.20	"	26.0	39.0	" "
	33.3	18.0	"	15.08	47.5	KClO <sub>4</sub>
	33.0	19.0	KCl + KClO <sub>4</sub>	11.34	51.9	"
	10.3	37.0	KClO <sub>4</sub>	Results at 250°		
	Results at 200°			42.6	11.6	KCl
	41.3	5.7	KCl	41.8	14.6	"
	38.8	12.2	"	35.3	26.5	"
	36.2	16.45	"	32.5	29.2	"
	33.9	21.5	"	24.1	45.6	"
	32.2	23.3	"	24.0	46.3	KCl + KClO <sub>4</sub>
				14.52	55.8	KClO <sub>4</sub>

### Results of Benrath, 1943

t°	Gms. per 100 gms. sat. sol.		Solid Phase
	KCl	KClO <sub>4</sub>	
75	32.2	1.52	KCl + αKClO <sub>4</sub>
100	43.1	3.36	" "
150	34.1	7.80	"
200	35.8	16.7	"
250	38.5	26.8	"

THE SYSTEM  $\text{KCl} + \text{NaClO}_4 \rightleftharpoons \text{KClO}_4 + \text{NaCl} (+\text{H}_2\text{O})$  AT  $25^\circ$   
(Hagemuller, 1951)

	Moles per mole dissolved salts		Gms. $\text{H}_2\text{O}$ per mole dissolved salts	Solid Phase
	$\text{ClO}_4^-$	$\text{Na}^+$		
(A)	0.0003	0.705	136.5	$\text{KCl} + \text{KClO}_4 + \text{NaCl}$
(B)	0.965	0.997	58	$\text{KClO}_4 + \text{NaCl} + \text{NaClO}_4 \cdot \text{H}_2\text{O}$

The shapes of the curves about point A are shown in a diagram.

SOLUBILITY OF POTASSIUM CHLORIDE IN POTASSIUM CHROMATE SOLUTIONS AT  $25^\circ$   
(Herz and Hiebenthal, 1929)

Cl

Gm. Mols. per liter		Gm. Mols. per liter	
$\text{K}_2\text{CrO}_4/6$	KCl	$\text{K}_2\text{CrO}_4/6$	KCl
0.0	4.19	1.73	3.61
0.4	4.01	2.11	3.47
0.8	3.87	2.57	3.33
1.28	3.74	4.69+	2.69

THE SYSTEM POTASSIUM CHLORIDE - POTASSIUM DICHROMATE - WATER  
(Herz and Hiebenthal, 1929)

Results at  $25^\circ$

Gm. Mols. per liter		Solid Phase
$\text{K}_2\text{Cr}_2\text{O}_7/6$	KCl	
0.04	4.15	KCl
0.08	4.12	"
0.16	4.10	"
+0.28	4.05	"

Invariant Solution Compositions at Several Temperatures:  
(Bogoyavlenskii, 1949)

$t^\circ$	Gms. per 100 gms. sat. sol.		Solid Phase
	KCl	$\text{K}_2\text{Cr}_2\text{O}_7$	
0	21.4	0.34	$\text{KCl} + \text{K}_2\text{Cr}_2\text{O}_7$
10	23.4	0.45	" "
20	25.40	0.90	" "
40	27.25	2.28	" "

## K KALIUM

THE SYSTEMS POTASSIUM CHLORIDE - POTASSIUM FLUORIDE - WATER  
 POTASSIUM CHLORIDE - POTASSIUM BIFLUORIDE - WATER  
 (Pinaevskaya and Golubchenko, 1953)

Results for KCl + KF + H <sub>2</sub> O			Results for KCl + KHF <sub>2</sub> + H <sub>2</sub> O		
Sat. Sol. wt. %		Solid Phase	Sat. Sol. wt. %		Solid Phase
KF	KCl		KHF <sub>2</sub>	KCl	
At 25°					
--	26.36	KCl	--	26.36	KCl
3.94	22.83	"	3.96	23.94	"
7.99	19.47	"	8.00	21.97	"
17.75	12.24	"	12.46	19.93	"
30.07	5.42	"	17.36	17.64	"
41.58	1.95	"	18.14	17.28	KCl + KHF <sub>2</sub>
48.56	1.07	"	19.27	15.54	KHF <sub>2</sub>
51.07	0.92	" + KF·2H <sub>2</sub> O	21.48	11.42	"
50.41	--	KF·2H <sub>2</sub> O	23.88	7.41	"
			26.20	4.24	"
			29.75	--	"
At 75°					
--	33.20	KCl	--	33.20	KCl
4.62	28.75	"	4.41	30.22	"
10.40	23.33	"	9.78	27.26	"
22.09	15.29	"	19.22	22.62	"
31.08	9.11	"	26.77	19.27	"
39.81	5.20	"	33.06	16.65	"
51.28	2.58	"	36.33	15.37	"
			40.61	14.15	KCl + KHF <sub>2</sub>
			41.36	12.95	KHF <sub>2</sub>
			44.50	7.51	"
			46.21	5.27	"
			46.68	3.96	"
			47.66	3.48	"
			51.20	--	"

THE SYSTEM POTASSIUM CHLORIDE - POTASSIUM IODIDE - WATER  
 (Zhdanov and Kovolenko, 1948; Amadori and Pampanini, 1911;  
 Harris and Christiansen, 1934; Etard, 1894)

The data are in good agreement: Amadori and Pampanini's results at 25° are similar to those of Zhdanov and Kovolenko, given in the table. Note the different units (g/100 cc) of Harris and Christiansen's data (20, 30, 40°). Empirical equations for the solubility of potassium chloride as a function of the concentration of potassium iodide in solution at 0°, 25°, 50°, and 75° are given by Zhdanov, 1948.

Saturated Solution		Solid Phase	Saturated Solution		Solid Phase
KI	KCl		KI	KCl	
At 0° (Wt. %).			At 0° (Wt. %)-Cont.		
0.0	22.20	KCl	22.21	13.71	KCl
2.45	21.33	"	27.02	12.06	"
4.65	20.43	"	31.51	10.59	"
7.54	19.12	"	35.83	9.34	"
10.08	18.40	"	38.97	8.12	"
12.51	17.12	"	39.75	7.27	"
14.89	16.48	"	41.75	6.74	"
18.17	15.18	"	45.01	5.89	"

(Cont.)

THE SYSTEM POTASSIUM CHLORIDE - POTASSIUM IODIDE - WATER--Cont.

Saturated Solution			Saturated Solution		
KI	KCl	Solid Phase	KI	KCl	Solid Phase
At 0° (Wt. %)-Cont.			At 40°		
47.59	5.48	KCl	(Gms. per 100 cc sat. sol.)		
49.56	4.67	"	0.0	33.98	KCl
51.89	4.07	KI + KCl	95.9	7.86	" + KI
51.88	4.07	" "	97.9	5.55	KI
57.70	0.0	KI	101.2	4.39	"
At 20°			104.5	2.04	"
(Gms. per 100 cc sat. sol.)			107.2	0.0	"
0.0	29.74	KCl	At 50°		
90.7	6.69	" + KI	(Wt. %)		
92.3	5.05	KI	0.0	30.10	KCl
95.3	3.47	"	5.01	27.49	"
97.4	1.82	"	7.52	26.34	"
100.3	0.0	"	10.02	24.85	"
At 25° (Wt. %)			15.39	22.89	"
0.0	26.30	KCl	19.07	19.98	"
3.07	24.55	"	27.87	15.79	"
4.73	23.86	"	35.03	13.15	"
7.19	22.57	"	40.01	11.13	"
8.16	22.10	"	48.82	7.75	"
8.64	21.77	"	54.97	5.73	"
11.80	21.20	"	57.34	5.04	KI + KCl
13.56	19.67	"	57.40	4.85	"
15.27	18.90	"	57.46	4.92	"
19.65	16.90	"	57.40	4.92	"
25.04	15.25	"	62.70	0.0	KI
26.25	14.2	"	At 75°		
29.97	12.80	"	(Wt. %)		
31.60	12.22	"	0.0	33.20	KCl
33.81	11.61	"	4.00	31.06	"
36.13	10.52	"	9.29	27.67	"
38.74	9.77	"	15.04	25.14	"
41.38	8.55	"	18.36	23.05	"
43.02	8.01	"	20.02	22.09	"
45.14	7.38	"	24.98	19.56	"
47.19	6.63	"	30.13	17.15	"
49.02	6.10	"	35.85	14.01	"
53.12	5.01	"	40.93	12.54	"
54.54	4.53	KI + KCl	45.02	9.40	"
54.52	4.57	"	49.84	8.70	"
54.67	4.60	"	55.86	6.65	"
54.60	4.52	"	58.00	5.43	KI + KCl
54.57	4.53	"	59.01	5.42	"
59.76	0.0	KI	59.06	5.46	"
At 30°			59.02	5.44	"
(Gms. per 100 cc sat. sol.)			65.30	0.0	KI
0.0	31.88	KCl			
92.9	7.84	" + KI			
96.8	5.53	KI			
98.0	4.21	"			
100.4	2.03	"			
103.2	0.78	"			

(Cont.)

## K KALIUM

COMPOSITION OF SOLUTIONS SATURATED WITH KCl + KI  
(Etard, 1894)

t°	Grams per 100 gms. Solution		t°	Grams per 100 gms. Solution	
	KCl	KI		KCl	KI
0	3.7	50.5	100	6.2	61.0
20	4.2	53.0	140	7.3	63.7
40	4.7	55.3	180	8.3	65.5
60	5.2	57.5	220	9.4	66.3
80	5.7	59.4	245	10.0	66.5

C1 THE SYSTEM POTASSIUM CHLORIDE - POTASSIUM IODATE - WATER  
(Hill and Ricci, 1931)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	KIO <sub>3</sub>	KCl			KIO <sub>3</sub>	KCl	
Results at 5°				Results at 25°-Cont.			
1.155	0.0	22.84	KCl	1.073	4.29	5.93	KIO <sub>3</sub>
1.170	1.44	22.64	" + KIO <sub>3</sub>	1.066	5.83	2.78	"
1.147	1.50	19.56	KIO <sub>3</sub>	1.071	8.45	0.0	"
1.084	1.79	10.13	"	Results at 50°			
1.044	2.91	3.03	"				
1.043	5.16	0.0	"				
Results at 25°				--	0.0	30.03	KCl
				--	1.77	29.40	"
				--	3.07	29.08	" + KIO <sub>3</sub>
1.179	0.0	26.36	KCl	--	3.74	23.17	KIO <sub>3</sub>
1.197	2.10	25.82	" + KIO <sub>3</sub>	--	4.71	15.64	"
1.153	2.40	19.64	KIO <sub>3</sub>	--	7.42	6.83	"
1.109	3.01	12.37	"	--	13.21	0.0	--

SOLUBILITY OF POTASSIUM CHLORIDE IN AQUEOUS SOLUTIONS OF  
POTASSIUM PERMANGANATE AT 25°  
(Herz and Hiebenthal, 1929)

Gm. Moles per liter		
K <sub>2</sub> MnO <sub>4</sub>	KCl	Solid Phase
5		
0.0	4.19	KCl
0.05	4.02	"
0.11	4.04	"
0.40+	4.00	"

## THE SYSTEM POTASSIUM CHLORIDE - POTASSIUM NITRATE - WATER

The various data have been recalculated to a weight percent basis. Additional results for this system at 0°, 20°, 40°, 60°, 80°, 100° and 320° in terms of the number of gm. mols. H<sub>2</sub>O required to dissolve 100 gm. mols. of the two salts of determined molecular ratio, are given by Janecke, 1928. Results at 14.5° and 25.2° in gm. per liter of saturated solution are given by Touren, 1900. Additional data at 20° are given by Leather and Mukerji, 1913 and Soch, 1898, and at 25° by Armstrong and Eyre, 1910-11. Additional data at 80, 100 and 125° are given by Uspenskaya and Bergman, 1955. Early work by Etard, 1894, Rudorff, 1873, Nichol, 1891.

Gms. per 100 gms. sat. sol.				Gms. per 100 gms. sat. sol.				Gms. per 100 gms. sat. sol.			
KCl		KNO <sub>3</sub>		Solid Phase		KCl		KNO <sub>3</sub>		Solid Phase	
Results at 0° (Hering, 1926; Armstrong and Eyre, 1910-11; Tanaka, 1930)				Results at 18.5° (Holluta and Mautner, 1927)-Cont.							
0.0	11.7	--	KNO <sub>3</sub>	5.80	18.7	1.1682	KNO <sub>3</sub>				
0.0	11.75	--	"	11.7	15.5	1.1887	"				
12.47	8.04	--	"	17.1	13.5	1.2141	"				
20.07	6.96	--	KNO <sub>3</sub> + KCl	21.8	12.0	1.2415	" + KCl				
20.3	6.39	--	" + "	22.2	10.8	1.2348	KCl				
(20.44	6.38	--	" + ")*	23.3	7.31	1.2147	"				
20.7	8.02	--	KCl	24.1	4.44	1.1985	"				
21.25	3.48	--	"	24.6	2.98	1.1899	"				
21.71	1.98	--	"	24.9	1.50	1.1820	"				
21.46	0.0	--	"	25.4	0.0	1.1738	"				
21.8	0.0	--	"	Results at 20.5° (Bodlander, 1891)							
22.10	0.0	--	"	0.0	23.8	1.1625	KNO <sub>3</sub>				
*Nikalajew, 1929 at 0.2°				4.03	20.8	1.1700	"				
Results at 10° (Tanaka, 1930)				6.58	19.1	1.1765	"				
0.0	17.3	--	KNO <sub>3</sub>	10.3	17.0	1.1895	"				
12.03	11.43	--	"	12.6	15.8	1.1983	"				
21.18	9.33	--	" + KCl	16.1	14.5	1.2150	"				
23.7	0.0	--	KCl	18.0	13.9	1.2265	"				
Results at 17.5° (Bodlander, 1891)				20.1	13.5	1.2400	"				
25.0	0.0	1.1730	KCl	Results at 25° (Hering, 1926; Nikalajew, 1929)							
22.9	5.48	1.1980	"	0.0	27.86	--	KNO <sub>3</sub>				
22.6	7.34	1.2100	"	0.0	27.6	1.189	"				
21.6	10.2	1.2250	"	4.50	24.02	--	"				
21.0	12.0	1.2360	"	5.7	22.9	1.197	"				
20.9	12.3	1.2390	"	6.74	22.30	--	"				
20.9	12.5	1.2388	"	10.65	19.82	--	"				
21.1	12.4	1.2410	"	11.0	19.4	1.213	"				
Results at 18.5° (Holluta and Mautner, 1927)				15.64	17.20	--	"				
0.0	23.0	1.1560	KNO <sub>3</sub>	21.0	14.9	1.256	"				
1.15	22.0	1.1573	"	21.9	14.6	1.261	" + KCl				
2.31	21.2	1.1598	"	21.94	14.72	--	" + "				
3.47	20.2	1.1621	"	22.95	11.41	--	KCl				
(Cont.)				23.0	10.8	1.238	"				
				23.75	7.92	--	"				
				25.05	4.30	--	"				
				26.4	0.0	1.179	"				
				26.5	0.0	--	"				

## K KALIUM

## THE SYSTEM POTASSIUM CHLORIDE - POTASSIUM NITRATE - WATER--Cont.

Gms. per 100 gms. sat. sol.				Solid Phase	Gms. per 100 gms. sat. sol.				Solid Phase
KCl		KNO <sub>3</sub>			KCl		KNO <sub>3</sub>		
Dens. Sat. Sol.					Dens. Sat. Sol.				
Results at 30° (Leather and Mikerji, 1913; Barbaudy, 1923)					Results at 100° ( <sup>a</sup> Nikalajew, 1929; <sup>b</sup> Uspenskaya and Bergman, 1955)				
0.0	31.4	--	KNO <sub>3</sub>	<sup>a</sup> 14.96	53.88	--	KNO <sub>3</sub> + KCl		
5.48	26.36	--	"	<sup>b</sup> 10.7	61.7	--	" + "		
6.40	25.8	1.225	"	Results at 125° (Uspenskaya and Bergman, 1955)					
10.48	22.0	--	"	7.40	73.5	--	KNO <sub>3</sub> + KCl		
12.8	21.3	1.241	"	Results at 150° (Benrath and Braun, 1940)					
18.2	18.5	1.258	"	1.18	81.9	--	KNO <sub>3</sub>		
C1 20.25	17.25	--	"	3.69	79.5	--	"		
21.3	16.8	--	"	7.85	78.0	--	" + KCl		
21.8	16.5	1.281	" + KCl	8.35	75.3	--	KCl		
21.9	16.65	--	" + "	9.50	71.3	--	"		
22.18	16.39	--	KCl	14.15	58.9	--	"		
22.78	13.42	--	"	18.70	47.4	--	"		
23.3	12.4	1.251	"	23.2	37.2	--	"		
23.43	11.63	--	"	29.8	21.8	--	"		
25.3	5.56	1.219	"	37.6	5.6	--	"		
27.2	0.0	--	"	Results at 200° (Benrath and Braun, 1940)					
27.3	0.0	1.186	"	3.19	87.0	--	KNO <sub>3</sub>		
Results at 40° (Leather and Mikerji, 1913)				6.24	85.4	--	" + KCl		
7.05	32.0	1.279	KNO <sub>3</sub>	7.72	82.0	--	KCl		
13.4	27.4	1.297	"	8.02	81.6	--	"		
18.5	23.9	1.312	"	11.95	70.9	--	"		
21.2	22.4	1.319	" + KCl	21.4	48.3	--	"		
(21.28	21.98	--	" + ")*	25.8	36.1	--	"		
21.5	20.5	1.305	KCl	28.0	33.1	--	"		
25.0	10.8	1.252	"	33.5	22.5	--	"		
28.9	0.0	1.194	"	36.2	16.85	--	"		
*Nikalajew, 1929				38.0	12.60	--	"		
Result at 60° (Nikalajew, 1929)				40.9	7.04	--	"		
18.56	34.12	--	KNO <sub>3</sub> + KCl	Results at 250° (Benrath and Braun, 1940)					
Results at 80° ( <sup>a</sup> Nikalajew, 1929; <sup>b</sup> Uspenskaya and Bergman, 1955)				0.59	93.7	--	KNO <sub>3</sub>		
<sup>a</sup> 15.47	46.29	--	KNO <sub>3</sub> + KCl	4.67	91.0	--	" + KCl		
<sup>b</sup> 11.0	54.2	--	KNO <sub>3</sub> + KCl	9.56	82.4	--	KCl		
Results at 91° (Leather and Mikerji, 1913)				12.34	75.7	--	"		
0.0	67.0	1.552	KNO <sub>3</sub>	18.3	62.0	--	"		
5.25	61.1	1.545	"	30.0	37.4	--	"		
11.1	55.4	1.544	"	39.6	18.3	--	"		
13.2	53.8	1.552	" + KCl	41.6	13.9	--	"		
16.8	44.5	1.486	KCl	44.9	5.9	--	"		
23.8	26.3	1.344	"						
34.8	0.0	1.222	"						

For additional data see p. 255, this volume.

THE SYSTEM  $\text{KCl} + \text{HNO}_3 \rightleftharpoons \text{KNO}_3 + \text{HCl} (+\text{H}_2\text{O})$   
(Epstein and Kosterina, 1939)

Compositions of solutions saturated with  $\text{KCl} + \text{KNO}_3$ .

Moles per 1000 moles $\text{H}_2\text{O}$				Moles per 1000 moles $\text{H}_2\text{O}$			
$\text{H}^+$	$\text{K}^+$	$\text{Cl}^-$	$\text{NO}_3^-$	$\text{H}^+$	$\text{K}^+$	$\text{Cl}^-$	$\text{NO}_3^-$
Results at $-20^\circ$				Results at $0^\circ$ —Cont.			
110	14.2	106.7	17.5	190	14.6	134.1	70.5
130	10.4	117.8	22.5	210	16.7	136.7	90.0
150	7.6	127.3	30.3	220	20.0	137.5	102.5
170	5.1	134.7	40.4				
190	4.8	141.2	53.6				
210	6.7	147.0	69.7				
220	8.7	149.2	79.5				
Results at $0^\circ$				Results at $21.5^\circ$			
110	20.5	104.0	26.5	110	39.5	104.5	45.0
130	17.4	104.7	32.7	130	33.6	111.6	52.0
150	15.1	123.1	42.0	150	30.8	117.7	63.1
170	14.2	129.7	54.5	170	30.0	122.5	77.5
				190	31.0	126.0	95.0
				210	34.7	128.2	116.5
				220	38.7	128.7	130.0

Cl

Nikolaeff and Kogan, 1938 determined the solubilities of  $\text{KNO}_3$ ,  $\text{KCl}$ , and  $\text{HNO}_3$  in solutions containing 5%, 7%, 10%, and 15%  $\text{HCl}$  in water from  $-50^\circ$  to  $+60^\circ$ . The results are expressed in %  $\text{N}_2\text{O}_5$ , %  $\text{K}_2\text{O}$ , and %  $\text{HCl}$  in the saturated solutions.

Data for the system  $\text{KCl} + \text{KNO}_3 + \text{H}_2\text{O}$  with added  $\text{HCl}$  and  $\text{KOH}$  are given by Nikalajew, 1929.

THE SYSTEM  $\text{KCl} + \text{KNO}_3 + \text{NH}_3 + \text{H}_2\text{O}$   
(Alexandrov, 1946)

Gms. per 100 gms. H <sub>2</sub> O			Density	Solid Phase
NH <sub>3</sub>	KCl	KNO <sub>3</sub>		
Results at -10°				
10.0	17.9	3.3	1.074	KCl + KNO <sub>3</sub>
25.0	12.0	1.8	0.995	"
39.3	9.2	1.7	0.946	"
Results at 0°				
10.0	20.8	5.7	1.096	KCl + KNO <sub>3</sub>
24.9	14.8	3.5	1.013	"
39.4	11.3	3.4	0.960	"
Results at 20°				
10.0	26.4	12.9	1.143	KCl + KNO <sub>3</sub>
25.0	19.2	9.4	1.042	"
41.4	14.7	9.2	0.979	"
Results at 40°				
10.0	31.0	28.9	1.190	KCl + KNO <sub>3</sub>
24.3	23.1	22.4	1.078	"
35.3	29.8	19.0	—	"
37.0	19.2	19.0	—	"



# K KALIUM

The system  $\text{KCl} - \text{K}_2\text{CrO}_4 - \text{KNO}_3 - \text{H}_2\text{O}$  was studied from the eutectic to  $40^\circ$  by Palkin and Bogoyavlenskii, 1941. No compounds, hydrates, nor solid solutions are found in the system.

## THE SYSTEM POTASSIUM CHLORIDE - POTASSIUM NITRATE - POTASSIUM SULFATE - WATER AT SEVERAL TEMPERATURES (Hering, 1926)

t°	d. of sat. sol.	Gms. per 100 gms. H <sub>2</sub> O			Solid Phase
		KCl	KNO <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>	
0	—	27.4	8.8	1.15	KCl + KNO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>
25	1.212	34.9	7.42	1.45	KCl + K <sub>2</sub> SO <sub>4</sub>
CI	"	1.236	34.5	1.41	" + "
"	1.266	34.2	23.1	1.40	" + " + KNO <sub>3</sub>
50	1.353	37.6	53.6	1.57	" + " + "
75	1.258	46.6	16.7	2.08	" + "
"	1.322	44.4	40.8	1.93	" + "
"	1.393	41.8	72.9	1.80	" + "
"	1.461	39.1	110.3	1.77	" + " + KNO <sub>3</sub>
100	1.573	39.8	204.0	1.86	" + " + "

The following values for this system are given by Kritschensky and Goldmann, 1933.

25	—	35.23	23.84	0.70	KCl + KNO <sub>3</sub>
"	—	35.82	12.48	1.45	" + K <sub>2</sub> SO <sub>4</sub>
"	—	31.22	21.66	1.38	" + " + KNO <sub>3</sub>
"	—	12.57	29.77	2.66	KNO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>

## THE SYSTEM $\text{KCl} + \text{NH}_4\text{NO}_3 \rightleftharpoons \text{KNO}_3 + \text{NH}_4\text{Cl} (+\text{H}_2\text{O})$

Data for this system are given by Janecke, 1928 from  $0^\circ$ – $80^\circ$ , Aronawa and Lunskaia, 1933 at  $100^\circ$ , Kritschewsky and Goldmann, 1934 at  $-10^\circ$  and  $-15^\circ$ . Bergman, 1938 gives data from  $-15^\circ$  to  $+30^\circ$  for the sections  $\text{KCl} + \text{NH}_4\text{NO}_3 + \text{H}_2\text{O}$  and  $\text{KNO}_3 + \text{NH}_4\text{Cl} + \text{H}_2\text{O}$ . The eutectic is at  $-16.4^\circ$ , with  $\text{KNO}_3 + \text{NH}_4\text{Cl} + \text{ICE}$  as saturating phases. Below  $24.4^\circ$  the stable salt pair is  $\text{KNO}_3 + \text{NH}_4\text{Cl}$ .

## THE SYSTEM $\text{KCl} + \text{NaNO}_3 \rightleftharpoons \text{KNO}_3 + \text{NaCl} (+\text{H}_2\text{O})$ (Reinders, 1914, 1915; see also Uyeda, 1909–10)

Additional data at  $80^\circ$ ,  $100^\circ$  and  $125^\circ$  are given by Uspenskaya and Bergman, 1955. For data below  $25^\circ$ , see Khitrova, 1956.

Results at  $25^\circ$

Results at  $50^\circ$

Gms. per 100 Gms. H <sub>2</sub> O				Gms. per 100 Gms. H <sub>2</sub> O				Solid Phase
NaCl	KCl	NaNO <sub>3</sub>	KNO <sub>3</sub>	NaCl	KCl	NaNO <sub>3</sub>	KNO <sub>3</sub>	
36.04	—	—	—	36.72	—	—	—	A
32.28	10	—	—	—	—	—	—	A
30.27	16.45	—	—	28.35	23.09	—	—	A, B
12	26.78	—	—	—	42.80	—	—	B
—	35.54	—	10	—	41.39	—	24.05	B
—	34.92	—	22.79	—	38.75	—	52.54	B, D

A = NaCl, B = KCl, D = KNO<sub>3</sub>

(Cont.)

## Results at 25°--Cont.

## Results at 50°--Cont.

Gms. per 100 Gms. H <sub>2</sub> O				Gms. per 100 Gms. H <sub>2</sub> O				Solid Phase
NaCl	KCl	NaNO <sub>3</sub>	KNO <sub>3</sub>	NaCl	KCl	NaNO <sub>3</sub>	KNO <sub>3</sub>	
--	10	--	31.48	--	--	--	85.10	D
--	--	10	37.49	--	--	--	--	D
--	--	60	41.87	--	--	--	--	D
--	--	100.9	46.15	--	--	134.9	90.2	C, D
--	--	96.06	20	--	--	114.1	--	C
10	--	77.46	--	--	--	--	--	C
23.62	--	58.01	--	20.5	--	84.8	--	A, C
33.90	--	10	--	28.4	--	43.9	--	A
24.82	22.2	15.4	--	34	13.4	--	24.3	A, B
21.36	20	--	32.9	12.7	25.4	--	58.6	B, D
24.5	--	61.3	17.2	--	--	--	--	C, D
7	--	82.1	43.15	19.2	--	104.1	27.2	A, C
23.8	--	64	41.2	12.2	--	110.7	82.2	A, C, D
4.5	--	--	40.3	59.9	--	6.1	70.9	A, B, D

## Results at 5°

## Results at 100°

31.50	10.4	--	--	27.3	36.2	--	--	A, B
--	29.84	--	10.14	--	41.6	--	199	B, D
--	--	82.10	18.1	--	--	233.6	218	C, D
27.6	--	41.7	--	19.2	--	158	--	A, C
				22.4	--	326	312	A, C, D

## Results at 80°

14.9	--	203	164	--	--	--	--	A, C, D
------	----	-----	-----	----	----	----	----	---------

## Results at 125°

30.7	--	463	476	--	--	--	--	A, C, D
------	----	-----	-----	----	----	----	----	---------

A = NaCl, B = KCl, C = NaNO<sub>3</sub>, D = KNO<sub>3</sub>.

THE SYSTEM  $K^+$ ,  $Na^+||Cl^-$ ,  $NO_3^-$ ,  $SO_4^{=}$ , +  $H_2O$ 

Complete experimental data, including densities, in the form of tabular results and diagrams for this complex system at temperatures between 0° and 90° are given by Cornec and Krombach, 1929, and Cornec, Krombach and Spack, 1930. These authors have made use, when necessary, of the results for the ternary and quaternary systems previously reported from their own laboratory and by other workers, including, Chretien, 1929, Cornec and Hering, 1925-7, Cornec and Krombach, 1929, Meyerhoffer and Saunders, 1899, d'Ans, 1915 and Blasdale, 1918.

# K KALIUM

## THE SYSTEM $K^+, NH_4^+, Na^+ || Cl^-, NO_3^- + H_2O$ AT $20^\circ$ (Schutse, Piechowicz, and Wahl, 1943)

Moles per 1000 moles of Water					Solid Phases
$K^+$	$NH_4^+$	$Na^+$	$Cl^-$	$NO_3^-$	
26.1	66.9	73.1	166.1	--	$KCl + NH_4Cl + NaCl$
91	320	160	--	571	$KNO_3 + NH_4NO_3 + NaNO_3$
65.6	99.7	104.6	158.7	112.2	$KCl + NH_4Cl + NaCl + KNO_3$
80	202	181	114	349	$NH_4Cl + NaCl + NaNO_3 + KNO_3$
95	415	172	100	582	$NH_4Cl + KNO_3 + NH_4NO_3 + NaNO_3$

Results for the system  $KCl + KNO_3 + NH_4H_2PO_4 + H_2O$  from  $-11.7^\circ$  to  $+35^\circ$  are given by Bergman and Shakhparonov, 1952.

Cryoacopic, transport and pH data for the system  $KCl - HgCl_2 - H_2O$  showing 2 complexes (2:1, 1:1) are given by Aggarwal, 1957.

## THE SYSTEM POTASSIUM CHLORIDE - POTASSIUM DIHYDROGEN PHOSPHATE - WATER

The system  $KCl - KH_2PO_4 - H_2O$  was studied by Polosin and Shakhparonov, 1939 from the eutectic to  $+35^\circ$ . No compounds were formed. The eutectic temperature is  $-10.8^\circ$  and the saturated solution contains 18.84%  $KCl$  and 2.31%  $KH_2PO_4$ .

The data below are those of Askenasy and Nessler, 1930 at  $0^\circ$ . They are expressed in the Janecke method which is in terms of the number of gm. mols. of  $H_2O$  required to dissolve 100 gm. mols. of salt or salt mixture of determined molecular composition.

d. of sat. sol.	Composition of Dissolved Salts in Gm. Mols.		Gm. Mols. $H_2O$ to dissolve 100 gm. mols. salt mixture	Solid Phase
	$KCl$	$KH_2PO_4$		
1.1420	100.0	0.0	1440	$KCl$
1.1690	95.8	4.2	1420	"
1.1750	92.1	7.9	1415	" + $KH_2PO_4$
1.1427	73.0	27.0	1840	$KH_2PO_4$
1.1199	62.7	37.3	2210	"
1.1183	44.9	55.1	2860	"
1.1179	31.7	68.3	3320	"
1.1158	18.1	81.9	3540	"
1.1151	0.0	100.0	4125	"

## THE SYSTEM $KCl + NH_4H_2PO_4 \rightleftharpoons KH_2PO_4 + NH_4Cl (+H_2O)$

Data for the composition of saturated solutions containing  $KCl$  and  $NH_4H_2PO_4$ , with solid solutions  $(K, NH_4)Cl$  and  $(K, NH_4)H_2PO_4$  as saturating phases are given by Polosin and Shakhparonov, 1947 from  $-11.2$  to  $35^\circ$ . Askenasy and Nessler, 1930 give data for the system at  $0^\circ$ . Kurnakov, Zvorykin and Ketkovich, 1948 give data for the system at  $25^\circ$ , alone and with various amounts of added  $NH_3$ .

THE SYSTEM POTASSIUM CHLORIDE - POTASSIUM PERRHENATE - WATER  
(Smith, 1946)

Results at 0°			Results at 30°		
Gms. per 100 gms. H <sub>2</sub> O			Gms. per 100 gms. H <sub>2</sub> O		
KReO <sub>4</sub>	KCl	Solid Phase	KReO <sub>4</sub>	KCl	Solid Phase
0.36	0.0	KReO <sub>4</sub>	1.47	0.0	KReO <sub>4</sub>
.027	9.51	"	0.423	1.63	"
.023	20.63	"	.173	1.53	"
.022	28.05	KReO <sub>4</sub> + KCl	.114	13.84	"
.017	28.10	KCl	.072	37.47	KReO <sub>4</sub> + KCl
.007	28.04	"	.000	37.42	KCl
.000	28.02	"			

THE SYSTEM POTASSIUM CHLORIDE - POTASSIUM SULFATE - WATER  
(Shul'gina, Kharchuk and Yanat'eva, 1955 (-8° to +20°); Anosov and Byzova,  
1947 (0 to 100°); Dolique and Pauc, 1947, 1948 (20°, 30°); Hering, 1926  
(0 to 100°); Campbell, Downes and Samis, 1934 (100°);  
Blasdale, 1918 (0 - 100°))

Results from 200-650° at up to 350 atm. are reported by Ravich and Borovaya, 1949 and by Ravich, Borovaya, and Ketkovich, 1953.

**I = Ice**

$$C_1 = KC_1$$
$$S = K_2SO_4$$
$$S.1 = K_2SO_4 \cdot H_2O$$

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
KCl	K <sub>2</sub> SO <sub>4</sub>	Density		KCl	K <sub>2</sub> SO <sub>4</sub>	Density	
Results at -8°				Results at 0° (Shul'gina, Kharchuk and Yanat'eva, 1955)			
15.8	0.0	--	I				
15.5	0.4	--	"				
14.9	1.0	--	"	21.8	0.0	--	CI
14.65	1.3	--	"	21.7	0.5	--	"
				21.6	0.8	--	"
				21.5	0.9	--	" + S-I
				(21.6)	(0.93) <sup>1</sup>	1.163	" + S
				(21.5)	(0.84) <sup>2</sup>	--	" + "
				(21.6)	(0.94) <sup>3</sup>	--	" + "
				19.3	1.2	--	S-I
				17.3	1.4	--	"
				12.9	2.1	--	"
				8.4	3.2	--	"
				3.3	5.5	--	"
				--	7.2	--	"
Results at -6°				<sup>1</sup> Anosov and Bysova, 1947 <sup>2</sup> Hering, 1926 <sup>3</sup> Blasdale, 1918			
12.7	0.0	--	I				
12.5	0.3	--	"				
11.6	1.1	--	"				
11.0	1.8	--	"				
Results at -4°							
8.8	0.0	--	I				
8.2	0.8	--	"				
7.6	1.3	--	"				
6.9	2.7	--	"				
Results at -2°							
4.7	0.0	--	I				
4.1	0.7	--	"				
3.8	1.4	--	"	23.3	1.00	--	CI + S
2.7	4.5	--	"				

(Cont.)

## K KALIUM

## THE SYSTEM POTASSIUM CHLORIDE - POTASSIUM SULFATE - WATER—Cont.

I = Ice

Cl = KCl

S =  $K_2SO_4$ S-1 =  $K_2SO_4 \cdot H_2O$ 

Gms. per 100  
gms. sat. sol.

Gms. per 100  
gms. sat. sol.

KCl	K <sub>2</sub> SO <sub>4</sub>	Density	Solid Phase
Results at 15° (Shul'gina, Kharchuk and Yanat'eva, 1955)			
24.6	0.0	---	Cl
24.3	0.8	---	"
24.2	1.1	---	Cl + S
(21 )	(1.8) <sup>1</sup>	---	Cl + S
21.7	1.3	---	S
19.6	1.7	---	"
14.7	2.5	---	"
10.1	3.8	---	"
3.9	6.5	---	"
0.0	9.0	---	"

<sup>1</sup>Kopp, at 15.8°.

Results at 20°  
(Shul'gina, Kharchuk and Yanat'eva, 1955; Dolique and Pauc, 1947 give the figures with densities)

25.5	0.0	---	Cl
25.6	0.0	1.173	"
25.4	0.5	---	"
25.2	0.8	---	"
25.1	1.15	1.179	"
25.1	1.15	---	Cl + S
25.0	2.31	1.181	" + "
(24.8)	(1.06) <sup>1</sup>	---	" + "
22.8	1.45	---	S
22.7	1.52	1.171	"
20.5	1.8	---	"
16.2	2.80	1.129	"
15.5	2.5	---	"
11.0	4.2	---	"
10.9	4.3	1.100	"
6.24	5.1	1.085	"
4.3	7.2	---	"
0.0	9.7	---	"
0.0	10.0	1.081	"

<sup>1</sup>Precht and Wittgen.

Results at 25°  
(Hering, 1926)

26.4	0.0	1.179	Cl
26.0	1.06	1.185	" + S
(25.2)	(2.13) <sup>1</sup>	---	" + "
(25.7)	(1.11) <sup>2</sup>	(1.191)	" + "

<sup>1</sup>Van't Hoff and Meyerhoffer.

<sup>2</sup>Anosov and Byzova, 1947.

KCl	K <sub>2</sub> SO <sub>4</sub>	Density	Solid Phase
Results at 25°—Cont.			
21.0	1.65	1.153	S
15.0	2.79	1.120	"
8.0	5.26	1.092	"
0.0	10.8	1.086	"

Results at 30°  
(Anosov and Byzova, 1947)

27.2	0.0	1.189	Cl
26.9	0.35	1.190	"
26.22	1.135	1.193	" + S
(26.2)	(1.14) <sup>1</sup>	---	" + "
(25.7)	(2.3) <sup>2</sup>	---	" + "
(26.2)	(1.09) <sup>3</sup>	---	" + "
24.4	1.61	1.182	S
19.55	2.39	1.166	"
14.32	4.18	1.121	"
8.59	6.41	1.105	"
4.73	7.92	1.095	"
2.83	9.10	1.093	"
0.0	11.48	1.089	"

<sup>1</sup>Precht and Wittgen.

<sup>2</sup>Dolique and Pauc, 1948.

<sup>3</sup>Schreinemakers and DeBaat, 1914.

Result at 40°  
(Precht and Wittgen)

27.5	1.20	---	Cl + S
------	------	-----	--------

Results at 50°  
(Anosov and Byzova, 1947)

30.0	0.0	1.198	Cl
28.8	1.27	1.204	" + S
(28.8)	(1.27) <sup>1</sup>	---	" + "
(29.4)	(1.24) <sup>2</sup>	1.200	" + "
18.70	3.53	1.143	S
12.80	6.00	1.123	"
9.76	7.39	1.120	"
2.84	11.69	1.115	"
0.0	14.17	1.112	"

<sup>1</sup>Precht and Wittgen.

<sup>2</sup>Hering, 1926.

Result at 60°  
(Precht and Wittgen)

30.1	1.33	---	Cl + S
------	------	-----	--------

(Cont.)

## THE SYSTEM POTASSIUM CHLORIDE - POTASSIUM SULFATE - WATER—Cont.

I = Ice

Cl = KCl

S =  $K_2SO_4$ S-1 =  $K_2SO_4 \cdot H_2O$ Gms. per 100  
gms. sat. sol.Gms. per 100  
gms. sat. sol.

KCl	$K_2SO_4$	Density	Solid Phase	KCl	$K_2SO_4$	Density	Solid Phase
-----	-----------	---------	-------------	-----	-----------	---------	-------------

Results at 70°  
(Anosov and Byzova, 1947)

32.6	0.0	1.212	Cl
31.3	1.39	1.223	Cl + S
30.0	1.81	1.206	S
22.19	4.09	1.160	"
13.40	7.80	1.130	"
8.89	10.08	1.125	"
3.83	13.65	1.121	"
0.0	16.60	1.120	"

Results at 75°  
(Hering, 1926)

33.1	0.0	1.203	Cl
32.3	1.42	1.211	" + S
26.0	2.47	1.171	S
18.7	4.47	1.135	"
10.0	8.77	1.110	"
0.0	17.1	1.116	"

Result at 80°  
(Precht and Wittgen)

32.5	1.46	--	Cl + S
------	------	----	--------

Results at 100°  
(Anosov and Byzova, 1947)

36.1	0.0	--	Cl
34.77	1.64	--	" + S
(35.96)	(1.63) <sup>1</sup>	--	" + "
(34.9)	(1.62) <sup>2</sup>	1.216	" + "
(34.7)	(1.61) <sup>3</sup>	--	" + "
34.4	1.81	--	S
26.7	3.77	--	"
22.1	5.32	--	"
15.7	8.32	--	"
9.47	12.36	--	"
0.0	19.4	--	"

<sup>1</sup>Campbell, Downs, and Samis, 1934.<sup>2</sup>Hering, 1926.<sup>3</sup>Precht and Wittgen.THE SYSTEM  $2KCl + (NH_4)_2SO_4 \rightleftharpoons K_2SO_4 + 2NH_4Cl (+H_2O)$  AT 25°  
(Hill and Loucks, 1937)

The authors also give results for the 4 component systems saturated with solid phases composed of mixtures of the three solid solutions of the salts. They also investigated, for the purpose of industrial preparation of  $K_2SO_4$ , the field in which this salt separates in order to learn what percentage of  $(NH_4)_2SO_4$  accompanies it as a contamination.

The results in parentheses show the composition of the solid solutions present as solid phases.

Results for the 3 component Systems in water at 25°:

Gms. per 100 gms. sat. solution				Solid Phase
$(NH_4)_2SO_4$	KCl	$K_2SO_4$	$NH_4Cl$	
--	26.42	--	--	KCl
--	25.90	1.05	--	" + $K_2SO_4$
--	0.0	10.80	--	$K_2SO_4$
10.36	--	9.59	--	(0.953 $K_2SO_4$ + 0.047 $(NH_4)_2SO_4$ )
15.40	--	8.72	--	(0.925 " + 0.075 " )
28.31	--	6.12	--	(0.773 " + 0.227 " )
39.20	--	2.86	--	(0.195 " + 0.805 " )
43.42	--	--	--	$(NH_4)_2SO_4$
26.12	--	--	16.35	" + $NH_4Cl$
--	11.02	--	21.97	(0.166 $NH_4Cl$ + 0.834 KCl) + (0.975 $NH_4Cl$ + 0.025 KCl)
--	26.42	--	--	KCl

(Cont.)

## K KALIUM

Results for the 3 component Systems in Water at 25°,  
sat. with NH<sub>3</sub> at 1 atm. pressure:

Gms. per 100 gms. sat. solution					Solid Phase
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	KCl	K <sub>2</sub> SO <sub>4</sub>	NH <sub>4</sub> Cl		
--	15.26	--	--	KCl	
--	15.30	trace	--	" + K <sub>2</sub> SO <sub>4</sub>	
--	0.0	0.20	--	K <sub>2</sub> SO <sub>4</sub>	
2.85	--	--	--	(0.932 K <sub>2</sub> SO <sub>4</sub> + 0.068 (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> )	
7.56	--	0.23	--	(0.776 " + 0.224 " )	
11.35	--	--	--	(0.676 " + 0.324 " )	
11.98	--	--	--	(0.525 " + 0.475 " )	
13.54	--	0.20	--	(0.342 " + 0.658 " )	
14.97	--	--	--	(0.186 " + 0.814 " )	
17.55	--	0.07	--	(0.083 " + 0.917 " )	
18.4	--	0	--	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	
4.66	--	--	33.72	" + NH <sub>4</sub> Cl	
--	--	--	35.59	NH <sub>4</sub> Cl	
--	2.86	--	33.59	(0.158 NH <sub>4</sub> Cl + 0.842 KCl) + (0.977 NH <sub>4</sub> Cl + 0.023 KCl)	

THE SYSTEM  $2\text{KCl} + \text{Na}_2\text{SO}_4 \rightleftharpoons \text{K}_2\text{SO}_4 + 2\text{NaCl} (+\text{H}_2\text{O})$   
(Meyerhoffer and Saunders, 1899 (below 30°); Blasdale, 1918 (0, 25, 50, 75, 100°); Teeple, 1929 (35, 50, 75°); Zaslavsky, Sinani and Sokolova, 1938 (-5, 25, 75°); Rustamov, 1957, 1957a (below 30°); Ravich and Borovaya, 1953 (up to 500°, 70 kg./cm.<sup>2</sup>))

Data of Meyerhoffer and Saunders, 1899:						
t°	Sp. Gr. of Solutions	Mols. per 1000 Mols. H <sub>2</sub> O				Solid Phase
		SO <sub>4</sub>	K <sub>2</sub>	Na <sub>2</sub>	Cl <sub>2</sub>	
*4.4	--	5.42	14.39	51.83	60.8	K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub> +Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O+KCl+NaCl
0.2	--	3.35	12.78	50.93	60.36	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O+KCl+NaCl
0.4	--	3.59	16.38	40.75	53.54	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O+KCl+K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub>
16.3	--	4.72	17.58	50.56	63.42	K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub> +KCl+NaCl
24.8	1.2484	4.37	20.00	48.36	64.01	K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub> +KCl+NaCl
*16.3	--	16.29	9.16	61.06	53.93	K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub> +NaCl+Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O+Na <sub>2</sub> SO <sub>4</sub>
24.5	1.2625	14.45	9.90	58.46	53.91	K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub> +NaCl+Na <sub>2</sub> SO <sub>4</sub>
0.3	--	2.75	25.77	17.93	40.95	K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub> +KCl+K <sub>2</sub> SO <sub>4</sub>
25.0	1.2034	2.94	36.20	14.80	48.06	K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub> +KCl+K <sub>2</sub> SO <sub>4</sub>
*17.9	1.2474	13.84	0.0	62.57	48.70	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O+Na <sub>2</sub> SO <sub>4</sub> +NaCl
*30.1	1.2890	50.41	10.08	40.33	0.0	K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub> +Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O+Na <sub>2</sub> SO <sub>4</sub>
-21.4	--	--	--	46.61	46.36	NaCl·2H <sub>2</sub> O+Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
-23.7	--	--	10.51	39.58	50.09	NaCl·2H <sub>2</sub> O+KCl
-10.9	--	1.45	30.68	--	29.23	KCl+K <sub>2</sub> SO <sub>4</sub>
-3	--	16.25	10.03	6.21	--	K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub> +Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
-3	--	16.24	10.03	6.21	--	K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub> +K <sub>2</sub> SO <sub>4</sub>
-14	--	1.39	25.59	8.78	32.94	K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub> +Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O+KCl
-14	--	1.39	25.59	8.78	32.94	K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub> +K <sub>2</sub> SO <sub>4</sub> +KCl
-23.3	--	0.41	15.15	44.20	58.97	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O+KCl+NaCl·2H <sub>2</sub> O

\*Indicates transition points.

(Cont.)

Data of Rustamov, 1957, 1957a:

t°	Moles per 1000 moles H <sub>2</sub> O				Solid Phase
	Na <sub>2</sub> Cl <sub>2</sub>	K <sub>2</sub> Cl <sub>2</sub>	Na <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	
-23.6	--	--	--	--	Ice, KCl, NaCl·2H <sub>2</sub> O, Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
-20	36.85	9.57	1.19	--	Ice, KCl, Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
	42.8	11.1	0.91	--	NaCl·2H <sub>2</sub> O, KCl, Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
-15	45.07	11.26	1.13	--	NaCl·2H <sub>2</sub> O, KCl, Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
	29.88	7.85	1.21	--	Ice, KCl, Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
-10	45.88	11.18	1.76	--	NaCl·2H <sub>2</sub> O, KCl, Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
	13.13	25.69	--	0.39	KCl, K <sub>2</sub> SO <sub>4</sub> , Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
	9.62	16.48	--	3.79	Ice, Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O, K <sub>2</sub> SO <sub>4</sub>
- 5 <sup>a</sup>	49.03	10.14	--	1.89	NaCl·2H <sub>2</sub> O, KCl, Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
	25.49	17.67	--	3.33	KCl, Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O, NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	10.96	8.44	--	5.96	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O, K <sub>2</sub> SO <sub>4</sub> , NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	7.60	2.59	--	7.93	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O, K <sub>2</sub> SO <sub>4</sub> , Ice
	17.5	21.48	--	2.88	KCl, K <sub>2</sub> SO <sub>4</sub> , NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
0	48.0	12.0	2.56	--	NaCl·2H <sub>2</sub> O, Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O, KCl
	38.33	14.44	2.89	--	KCl, Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O, NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	16.54	25.58	--	0.43	KCl, K <sub>2</sub> SO <sub>4</sub> , NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	--	7.20	8.88	2.62	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O, K <sub>2</sub> SO <sub>4</sub> , NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
+ 5	47.63	13.15	5.07	--	NaCl, Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O, NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	47.88	13.33	2.83	--	NaCl, KCl, NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	16.55	28.45	--	0.45	KCl, K <sub>2</sub> SO <sub>4</sub> , NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
10	43.4	11.94	7.55	--	NaCl, Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O, NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	47.82	15.23	3.31	--	NaCl, KCl, NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	16.44	28.77	--	0.46	KCl, K <sub>2</sub> SO <sub>4</sub> , NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
15	46.47	10.58	8.33	--	NaCl, Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O, NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	46.66	17.0	3.0	--	NaCl, KCl, NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	16.74	29.95	--	0.47	KCl, K <sub>2</sub> SO <sub>4</sub> , NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
20	17.77	30.2	--	2.79	KCl, K <sub>2</sub> SO <sub>4</sub> , NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	45.15	17.6	3.71	--	NaCl, KCl, NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	43.44	9.18	15.30	--	NaCl, Na <sub>2</sub> SO <sub>4</sub> , NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	36.46	10.42	22.57	--	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O, Na <sub>2</sub> SO <sub>4</sub> , NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
25	26.54	--	29.01	7.40	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O, Na <sub>2</sub> SO <sub>4</sub> , NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	43.53	9.47	13.67	--	NaCl, Na <sub>2</sub> SO <sub>4</sub> , NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	43.58	19.93	4.06	--	NaCl, KCl, NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	17.25	35.22	--	3.08	KCl, K <sub>2</sub> SO <sub>4</sub> , NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
30	9.37	--	48.62	5.62	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O, Na <sub>2</sub> SO <sub>4</sub> , NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	43.93	9.33	13.4	--	NaCl, Na <sub>2</sub> SO <sub>4</sub> , NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	43.59	20.95	3.53	--	NaCl, KCl, NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
	16.06	34.2	--	2.93	K <sub>2</sub> SO <sub>4</sub> , KCl, NaK <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>

<sup>a</sup>data of Zaslavsky, Sinani and Sokolova, 1938.

Data of Blasdale, 1818 at 25°:

(Similar results are given for 0°, 50°, 75° and 100°)

d. of sat. sol.	Gms. per 100 gms. H <sub>2</sub> O				Solid Phase
	KCl	K <sub>2</sub> SO <sub>4</sub>	NaCl	Na <sub>2</sub> SO <sub>4</sub>	
1.212	--	--	--	27.93	Na <sub>2</sub> SO <sub>4</sub>
1.088	--	12.02	--	--	K <sub>2</sub> SO <sub>4</sub>
1.187	36.96	--	--	--	KCl
1.199	--	--	35.63	--	NaCl
1.282	--	9.31	--	30.97	Na <sub>2</sub> SO <sub>4</sub> +K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub> (Glaserite)

(Cont.)



## K KALIUM

Data of Blasdale, 1818 at 25°—Cont.

d. of sat. sol.	Gms. per 100 gms. H <sub>2</sub> O				Solid Phase
	KCl	K <sub>2</sub> SO <sub>4</sub>	NaCl	Na <sub>2</sub> SO <sub>4</sub>	
1.149	—	13.24	—	6.69	K <sub>2</sub> SO <sub>4</sub> + K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub> (Glaserite)
1.190	36.63	1.53	—	—	" + KCl
1.237	16.28	—	29.88	—	NaCl + "
1.239	—	—	32.19	9.81	" + Na <sub>2</sub> SO <sub>4</sub>
1.243	—	—	18.82	21.68	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub>
1.273	—	7.32	14.28	22.28	" + " + K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub>
1.200	29.38	2.23	6.78	—	KCl + K <sub>2</sub> SO <sub>4</sub> + K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub>
1.250	16.37	—	27.96	3.51	" + NaCl + "
1.266	—	11.04	34.90	2.25	Na <sub>2</sub> SO <sub>4</sub> + NaCl + K <sub>3</sub> Na(SO <sub>4</sub> ) <sub>2</sub>

Cl

Results for the system  $2\text{KCl} + \text{Na}_2\text{SO}_4 \rightleftharpoons \text{K}_2\text{SO}_4 + 2\text{NaCl}$  in solutions containing up to 35% NH<sub>3</sub> at 20°, 0° and -15° are given by Chevetin and Gilliot, 1950 and Gilliot, 1951.

THE SYSTEM K<sup>+</sup>, Na<sup>+</sup> || Cl<sup>-</sup>, SO<sub>4</sub><sup>=</sup>, NO<sub>3</sub><sup>-</sup> (+H<sub>2</sub>O)

Complete experimental data, including densities, in the form of tabular results and diagrams for these complex systems at temperatures between 0° and 90° are given by Cornec and Krombach, 1929 and Cornec, Krombach and Spack, 1930. These authors made use, wherever necessary of the results for the ternary systems previously reported from their own laboratory or by others including Chretien, 1929; Cornec and Hering, 1925-7, Cornec and Krombach, 1929; Meyerhoffer and Saunders, 1899; d'Ans, 1915 and Blasdale, 1918.

THE SYSTEM K<sup>+</sup>, Na<sup>+</sup>, Mg<sup>++</sup> || Cl<sup>-</sup>, SO<sub>4</sub><sup>=</sup> (+H<sub>2</sub>O)

Data for this system are given by Froehlich, 1929 (20°-200°); Campbell, Downs, and Samis, 1934 (100°); Karsten, 1950, who refers to Yanat'eva work (1949a); Feakes, 1952 (90°). A study of the metastable equilibria in the system is reported by Valyashko and Solov'eva, 1949.

Data for the system  $2\text{KCl} + \text{MgBr}_2 \rightleftharpoons 2\text{KBr} + \text{MgCl}_2$  (+H<sub>2</sub>O) at 20°, re-calculated from the results of Boeke, 1908, are given by Janেকে, 1938.

THE SYSTEM 2KCl + MgSO<sub>4</sub> = K<sub>2</sub>SO<sub>4</sub> + MgCl<sub>2</sub> (+H<sub>2</sub>O)

The system has been studied by Kurnakov and Shoikhet, 1938 (25°); Kurnakov and Loukianova, 1938 (25°); Lepeahkov and Bodaleva, 1949 (25°); Autenrieth, 1954 (15, 25, 35, 55°); Zorkin and Petukhova, 1940 (35, 50°); Solov'eva, 1949 (24°); Solov'eva, 1953 (15°); Luk'yanova, Sokol and Sololova, 1956 (75°). Autenrieth, 1954 also gives data in solutions simultaneously saturated with NaCl at 25°, 35° and in solutions saturated with KCl at 15, 25, 35, 55°.

THE SYSTEM POTASSIUM CHLORIDE - BERYLLIUM CHLORIDE - WATER AT 25°  
(Bliden, 1956)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
KCl	BeCl <sub>2</sub>		KCl	BeCl <sub>2</sub>	
26.48	0.0	KCl	6.01	17.99	KCl
24.24	1.44	"	3.65	23.93	"
18.11	5.52	"	2.73	32.22	"
14.05	9.60	"	0.80	34.30	"
8.92	13.02	"	0.0	41.72	BeCl <sub>2</sub> ·4H <sub>2</sub> O

THE SYSTEM KCl - BiCl<sub>3</sub> - HCl - H<sub>2</sub>O AT 25°  
(Nardelli, Braibanti and Chierici, 1956)

Cl

Sat. Sol. wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
KCl	BiCl <sub>3</sub>	HCl		KCl	BiCl <sub>3</sub>	HCl	
3.08	17.11	23.98	KCl	4.89	40.22	9.18	K <sub>2</sub> BiCl <sub>5</sub> ·2H <sub>2</sub> O
3.28	17.91	23.47	"	3.04	53.83	9.78	"
3.72	20.22	21.91	"	3.14	55.76	10.11	"
6.10	22.62	19.57	KCl+K <sub>7</sub> Bi <sub>3</sub> Cl <sub>16</sub>	3.51	56.21	8.79	"
7.15	23.23	19.96	"	1.87	51.13	15.05	K <sub>2</sub> BiCl <sub>5</sub>
6.96	23.76	17.06	"	2.67	51.60	12.50	"
7.18	23.96	16.70	"	1.29	53.16	15.85	"
3.85	19.61	24.32	K <sub>7</sub> Bi <sub>3</sub> Cl <sub>16</sub>	2.43	56.58	11.91	"
2.12	20.52	27.61	"	2.71	57.42	11.19	"
1.77	17.03	28.19	"	1.87	58.92	13.09	"
1.29	24.73	26.64	"	3.14	61.06	9.06	"
2.63	25.92	25.19	"	2.61	68.06	9.86	"
1.19	26.13	25.99	"	1.97	76.77	6.60	KBiCl <sub>4</sub> ·H <sub>2</sub> O
7.70	27.26	14.78	"	1.95	77.46	6.68	"
2.47	27.39	25.05	"	1.21	74.63	9.07	"
2.30	30.33	22.85	"	2.71	74.43	7.02	KBiCl <sub>4</sub> ·H <sub>2</sub> O+BiCl <sub>3</sub>
3.01	32.11	24.95	"	1.22	81.48	4.82	"
3.91	34.22	17.23	"	2.83	82.90	3.56	"
4.55	36.61	15.06	"	--	80.55	7.10	BiCl <sub>3</sub>
3.12	38.51	19.44	"	--	81.08	5.74	"
2.24	44.29	21.80	"	--	64.90	9.73	"
				--	78.18	3.80	"

FREEZING POINTS IN THE SYSTEM KCl + CaCl<sub>2</sub> + H<sub>2</sub>O  
(Mun and Darier, 1956)

m = moles KCl + CaCl<sub>2</sub> per 1000 gms. H<sub>2</sub>O.

KCl = moles KCl per 100 moles dissolved salts.

t° = freezing point, °C.

m	KCl	t°	m	KCl	t°	m	KCl	t°
2.46	0.00	-20.60	1.80	42.00	-9.12	1.11	81.24	-3.90
2.46	22.61	-16.60	1.80	61.08	-7.67	1.11	100.00	-3.50
2.46	41.71	-13.48	1.80	80.07	-6.60	0.64	0.00	-3.20
2.46	61.64	-10.95	1.80	100.00	-5.80	0.64	21.68	-2.80
2.46	80.76	-9.15	1.11	0.00	-6.60	0.64	40.44	-2.50
2.46	100.00	-7.90	1.11	21.02	-5.80	0.64	61.29	-2.35
1.80	0.00	-13.20	1.11	41.21	-4.90	0.64	80.00	-2.20
1.80	21.73	-10.81	1.11	61.16	-4.46	0.64	100.00	-2.10

## K KALIUM

THE SYSTEM  $\text{KCl} + \text{CaCl}_2 + \text{MgCl}_2 + \text{H}_2\text{O}$   
(Perova, 1957)

Results at 25°				Results at 55°			
Sat. Sol. wt. %			Solid Phase	Sat. Sol. wt. %			Solid Phase
KCl	CaCl <sub>2</sub>	MgCl <sub>2</sub>		KCl	CaCl <sub>2</sub>	MgCl <sub>2</sub>	
3.0	2.80	25.2	A + B	4.0	2.80	25.20	A + B
3.2	11.60	17.40	"	4.0	11.88	17.82	"
3.3	18.45	12.30	"	4.2	18.25	12.16	"
3.2	24.0	8.0	"	4.1	26.25	8.75	"
3.4	28.26	3.14	"	4.3	36.30	3.70	"
3.4	28.50	1.50	"	4.3	34.39	1.81	"
C 4.0	44.20	1.30	A + B + C	5.9	49.90	2.10	A + B + F
1.0	42.47	2.23	B + C	4.1	54.20	1.50	B + F + G
1.0	40.97	4.53	"	2.5	54.15	2.85	B + F
0.85	38.5	9.30	B + C + D	1.80	53.10	5.02	B + D + G
0.4	34.88	11.62	B + D	1.70	51.30	5.80	B + D
0.25	30.5	14.80	B + D + E	1.5	38.63	12.87	"
0.5	26.10	17.40	B + E	1.2	28.20	18.80	"
0.3	15.92	23.88	"	1.0	17.52	26.28	"
0.25	3.62	32.58	"	0.8	13.80	29.2	B + D + E
				0.7	3.90	35.1	B + E

A = KCl; B = Carnallite =  $\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ ; C =  $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$ ;  
 D = Takhydrite =  $\text{CaCl}_2 \cdot \text{MgCl}_2 \cdot 12\text{H}_2\text{O}$ ; E =  $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ ;  
 F = Gidrofillite =  $\text{KCl} \cdot \text{CaCl}_2$ ; G =  $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ .

THE SYSTEM POTASSIUM CHLORIDE - LITHIUM CHLORIDE - WATER  
(Blidin, 1953c (30, 40°); Campbell and Kartzmark, 1956 (25°))

Results at 25°		Results at 30°		Results at 40°		Solid Phase
Sat. sol. wt. %		Sat. sol. wt. %		Sat. sol. wt. %		
LiCl	KCl	LiCl	KCl	LiCl	KCl	
45.4	0.0	45.48	0.0	47.98	0.0	LiCl·H <sub>2</sub> O
44.2	2.3	45.07	0.86	47.41	1.52	"
45.3	3.2	43.52	2.04	45.56	2.42	" + KCl
37.8	0.6	41.13	2.78	44.54	3.02	KCl*
28.3	3.5	37.04	3.52	40.15	4.48	"
23.1	4.7	31.27	4.65	34.48	5.17	"
18.5	7.3	24.58	6.87	24.27	7.61	"
4.1	21.2	20.26	8.50	20.16	8.84	"
0.0	26.99	13.35	13.41	15.76	11.22	"
		5.69	20.25	5.86	21.07	"
		0.0	26.78	0.0	28.67	"

\*Tie line data indicate the presence of about 2% KCl in the solid phase at 30°.

THE SYSTEM POTASSIUM CHLORIDE - SODIUM CHLORIDE -  
LITHIUM CHLORIDE - WATER  
(Yanatieva, 1947)

These results differ somewhat from those following.

t°	Gms. per 100 gms. sat. sol.			Density	Solid Phase
	KCl	NaCl	LiCl		
0	1.43	0.73	36.80	1.252	KCl + NaCl + LiCl·H <sub>2</sub> O
25	9.76	13.98	6.05	1.217	KCl + NaCl
25	6.14	5.25	16.95	1.189	"
25	3.32	0.80	44.20	1.322	KCl + NaCl + LiCl·H <sub>2</sub> O
50	13.00	12.77	6.15	1.233	KCl + NaCl
50	8.49	6.94	15.71	1.207	"
50	6.03	1.09	45.59	1.359	KCl + NaCl + LiCl·H <sub>2</sub> O

Cl

Data of Campbell and Kartzmark, 1956 at 25°

Gms. per 100 gms. sat. sol.	Gms. per 100 gms. sat. sol.			Density	Solid Phase
	KCl	NaCl	LiCl		
10.4	21.1	0.0		--	KCl + NaCl
9.9	15.7	4.5		--	" "
8.8	12.5	8.1		--	" "
7.6	10.7	8.2		--	" "
1.3	2.2	32.9		--	" "
3.1	0.2	41.5		--	" + LiCl·H <sub>2</sub> O

THE SYSTEM POTASSIUM CHLORIDE - MAGNESIUM CHLORIDE - WATER

In addition to the data below, the system has been studied by Precht and Wittgen (1881), Feit and Przibylla (1909), d'Ans and Syplena (1942), Zorkin and Petuthova (1940), Solov'eva (1953a), Pozner and Biryukova (1954), van't Hoff and Meyerhoffer (1899, 1912), Mun and Darer (1957).

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
MgCl <sub>2</sub>	KCl	MgCl <sub>2</sub>		KCl			
Results at 0° (Igelsrud, and Thompson, 1936)				Results at 25° (Lee & Egerton, 1923, Keitel, 1923) Data in parentheses are densities.			
0.0	21.87	KCl	0.0	26.74	KCl		
5.88	15.21	"	(1.182)				
9.49	11.70	"	7.68	19.50	"		
16.33	6.31	"	12.11	13.56	"		
25.24	2.35	"	(1.201)				
26.79	2.12	KCl + 1.1.6	15.64	11.54	"		
27.03	1.68	1.1.6	16.40	10.36	"		
29.70	0.49	"	19.83	7.90	"		
34.68	0.026	" + MgCl <sub>2</sub> ·6H <sub>2</sub> O	(1.234)				
34.63	0.0	MgCl <sub>2</sub> ·6H <sub>2</sub> O	23.10	6.06	"		
Results at 15° (Keitel, 1923)				24.58	5.22	"	
				26.81	4.56	"	
				26.66	3.19	"	
7.66	17.66	KCl	26.80	3.27 (L.&E.)	" + 1.1.6		
16.57	10.73	"	27.70	3.70 (K.)	" + "		
23.83	5.49	"	35.14	0.50	1.1.6 + MgCl <sub>2</sub>		
27.59	2.76	KCl + 1.1.6	35.54	0.0	MgCl <sub>2</sub>		
35.10	0.0	MgCl <sub>2</sub> ·6H <sub>2</sub> O	(1.341)				

(Cont.)

## K KALIUM

## THE SYSTEM POTASSIUM CHLORIDE - MAGNESIUM CHLORIDE - WATER--Cont.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
MgCl <sub>2</sub>	KCl	Solid Phase	MgCl <sub>2</sub>	KCl	Solid Phase
Results at 35° (Lightfoot and Prutton, 1946, 1947)			Results at 100° (Campbell, Downs and Samis, 1934; Achumow & Wassilijew, 1932, starred) Data in parentheses are densities.		
0.0	28.04	KCl	0.0	36.0	KCl
3.70	23.53	"	4.35	29.80	"
9.41	16.95	"	*6.60	27.4	"
15.24	11.42	"	9.93	23.59	"
21.41	6.85	"	16.35	17.50	"
27.32	3.80	" + 1.1.6	*19.7	14.5	"
27.34	3.81	" + "	20.15	13.45	"
30.40	1.38	1.1.6	24.80	9.60	"
33.63	0.38	"	*31.1	6.72	"
36.17	0.14	1.1.6 + MgCl <sub>2</sub> ·6H <sub>2</sub> O	*40.9	0.585	"
36.28	0.0	MgCl <sub>2</sub> ·6H <sub>2</sub> O	29.89	5.15	" + 1.1.6
Results at 55° (Keitel, 1923)			*31.5	6.40	1.1.6
7.24	23.40	KCl	(1.307)		
15.14	14.79	"	40.0	1.88	1.1.6
22.72	9.79	"	40.0	1.64	1.1.6
28.74	4.43	" + 1.1.6	41.0	0.73	" + MgCl <sub>2</sub> ·6H <sub>2</sub> O
36.88	0.62	MgCl <sub>2</sub> ·6H <sub>2</sub> O + 1.1.6	*41.7	0.52	" + MgCl <sub>2</sub> ·4H <sub>2</sub> O
37.38	0.21	MgCl <sub>2</sub> ·6H <sub>2</sub> O	(1.384)		
37.55	0.0	"	Results at 105° (Keitel, 1923)		
Results at 75° (Lightfoot and Prutton, 1946, 1947)			0.0	36.45	KCl
0.0	33.16	KCl	6.52	29.90	"
7.51	23.98	"	13.97	21.87	"
12.65	18.36	"	14.08	21.72	"
20.95	10.73	"	21.44	14.83	"
28.43	5.88	"	30.82	7.00	" + 1.1.6
29.26	5.57	" + 1.1.6	36.51	3.62	1.1.6
29.25	5.57	" + "	40.75	1.07	" + MgCl <sub>2</sub> ·6H <sub>2</sub> O
30.08	4.54	1.1.6	43.47	0.0	MgCl <sub>2</sub> ·6H <sub>2</sub> O
31.75	3.00	"	Results at 125° (Achumow and Wassilijew, 1932)		
33.57	1.73	"	6.33	30.4	KCl
35.84	0.81	"	19.0	17.7	"
37.04	0.58	"	30.1	9.65	"
38.85	0.32	1.1.6 + MgCl <sub>2</sub> ·6H <sub>2</sub> O	39.3	4.60	"
38.86	0.32	" + "	38.5	5.58	" + 1.1.6
39.12	0.0	MgCl <sub>2</sub> ·6H <sub>2</sub> O	(1.335)		
Results at 83° (Keitel, 1923)			46.4	1.46	1.1.6 + MgCl <sub>2</sub> ·4H <sub>2</sub> O
7.15	26.85	KCl	(1.420)		
14.63	18.31	"	Results at 150° (Achumow and Wassilijew, 1932)		
14.77	18.27	"	6.03	33.7	KCl
20.53	12.75	"	18.2	21.0	"
29.45	5.80	" + 1.1.6	29.2	12.5	"
36.99	2.52	1.1.6			
37.80	1.01	" + MgCl <sub>2</sub> ·6H <sub>2</sub> O			
39.80	0.0	MgCl <sub>2</sub> ·6H <sub>2</sub> O			

(Cont.)

## THE SYSTEM POTASSIUM CHLORIDE - MAGNESIUM CHLORIDE - WATER--Cont.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
MgCl <sub>2</sub>	KCl	Solid Phase	MgCl <sub>2</sub>	KCl	Solid Phase
Results at 150°--Cont.			Results at 200°		
44.9	5.24	KCl	(Achumow and Wassilijew, 1932)		
44.2	4.60	" + 1.1.6	Data in parentheses are densities.		
(1.381)			5.60	38.6	KCl
50.5	1.77	1.1.6 + MgCl <sub>2</sub> ·4H <sub>2</sub> O	17.1	25.8	"
(1.435)			27.8	16.4	"
[53.0	2.07	KCl + MgCl <sub>2</sub> ·4H <sub>2</sub> O] *	43.6	7.86	"
(1.455)			55.0	2.30	" + MgCl <sub>2</sub> ·2H <sub>2</sub> O
*167°			(1.472)		

Cl

Data for the System KCl + RbCl + MgCl<sub>2</sub> + H<sub>2</sub>O at 25°, recalculated from the results of D'ans and Bush, 1937, are given by Janecke, 1937, 1938. The 100° isotherm of this system is reported by Makarov, Perelman and Logkova, 1941.

The distribution of bromide ions between solid phases and liquid phases in systems containing K<sup>+</sup>, Mg<sup>++</sup>, Na<sup>+</sup>, Cl<sup>-</sup> and H<sub>2</sub>O was studied by Cirkov and Schnee, 1939. The effect of the rate of crystallization on the distribution was also determined.

The distribution of micro amounts of Br<sup>-</sup> between the solution and solid phases during isothermal evaporation was studied by Cirkov, 1944, in the following systems: KCl + H<sub>2</sub>O at 25°, 107°; KCl + NaCl + H<sub>2</sub>O at 25°; KCl + I<sup>-</sup> + H<sub>2</sub>O at 25°; KCl + NaCl + I<sup>-</sup> + H<sub>2</sub>O at 25°; KCl + MgCl<sub>2</sub> + H<sub>2</sub>O at 35°.

The system K<sup>+</sup>, Mg<sup>++</sup>, Na<sup>+</sup> || Cl<sup>-</sup>, SO<sub>4</sub><sup>=</sup> + H<sub>2</sub>O is reported by Yanat'eva, 1949a. Various graphical representations of the system are given by Pel'sh, 1953. For data above 100° see Achoumow and Wassilijew, 1932.

The system KCl - MnCl<sub>2</sub> - H<sub>2</sub>O was studied from the eutectic to + 20° by polythermal analysis by Ozerov, 1953.

## THE SYSTEM POTASSIUM CHLORIDE - AMMONIUM CHLORIDE - WATER

The salts from 2 series of limited solid solutions. Most of the data are in good agreement. Additional results are given by Uyeda, 1912.

Results expressed on a weight basis. (See also below)  
(Jarykoff, 1934; Dolique and Pauc, 1947 (20°), 1948b (30°))  
[K = KCl rich phase; N = NH<sub>4</sub>Cl rich phase]

Gms. per 100 Gms. H <sub>2</sub> O			Solid Phase	Gms. per 100 Gms. H <sub>2</sub> O			Solid Phase
KCl	NH <sub>4</sub> Cl	Density		KCl	NH <sub>4</sub> Cl	Density	
Results at 0°				Results at 20°			
28.10	0.0	1.1642	K	34.39	0.0	1.173	K
20.80	10.37	1.1316	K	20.74	20.22	--	K
13.69	24.07	1.1162	K + N	20.15	20.59	--	K
11.04	25.65	1.1057	N	16.26	29.48	1.130	K
0.0	29.9	1.066	N	15.8	30.92	--	K

(Cont.)

# K KALIUM

## THE SYSTEM POTASSIUM CHLORIDE - AMMONIUM CHLORIDE - WATER--Cont.

[K = KCl rich phase; N = NH<sub>4</sub>Cl rich phase]

	Gms. per 100 Gms. H <sub>2</sub> O		Density	Solid Phase	Gms. per 100 Gms. H <sub>2</sub> O		Density	Solid Phase
	KCl	NH <sub>4</sub> Cl			KCl	NH <sub>4</sub> Cl		
Cl	Results at 20°--Cont.				Results at 30°--Cont.			
	15.3	31.9	1.132	K + N	7.23	36.56	--	N
	14	31.8	1.124	N	4.53	39.36	--	N
	6.72	35.6	1.098	N	0.0	41.6	--	N
	3.35	35.93	1.089	N	Results at 45°			
	0.0	37.4	1.076	N				
	Results at 25°				41.13	0.0	1.1956	K
					35.6	7.62	1.1775	K
	36.40	0.0	1.1775	K	26.9	21.90	1.1506	K
	26.71	12.24	1.1540	K	17.51	39.70	1.350	K + N
	27.37	21.60	1.1417	K	7.67	44.1	1.1075	N
	16.40	32.0	1.1322	K	0.0	48.0	1.085	N
	15.73	32.70	1.1322	K + N	Results at 65°			
	14.64	32.9	1.1282	N				
	0.0	40.1	1.064	N	46.9	0.0	1.209	K
	Results at 30°				35.76	15.60	1.1788	K
		38.10	0.0	--	K	30.3	27.30	1.526
	33.64	5.77	--	K	18.8	48.5	1.1390	K + N
	28.73	13.79	--	K	0.0	56.5	1.086	N
	24.77	20.02	--	K	Results at 90°			
	22.99	19.55	--	K				
	17.83	28	--	K	52.5	0.0	1.2184	K
	16.85	30.22	--	K	39.3	20.5	1.1760	K
	16.57	34.93	--	K	32.4	36.9	1.1547	K
	16.44	28.15	--	K	21.5	59.31	1.1570	K + N
	15.63	33.88	--	K	18.0	60.9	1.1450	N
	15.25	30.69	--	K + N	0.0	68.1	1.1020	N
	14.1	30.55	--	N				

Results on a mole basis (see also below)

(Janecke, 1923; Flatt and Burkhardt, 1944; Askenasy and Nessler, 1930)

Moles H <sub>2</sub> O per mole dissolved salts	Mole % NH <sub>4</sub> Cl in:		Moles H <sub>2</sub> O per mole dissolved salts	Mole % NH <sub>4</sub> Cl in:	
	dissolved salts	Solid Phase		dissolved salts	Solid Phase
Results at 0°			Results at 20°		
14.30	0.0	0	12.10	0.0	0
13.30	20 (A.&N.)	5	10.90	20	--
12.20	40 ( " )	10	9.70	40	--
10.30	60 ( " )	16	8.40	60	--
9.50	71.5	19 + 95.5	7.40	72.5	25 + 95
9.90	80 (A.&N.)	96.5	7.20	80	--
10.00	100	100	8.00	100	100

(Cont.)

Moles H <sub>2</sub> O per mole dissolved salts	Mole % NH <sub>4</sub> Cl in:		Moles H <sub>2</sub> O per mole dissolved salts	Mole % NH <sub>4</sub> Cl in:	
	dissolved salts	Solid Phase		dissolved salts	Solid Phase
Results at 25° (F.&B.)			Results at 60°		
11.40	0.0	0.0	9.05	0.0	0
10.00	27.9	3.0	7.60	20	--
9.58	32.2	2.5	6.50	40	--
8.47	52.4	9.2	5.50	60	---
8.05	56.2	11.0	5.10	76	56 + 91
7.13	68.5	19.4	5.20	80	--
7.07	70.5	22.4	5.40	100	100
6.89	73.3	26.6			
6.67	74.2	98.6			
6.78	76.1	98.5			
7.00	84.6	99.1			
7.47	100.0	100.0			
Results at 40°			Results at 80°		
			8.10	0.0	0
			4.30	80	62 + 90
			4.50	100	100
10.30	0.0	0			
9.20	20	--			
8.20	40	--			
7.50	60	---			
6.20	74	34 + 93.5	7.30	0.0	0
6.20	80	--	3.60	84.5	72 + 91
6.50	100	100	3.90	100	100
			Results at 100°		

Other results at 25°  
(Fock, 1897)

Grams per Liter Solution		Mol. per cent in Solution		Sp. Gr. of Solutions	Mol. per cent in Solid Phase	
NH <sub>4</sub> Cl	KCl	NH <sub>4</sub> Cl	KCl		NH <sub>4</sub> Cl	KCl
0.00	311.3	0.00	100.0	1.1807	0.0	100
22.81	293.3	9.41	90.59	1.1716	1.21	98.79
35.39	278.7	15.04	84.96	1.1678	2.11	97.89
89.17	273.2	34.26	65.74	1.1591	6.18	93.82
127.8	234.6	46.59	53.44	1.1493	8.90	91.10
147.2	204.2	51.63	48.37	1.1461	10.53	89.47
197.3	157.7	63.56	36.44	1.1391	17.86	82.14
232.5	116.8	73.49	26.51	1.1326	60.20	39.80
244.5	123.0	73.48	26.52	1.1329	76.88	23.12
261.9	111.0	79.10	20.90	1.1245	97.51	2.49
259.0	102.2	82.14	17.86	1.1212	97.79	2.21
278.6	53.16	87.96	12.04	1.1009	98.85	1.15
320.7	31.24	93.45	6.55	1.0912	99.33	0.67
273.5	0.00	100.00	0.00	1.0768	100.0	0.00

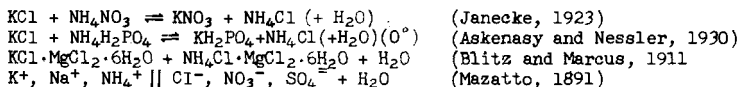
(Cont.)



Other results at 25°--Cont.  
(Blitz and Marcus, 1911)

Composition of Sat. Solution				Composition of Solid Phase		
Gms. per 100 gms. sat. sol.		Mols. per 1000 Mols. H <sub>2</sub> O		Gms. per 100 gms. Crystals		Mol. % NH <sub>4</sub> Cl in Crystals
NH <sub>4</sub> Cl	KCl	NH <sub>4</sub> Cl	KCl	NH <sub>4</sub> Cl	KCl	
5.13	22.29	23.8	74.2	1.21	98.79	1.7
7.00	20.40	32.5	67.9	2.22	97.78	3.1
11.00	18.04	52.2	61.4	4.00	96.00	5.5
13.73	16.11	65.9	55.5	5.89	94.11	8.0
15.46	14.53	74.4	50.2	7.24	92.76	9.8
19.54	12.16	96.3	43.0	11.20	88.80	14.9
22.04	10.49	109	37.4	16.90	83.10	22.1
21.68	10.40	109	37.4	26.04	73.96	32.9
21.95	10.48	109	37.4	97.60	2.40	98.3
24.30	6.48	118.2	22.6	98.28	1.72	98.8

Results are given for the following systems:



#### THE SYSTEM POTASSIUM CHLORIDE - SODIUM CHLORIDE - WATER

(Cornec and Krombach, 1932; Blasdale, 1918; Ackoumov and Wassilijew, 1932; Bergman and Vlassov, 1949; See also DiCapua and Scalletti, 1927 at 20°, Holluta and Moutner, 1927 at 18.5°)

The earlier data of Precht and Wittgen, 1881; Etard, 1897; Leather and Mukerji, 1913; Nichol, 1891; Reinders, 1915; and D'Ans, 1915 are not in very good agreement with those given below. From the eutectic to 190°, the data are those of Cornec and Krombach, 1932; from 100 to 300°, Ackoumov and Wassilijew. Results from 300 to 600°, up to 350 atm. pressure are given by Ravich and Borovaya, 1949, 1950.

t°	Density	Sat. sol. wt. %		Solid Phase	t°	Density	Sat. sol. wt. %		Solid Phase
		KCl	NaCl				KCl	NaCl	
-22.9	--	5.81	20.17	1 + K + N	-17.8	--	9.01	14.40	I + K
-21.8	--	2.60	21.71	" + N <sub>2</sub>	-13.7	--	13.64	7.59	" + "
-21.1	--	--	23.07	" + "	-10.7	--	19.54	--	" + "
-20	--	0.0	23.42	N <sub>2</sub>	-11.9	--	6.49	21.41	K + N <sub>2</sub>
"	--	3.26	21.72	"	-10.0	--	--	24.70	N <sub>2</sub>
"	--	6.06	19.98	K	"	--	0.0	24.80	"
"	--	6.49	18.82	"	"	--	3.86	22.98	"
"	--	7.20	17.20	"	"	--	5.07	22.38	"
"	--	6.15	20.54	" + N <sub>2</sub>	"	--	6.46	21.91	" + K
"	--	6.24	18.6	K + I	"	--	7.31	19.87	K
"	--	3.6	20.4	I	"	--	9.43	15.28	"
"	--	3.0	20.7	"	"	--	12.31	10.43	"
"	--	0.0	22.3	"	"	--	13.39	8.66	"

I = Ice; K = KCl; N = NaCl; N<sub>2</sub> = NaCl·2H<sub>2</sub>O

(Cont.)

## THE SYSTEM POTASSIUM CHLORIDE - SODIUM CHLORIDE - WATER--Cont.

t°	Density	Sat. sol. wt. %		Solid Phase	t°	Density	Sat. sol. wt. %		Solid Phase
		KCl	NaCl				KCl	NaCl	
-10.0	--	19.82	0.0	K	80	1.216	27.59	6.79	K
"	--	19.0	0.0	I	"	1.229	22.34	13.17	"
"	--	13.7	4.4	"	"	1.241	19.03	17.59	" + N
"	--	7.1	9.3	"	"	1.223	14.10	20.03	N
"	--	3.3	11.6	"	"	1.199	7.38	23.53	"
"	--	0.0	13.4	"	"	1.175	0.0	27.51	"
- 2.3	--	6.96	22.54	N2 + N + K	90	1.242	20.32	17.24	" + K
+ 0.1	--	--	26.27	" + "	100	1.209	35.69	0.0	K
0	1.154	21.92	0.0	K	"	--	30.4	6.3	Cl
"	1.175	16.09	7.67	"	"	1.219	29.95	6.48	
"	1.200	14.39	14.82	"	"	--	27.7	9.43	
"	1.221	8.46	20.03	"	"	--	25.0	12.5	
"	1.234	7.28	22.40	" + N	"	1.232	24.88	12.69	"
"	1.226	5.10	23.52	N	"	--	22.4	15.5	"
"	1.218	2.58	24.86	"	"	1.245	22.2	15.9	" + N
"	1.209	0.0	26.25	"	"	1.244	21.68	16.90	" + "
10	1.233	8.71	21.66	" + K	"	1.232	19.12	18.12	N
20	1.174	25.57	0.0	K	"	--	19.0	17.7	"
"	1.190	19.48	7.36	"	"	1.200	10.25	22.57	"
"	1.210	14.29	14.40	"	"	1.166	0.0	28.00	"
"	1.221	12.24	17.64	"	110	1.245	23.04	16.58	K + N
"	1.234	10.19	20.03	" + N	"	1.255	23.6	15.7	" + "
"	1.223	6.98	22.65	N	108.5	1.209	36.50	0.0	K
"	1.213	3.54	24.47	"	111.9	1.246	23.28	16.52	" + N
"	1.201	0.0	26.34	"	108.7	1.162	0.0	28.30	N
25	--	26.52	0.0	K	120	--	37.65	0.0	K
"	--	16.58	12.30	"	"	--	32.28	6.24	"
"	--	15.71	13.45	"	"	--	27.33	12.25	"
"	--	11.14	20.42	" + N	"	1.264	24.7	15.8	" + N
"	--	8.16	22.11	N	"	--	24.23	16.35	" + "
"	--	3.34	24.58	"	"	--	17.29	19.69	N
"	--	0.0	26.48	"	"	--	9.48	23.66	"
30	1.235	11.70	20.25	" + K	"	--	0.0	28.60	"
40	1.189	28.65	0.0	K	130	1.274	25.7	15.8	K + N
"	1.201	22.44	7.19	"	"	--	25.29	16.33	" + "
"	1.218	17.05	14.04	"	140	--	39.60	0.0	K
"	1.236	13.16	19.66	" + N	"	--	34.43	6.17	"
"	1.221	8.94	21.87	N	"	--	29.71	11.86	"
"	1.207	4.62	24.15	"	"	1.282	26.7	15.8	" + N
"	1.192	0.0	26.64	"	"	--	26.45	16.17	" + "
50	1.237	14.70	19.02	" + K	"	--	19.07	19.61	N
60	1.199	31.29	0.0	K	"	--	9.98	24.13	"
"	1.210	25.14	6.90	"	"	--	0.0	29.30	"
"	1.224	19.79	13.52	"	149	--	27.44	16.08	K + N
"	1.238	16.07	18.57	" + N	150	--	35.5	5.9	K
"	1.220	10.97	21.17	N	"	--	33.1	8.73	"
"	1.202	5.71	23.94	"	"	--	30.7	11.5	"
"	1.184	0.0	27.03	"	"	--	28.6	14.3	"
70	1.239	17.59	18.05	" + K	"	1.289	27.5	15.8	" + N
80	1.205	33.59	0.0	K	"	--	23.5	17.8	N

I = Ice; K = KCl; N = NaCl; N2 = NaCl·2H<sub>2</sub>O

(Cont.)

## K KALIUM

## THE SYSTEM POTASSIUM CHLORIDE - SODIUM CHLORIDE - WATER--Cont.

t°	Density	Sat. sol. wt. %		Solid Phase	t°	Density	Sat. sol. wt. %		Solid Phase
		KCl	NaCl				KCl	NaCl	
150	--	18.4	20.4	N	189.6	--	18.36	22.01	N
160	1.295	28.3	15.9	K + N	"	--	9.88	26.13	"
169.5	--	42.42	0.0	"	"	--	0.0	31.45	"
"	--	37.24	5.92	"	190	1.330	31.9	16.1	K + N
"	--	33.04	11.41	"	200	--	40.3	5.43	"
"	--	30.72	14.52	"	"	--	38.1	8.08	"
"	--	29.63	16.03	" + N	"	--	36.2	10.6	"
"	--	23.38	18.78	N	"	--	34.6	13.1	"
Cl	--	15.24	22.66	"	"	1.340	33.0	16.2	" + N
"	--	8.68	25.93	"	"	--	31.2	16.7	N
"	--	0.0	30.62	"	"	--	27.2	18.5	"
170	1.305	29.6	16.0	K + N	"	--	22.7	20.6	"
180	1.318	30.7	16.0	" + "	"	--	17.8	23.0	"
189.6	--	44.34	0.0	K	220	--	34.4	16.3	K + N
"	--	39.36	5.68	"	230	--	35.0	16.4	" + "
"	--	35.44	10.86	"	250	--	36.2	16.5	" + "
"	--	33.38	13.64	"	270	--	37.3	17.1	" + "
"	--	31.74	16.33	" + N	280	--	38.0	17.1	" + "
"	--	25.58	18.78	N	300	--	39.1	17.4	" + "

I = Ice; K = KCl, N = NaCl; N2 = NaCl·2H<sub>2</sub>O

## THE SOLUBILITY OF POTASSIUM CHLORIDE IN AQUEOUS SOLUTIONS OF MIXTURES OF OTHER SALTS

The polytherms of the four salt points of the potassium chloride field in quinary systems of oceanic salt deposits have been redetermined with great care by Soroway, 1923. This is a repetition and extension of the fundamental work of Van't Hoff, D'Ans and others. Results at temperatures between 0° and 120° are given for the equilibrium solution Q (Van't Hoff) in contact with KCl + NaCl + carnallite + kainite or kieserite; at temperatures between 60.5° and 120° for the equilibrium solution P in contact with KCl + NaCl + glaserite + langbeinite; between 0° and 120° for the equilibrium solution F in contact with KCl + NaCl + glaserite; between 0° and 120° for the equilibrium solution E in contact with KCl + NaCl + carnallite and between 23° and 120° for the equilibrium solution R in contact with NaCl + kainite + kieserite + carnallite and with KCl + NaCl + kieserite + langbeinite.

SOLUBILITY OF MIXTURES OF POTASSIUM CHLORIDE AND OF SODIUM CHLORIDE IN AQUEOUS HYDROCHLORIC ACID SOLUTIONS AT 25°  
(Hicks, 1915)

Gms. per 100 gms. sat. solutions		
HCl	NaCl	KCl
0	19.95	10.90
8.61	10.65	7.58
17.16	3.56	3.80
20.65	2.03	2.86
32.78	0.18	1.27

POTASSIUM Palladium CHLORIDE  $K_2PdCl_6$ 

From measurements of the solubility of Potassium Chloro-palladate ( $K_2PdCl_6$ ) at  $25^\circ$  in normal aqueous Hydrochloric Acid containing KCl and saturated with Chlorine at atmospheric pressure, the Solubility Product  $-K^+)^2(PdCl_6^{--})$  was found to be  $5.97 \times 10^{-6}$ . (Wellman, 1930)

## POTASSIUM Platinum CHLORIDE (See PLATINUM CHLORIDES)

THE SYSTEM POTASSIUM CHLORIDE - RUBIDIUM CHLORIDE - WATER AT  $25^\circ$   
(D'Ans and Bush, 1937)

Gm. mols. per 1000 gm. mols. $H_2O$		Solid Phase mixed crystals containing	Gm. mols. per 1000 gm. mols. $H_2O$		Solid Phase mixed crystals containing	Cl
$Rb_2Cl_2$	$K_2Cl_2$		$Rb_2Cl_2$	$K_2Cl_2$		
0	43.5	100 Mol. % $K_2Cl_2$	41.2	22.5	67.8 Mol. % $K_2Cl_2$	
10.0	37.6	97.6 " "	51.0	17.5	41.8 " "	
19.2	33.5	92.6 " "	59.3	10.4	15.5 " "	
31.0	28.0	84.5 " "	70.1	0.0	0 " "	

THE SYSTEM KCl + RbCl IN AQ. ETHANOL SATURATED WITH HCl AT  $20^\circ$   
(Meier and Treadwell, 1951, 1951a)

100 mg. of the chlorides were dissolved in 5 ml. of hot conc. HCl ( $d = 1.19$ ) under reflux and then cooled. 25 ml. of alcohol ( $d = .795$ ) were then added dropwise to the clear solutions, with stirring, over a 30 minute period. The mixture was saturated with HCl gas. The crystals and liquid phase had the following composition:

Mole % KCl in:

Liquid phase	0.12	1.44	5.68	6.85	21.32
Solid phase	26.6	41.6	53.2	74.9	92.0

POTASSIUM Rhenium CHLORIDE  $K_2ReCl_6$ 

Cl

POTASSIUM Rhenium OXYCHLORIDE  $K_4Re_2OCl_{10}$ 

SOLUBILITY OF EACH SEPARATELY IN AQUEOUS HYDROCHLORIC ACID  
(Noddak and Noddak, 1933)

Wt. Percent HCl in Aq. Solvent	Gms. $K_2ReCl_6$ per 1000 cc. sat. solution at:		Gms. $K_4Re_2OCl_{10}$ per 1000 cc. sat. solution at:	
	$0^\circ$	$18^\circ$	$0^\circ$	$18^\circ$
12.0	21.38	30.28	75.0	--
20.0	25.0	46.0	--	--
37.0	3.3	3.72	5.5	--

# K KALIUM

## THE SYSTEM POTASSIUM CHLORIDE - STANNOUS CHLORIDE - WATER AT 25° (Fujimura, 1914)

	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
	SnCl <sub>2</sub>	KCl		SnCl <sub>2</sub>	KCl	
Cl	0	34.73	KCl	58.48	17.85	SnCl <sub>2</sub> ·KCl·H <sub>2</sub> O
	2.86	32.17	"	81.78	19.06	"
	4.37	34.08	"	107.65	17.79	"
	5.95	31.76	SnCl <sub>2</sub> ·2KCl·2H <sub>2</sub> O	170.70	21.26	"
	5.83	30.65	"	247.50	24.38	"
	10.24	27.30	"	337.26	25.51	"
	17.42	24.68	"	290.30	19.66	SnCl <sub>2</sub> ·2H <sub>2</sub> O
	27.88	24.40	"	235.50	7.49	"
	34.28	5.99	"	222.5	2.73	"
	54.19	19.45	SnCl <sub>2</sub> ·KCl·H <sub>2</sub> O	234.05	...	"

POTASSIUM Tin CHLORIDES Mono KSnCl<sub>3</sub>·H<sub>2</sub>O  
Di K<sub>2</sub>SnCl<sub>4</sub>·2H<sub>2</sub>O  
Tetra K<sub>4</sub>SnCl<sub>6</sub>·H<sub>2</sub>O

## SOLUBILITY OF MONO POTASSIUM STANNO CHLORIDE IN WATER (Rimbach und Fleck, 1916)

(Solid phase KSnCl<sub>3</sub>·H<sub>2</sub>O at all temperatures.)

t°	3.2°	14.2°	37.5°	59.4°	71.0°
Gms. KSnCl <sub>3</sub> per 100 gms. sat. sol.	26.1	34.9	54.0	72.8	82.1

## SOLUBILITY OF DI POTASSIUM STANNO CHLORIDE IN WATER (Rimbach and Fleck, 1916)

t°	Gms. per 100 gms. sat. sol.					Solid Phase
	Cl	Sn	K	K <sub>2</sub> SnCl <sub>4</sub>		
2.3*	9.14	3.28	7.94	--		K <sub>2</sub> SnCl <sub>4</sub> ·?H <sub>2</sub> O
14.1*	12.18	5.68	9.72	--		"
35.6	18.28	+ 14.56	+ 10.61	= 43.5		K <sub>2</sub> SnCl <sub>4</sub> ·2H <sub>2</sub> O
57.4	23.13	+ 19.50	+ 12.72	= 55.4		"
77.3	26.56	+ 22.35	+ 14.63	= 63.5		"

\*At these temperatures the atomic ratios in solution did not correspond to the double salt hence the solid phase is a mixture of the double salt and stannous chloride.

SOLUBILITY OF TETRA POTASSIUM STANNO CHLORIDE IN WATER  
(Rimbach and Fleck, 1916)

t°	Gms. per 100 gms. sat. sol.				Solid Phase
	Cl	Sn	K	K <sub>4</sub> SnCl <sub>6</sub>	
0.5*	10.99	0.93	11.55	--	K <sub>4</sub> SnCl <sub>6</sub> ·H <sub>2</sub> O + SnCl <sub>2</sub> ·H <sub>2</sub> O
19.5*	13.10	1.93	13.19	--	" "
41.0*	16.00	5.82	13.84	--	" "
61.7*	20.18	9.95	15.73	--	" "
70.0	22.71	+ 12.86	+ 16.63	= 52.20	K <sub>4</sub> SnCl <sub>6</sub> ·H <sub>2</sub> O
81.2	25.74	+ 19.57	+ 15.71	= 61.02	"

\*At these temperatures the atomic ratios in solution did not correspond to the double salt hence the solid phase is a mixture of the double salt and stannous chloride. Cl

Experiments on the Solubility of Potassium Stannic Chloride and Ammonium Stannic Chloride in Aqueous Solutions of Hydrochloric Acid containing sodium and ammonium chlorides are reported by Smith, 1928.

THE SYSTEM POTASSIUM CHLORIDE - STRONTIUM CHLORIDE - WATER  
(Assarsson, 1953)

A = KCl			B = SrCl <sub>2</sub> ·6H <sub>2</sub> O			C = SrCl <sub>2</sub> ·2H <sub>2</sub> O		
At 18°			At 60°			At 100°		
Sat. sol. wt. %			Sat. sol. wt. %			Sat. sol. wt. %		
SrCl <sub>2</sub>	KCl	Solid Phase	SrCl <sub>2</sub>	KCl	Solid Phase	SrCl <sub>2</sub>	KCl	Solid Phase
0.0	25.4	A	0.0	31.3	A	0.0	36.2	A
14.2	15.7	A	18.5	18.1	A	16.9	24.7	A
24.8	9.8	A	29.3	12.3	A	28.9	17.4	A
30.5	7.5	A	39.9	8.0	A	35.9	13.8	A
31.0	7.2	A B	43.5	7.2	A C	44.2	11.1	A
32.0	4.6	B	43.8	6.7	C	46.5	10.9	A
34.3	0.0	B	45.1	3.7	C	46.7	10.8	A C
			45.2	3.3	C	46.9	10.1	C
			45.6	2.7	B C	47.9	8.0	C
			45.7	2.6	B	50.8	0.0	C
			46.2	0.0	B			

Isothermally invariant points:

t°	Sat. sol. wt. %		Solid Phase	t°	Sat. sol. wt. %		Solid Phase
	SrCl <sub>2</sub>	KCl			SrCl <sub>2</sub>	KCl	
18	31.0	7.2	A B	58.7	43.3	7.2	A C
40	36.4	7.1	"	60	43.5	7.2	"
50	40.1	7.0	"	70	43.9	8.2	"
54.7	42.1	7.1	"	80	44.5	8.9	"
57.5	43.1	7.2	"	90	45.4	9.8	"
				100	46.7	10.8	"
				110	48.7	11.9	"
				114	49.4	12.4	"

# K KALIUM

## THE SYSTEM $\text{KCl} - \text{SrCl}_2 - \text{NaCl} - \text{H}_2\text{O}$ (Assarsson, 1953)

A = KCl

B =  $\text{SrCl}_2 \cdot 6\text{H}_2\text{O}$

C =  $\text{SrCl}_2 \cdot 2\text{H}_2\text{O}$

D = NaCl

### Results at 18°

	Sat. sol. wt. %			Solid Phase
	SrCl <sub>2</sub>	KCl	NaCl	
	0.0	0.0	26.0	D
	0.0	25.4	0.0	A
	0.0	10.1	20.9	A D
	7.7	9.0	16.4	"
C1	25.1	6.3	7.5	"
	26.1	6.1	7.4	"
	26.2	6.0	7.3	A B D
	26.5	5.8	7.4	"
	27.1	0.0	8.6	B D
	31.0	7.2	0.0	A B
	34.2	0.0	0.0	B

### Results at 60°

	Sat. sol. wt. %			Solid Phase
	SrCl <sub>2</sub>	KCl	NaCl	
	0.0	0.0	27.0	D
	0.0	31.3	0.0	A
	0.0	16.1	18.7	A D
	8.2	15.1	13.9	"
	16.2	12.6	10.6	"
	22.0	10.8	8.2	"
	34.3	7.9	4.0	"
	41.6	8.4	1.2	"
	41.4	6.9	2.5	"
	41.5	7.0	2.6	A C D
	41.6	7.1	2.6	"
	43.3	7.2	0.0	A C
	44.3	0.0	2.9	C D
	45.7	0.0	0.0	B

### Results at 100°

	Sat. sol. wt. %			Solid Phase
	SrCl <sub>2</sub>	KCl	NaCl	
	--	--	28.3	D
	--	36.0	--	A
	--	21.8	16.8	A D
	7.6	20.1	13.8	"
	20.8	15.7	8.3	"
	32.4	12.2	5.1	"
	44.6	10.1	2.9	"
	44.2	9.9	3.1	"
	44.8	10.3	2.9	A C D
	44.9	10.2	2.7	"
	46.7	10.8	0.0	A D
	48.2	0.0	3.6	C D
	50.8	0.0	0.0	C

### At various temperatures (t° in parentheses)

	Sat. sol. wt. %			Solid Phase
	SrCl <sub>2</sub>	KCl	NaCl	
	(18)26.2	6.0	7.3	A B D
	(40)33.5	6.5	7.2	"
	(50)38.4	6.7	3.0	"
	(54.7)40.8	6.8	2.6	"
	(55.8)41.5	6.9	2.5	"
	(56.5)41.3	6.8	2.6	A C D
	(57.0)41.3	6.7	2.5	"
	(60)41.5	7.0	2.6	"
	(70)42.0	7.8	2.8	"
	(80)42.6	8.6	2.8	"
	(90)43.4	9.2	2.8	"
	(110)46.9	11.4	2.9	"
	(114)47.6	11.8	2.9	"

THE SYSTEM POTASSIUM CHLORIDE - ZINC CHLORIDE - WATER  
(D'Ans and Kaufmann, 1957)

(See also Lipscomb and Hulett, 1915-16 for data at 25°)

Results at 25°

Results at 35°

Moles per 1000 moles H <sub>2</sub> O			Solid Phase	Moles per 1000 moles H <sub>2</sub> O			Solid Phase
ZnCl <sub>2</sub>	K <sub>2</sub> Cl <sub>2</sub>			ZnCl <sub>2</sub>	K <sub>2</sub> Cl <sub>2</sub>		
0.0	43.2		KCl	0.0	46.5		KCl
28.5	59.6		"	37.1	104		"
65.5	81.7		"	91.0	155		"
118	122		"	151	175		"
157	155		"	204	202	-	" + K <sub>2</sub> ZnCl <sub>4</sub>
195	190		"	218	175		K <sub>2</sub> ZnCl <sub>4</sub>
204	176	" + K <sub>2</sub> ZnCl <sub>4</sub>		264	97.8		"
244	106	K <sub>2</sub> ZnCl <sub>4</sub>		287	52.8		"
276	49.0	"		234	150		" + KZnCl <sub>3</sub> ·H <sub>2</sub> O
216	154	" + KZnCl <sub>3</sub> ·2H <sub>2</sub> O		197	88.9		KZnCl <sub>3</sub> ·2H <sub>2</sub> O
183	97.4	KZnCl <sub>3</sub> ·2H <sub>2</sub> O		186	60.8		"
166	58.3	"		188	42.0		"
164	35.7	"		220	28.9		"
170	27.8	"		274	23.8		"
200	17.5	"		326	24.3		"
243	12.7	"		453	36.8		" + KZnCl <sub>3</sub> ·H <sub>2</sub> O
284	13.0	"		591	51.5		KZnCl <sub>3</sub> ·H <sub>2</sub> O
325	14.6	"		666	58.3		" + (Zn, K <sub>2</sub> )Cl <sub>2</sub>
434	24.5	" + KZnCl <sub>3</sub> ·H <sub>2</sub> O		631	28.2		(Zn, K <sub>2</sub> )Cl <sub>2</sub>
571	16.8	ZnCl <sub>2</sub> ·H <sub>2</sub> O + (Zn, K <sub>2</sub> )Cl <sub>2</sub>		597	0.0		ZnCl <sub>2</sub>
557	6.1	ZnCl <sub>2</sub> ·H <sub>2</sub> O + ZnCl <sub>2</sub> ·1.5H <sub>2</sub> O					
599	36.7	(Zn, K <sub>2</sub> )Cl <sub>2</sub> + KZnCl <sub>3</sub> ·H <sub>2</sub> O					
550	0.0	ZnCl <sub>2</sub> ·1.5H <sub>2</sub> O					

Cl

THE SYSTEM 2KCl + ZnSO<sub>4</sub> = K<sub>2</sub>SO<sub>4</sub> + ZnCl<sub>2</sub> (+ H<sub>2</sub>O)  
(D'Ans and Kaufmann, 1957)

The ternary salt K<sub>2</sub>SO<sub>4</sub>·2ZnCl<sub>2</sub>·5H<sub>2</sub>O is formed at both temperatures. Additional data are given in the original. Kc = KCl; Zc = ZnCl<sub>2</sub>; Zcl = ZnCl<sub>2</sub>·1H<sub>2</sub>O; Zcl.5 = ZnCl<sub>2</sub>·1.5H<sub>2</sub>O; KZc<sub>4</sub> = K<sub>2</sub>ZnCl<sub>4</sub>; KZc<sub>3</sub>.2 = KZnCl<sub>3</sub>·2H<sub>2</sub>O; KZc<sub>3</sub>.1 = KZnCl<sub>3</sub>·1H<sub>2</sub>O; Zc<sub>m</sub> = (Zn, K<sub>2</sub>)Cl<sub>2</sub>; Ks = K<sub>2</sub>SO<sub>4</sub>; Zs<sub>7</sub> = ZnSO<sub>4</sub>·7H<sub>2</sub>O; Zs<sub>6</sub> = ZnSO<sub>4</sub>·6H<sub>2</sub>O; Zs<sub>1</sub> = ZnSO<sub>4</sub>·1H<sub>2</sub>O; KsZs<sub>6</sub> = K<sub>2</sub>SO<sub>4</sub>·ZnSO<sub>4</sub>·6H<sub>2</sub>O; KsZs<sub>5</sub> = K<sub>2</sub>SO<sub>4</sub>·2ZnCl<sub>2</sub>·5H<sub>2</sub>O.

Results at 25°

Results at 35°

Moles per 1000 moles H <sub>2</sub> O			Solid phase at each temp.	Moles per 1000 moles H <sub>2</sub> O		
ZnSO <sub>4</sub>	ZnCl <sub>2</sub>	K <sub>2</sub> Cl <sub>2</sub>		ZnSO <sub>4</sub>	ZnCl <sub>2</sub>	K <sub>2</sub> Cl <sub>2</sub>
63.9	--	--	Zs <sub>7</sub>	73.5	--	--
--	550	--	Zcl.5	--	597	--
--	--	43.2	Kc	--	--	46.5
--	(12.5)*	--	Ks	--	(14.3)*	--
65.9	(3.1)*	--	KsZs <sub>6</sub> /Zs <sub>7</sub>	75.7	(3.1)*	--
14.7	98.4	--	Zs <sub>7</sub> /Zs <sub>6</sub>	51.7	30.3	--
9.4	133	--	Zs <sub>6</sub> /Zs <sub>1</sub>	19.4	107	--
0.6	548	--	Zs <sub>1</sub> /Zcl.5	0.6	591	--

\*% K<sub>2</sub>SO<sub>4</sub>

(Cont.)



## K KALIUM

THE SYSTEM  $2\text{KCl} + \text{ZnSO}_4 \rightleftharpoons \text{K}_2\text{SO}_4 + \text{ZnCl}_2 (+ \text{H}_2\text{O})$ —Cont.

The ternary salt  $\text{K}_2\text{SO}_4 \cdot 2\text{ZnCl}_2 \cdot 5\text{H}_2\text{O}$  is formed at both temperatures. Additional data are given in the original.  $\text{Kc} = \text{KCl}$ ;  $\text{Zc} = \text{ZnCl}_2$ ;  $\text{Zcl} = \text{ZnCl}_2 \cdot 1\text{H}_2\text{O}$ ;  $\text{Zcl.5} = \text{ZnCl}_2 \cdot 1.5\text{H}_2\text{O}$ ;  $\text{KZc}_4 = \text{K}_2\text{ZnCl}_4$ ;  $\text{KZc}_32 = \text{KZnCl}_3 \cdot 2\text{H}_2\text{O}$ ;  $\text{KZc}_31 = \text{KZnCl}_3 \cdot 1\text{H}_2\text{O}$ ;  $\text{Zc}_m = (\text{Zn}, \text{K}_2)\text{Cl}_3$ ;  $\text{Ks} = \text{K}_2\text{SO}_4$ ;  $\text{Zs7} = \text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ ;  $\text{Zs6} = \text{ZnSO}_4 \cdot 6\text{H}_2\text{O}$ ;  $\text{Zs1} = \text{ZnSO}_4 \cdot 1\text{H}_2\text{O}$ ;  $\text{KsZs6} = \text{K}_2\text{SO}_4 \cdot \text{ZnSO}_4 \cdot 6\text{H}_2\text{O}$ ;  $\text{Ks2Zc5} = \text{K}_2\text{SO}_4 \cdot 2\text{ZnCl}_2 \cdot 5\text{H}_2\text{O}$ .

## Results at 25°—Cont.

## Results at 35°—Cont.

	Moles per 1000 moles $\text{H}_2\text{O}$			Solid Phase at each temp.	Moles per 1000 moles $\text{H}_2\text{O}$		
	$\text{ZnSO}_4$	$\text{ZnCl}_2$	$\text{K}_2\text{Cl}_2$		$\text{ZnSO}_4$	$\text{ZnCl}_2$	$\text{K}_2\text{Cl}_2$
C1	--	599	36.7	$\text{Zc}_m/\text{KZc}_31$	--	666	58.3
	--	557	6.1	$\text{Zcl.5}/\text{Zcl}$	--	--	--
	--	571	16.8	$\text{Zcl}/\text{Zc}_m$	--	--	--
	--	434	24.5	$\text{KZc}_31/\text{KZc}_32$	--	453	36.8
	--	216	154	$\text{KZc}_32/\text{KZc}_4$	--	234	150
	--	195	190	$\text{KZc}_4/\text{Kc}$	--	204	202
	--	(1.5)*	42.8	$\text{Kc}/\text{Ks}$	--	(1.6)*	46.0
	2.6	(12.8)*	--	$\text{Ks}/\text{KsZs6}$	3.5	(14.8)*	--
	17.7	92.6	8.4	$\text{Zs7}/\text{Zs6}/\text{KsZs6}$	54.6	30.0	2.5
	14.4	112	11.2	$\text{Zs6}/\text{Zs1}/\text{KsZs6}$	24.1	102	9.8
	10.8	143	29.6	$\text{Zs1}/\text{KsZs6}/\text{Ks2Zc5}$	12.9	153	43.7
	8.5	159	44.6	$\text{Zs1}/\text{KsZs6}/\text{KZc}_32^m$	12.3	182	78.9
	4.8	188	192	$\text{Kc}/\text{Ks}/\text{KZc}_4$	4.3	204	206
	5.5	196	182	$\text{Ka}/\text{KsZs6}/\text{KZc}_4$	9.8	213	196
	5.5	216	163	$\text{KsZs6}/\text{KZc}_4/\text{KZc}_32$	9.3	226	175
	8.0	160	49.0	$\text{KaZs6}/\text{Ks2Zc5}/\text{KZc}_32$	8.4	182	104
	9.0	160	37.5	$\text{Zs1}/\text{Ks2Zc5}/\text{KZc}_32$	9.4	184	57.0
	0.8	434	24.0	$\text{Zs1}/\text{KZc}_32/\text{KZc}_31$	0.7	454	36.0
	1.5	594	37.3	$\text{Zs1}/\text{KZc}_31/\text{Zc}_m$	0.9	661	58.1
	1.0	570	17.0	$\text{Zs1}/\text{Zc}_m/\text{Zcl}$	--	--	--
	0.7	556	6.5	$\text{Zs1}/\text{Zcl}/\text{Zcl.5}$	--	--	--
	--	--	--	$\text{KsZs6}/\text{KZc}_4/\text{Ks2Zc5}$	11.0	226	174

\*  $\text{K}_2\text{SO}_4$  <sup>m</sup>metastable

Data for equilibrium in the system potassium chloride + arsenic trioxide + water are given by Schreinemakers and de Baat, 1915.

## SOLUBILITY OF POTASSIUM CHLORIDE IN AQUEOUS METHANOL SOLUTIONS

## At 0°

(Armstrong and Eyre, 1910-11)

Solvent wt. % $\text{CH}_3\text{OH}$ :	0	0.79	1.57	3.10	8.76
Sat. sol. wt. % $\text{KCl}$ :	22.06	21.74	21.39	20.61	17.84

## At 10.2° and 19.9°

(Zeitlin, 1926)

Solvent wt. % $\text{CH}_3\text{OH}$ :		25.96	45.13	74.88	100.0
Sat. sol. gms. $\text{KCl}/\text{liter}$ (10.2°):		126.8	62.65	14.06	3.88
(19.9°):		141.4	64.87	15.81	4.18

## SOLUBILITY OF POTASSIUM CHLORIDE IN AQUEOUS METHANOL SOLUTIONS--Cont.

At 20°  
(Barkan, 1955)

Solvent wt. % CH <sub>3</sub> OH:	9.5	18.7	27.5	37.0	47.0	61.5
Sat. sol. wt. % KCl:	20.93	16.72	13.63	10.05	6.30	3.91
Wt. % KCl in sat. sol. when system is saturated with benzene:	21.24	17.8	14.07	10.89	7.15	4.68

At 25°  
(Akerlof and Turck, 1935; Armstrong and Eyre, 1910-11; Herz and Anders,  
1907; also McIntosh, 1903)

Solvent			Sat. sol.		Solvent			Sat. sol.		Cl
Wt. %		Density	Wt. %		Wt. %		Wt. %			
CH <sub>3</sub> OH			KCl	Density	CH <sub>3</sub> OH	Density	KCl	Density		
HA	0	0.9971	26.4	1.1782	AT	39.93	--	10.0	--	
AE	0	--	26.69	--	HA	47.1	0.9180	7.85	0.9679	
AT	0	--	26.4	--	AT	50.65	--	6.65	--	
AE	0.79	--	26.42	--	AT	59.28	--	4.63	--	
AE	1.57	--	26.01	--	HA	64.0	0.8820	3.80	0.9064	
AE	3.10	--	25.25	--	AT	69.74	--	2.74	--	
AE	8.76	--	22.82	--	HA	78.1	0.8489	1.79	0.8607	
HA	10.6	0.9791	21.8	1.125	AT	78.98	--	1.61	--	
AT	11.10	--	21.4	--	AT	80.45	--	1.48	--	
AT	20.11	--	17.4	--	AT	90.04	--	0.84	--	
AT	29.87	--	13.4	--	HA	98.9 (?)	0.8167	0.90	0.8242	
HA	30.8	0.9481	13.2	1.033	HA	100.0	0.7882	0.54	0.7937	
					AT	100.0	--	0.53	--	

SOLUBILITY OF POTASSIUM CHLORIDE IN AQUEOUS ETHANOL SOLUTIONS  
(Results on a weight basis - see also table following)

The results of Gerardin (1865), Armstrong, Eyre, Hussey, and Paddison (1907), Armstrong and Eyre (1910-11), Schiff (1861), Bathrick (1896), Platt and Jordan (1933), Ferner and Mellon (1934), Grinberg and Zemlyakova (1948), Wright (1927), Barkan (1955), were plotted and the following values read from the average curves. Additional data are given by Barkan (1953), Bodlander (1891) and in the table following. Above 30°, the agreement between various authors is poor.

Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	Gms. KCl per 100 gms. Solvent										
	0°	5°	10°	15°	20°	25°	30°	35°	40°	50°	60°
0	28.4	--	--	--	--	36.0	38.7	--	42.0	--	--
1	27.7	--	--	--	--	34.9	--	--	--	--	--
2	26.7	--	--	30.8	--	33.9	36.4	--	39.6	--	--
4	24.7	--	--	--	--	31.8	--	--	--	--	--
5	23.7	25.5	27.0	28.5	30.0	31.0	33.4	--	35.9	38.3	--
8	21.2	22.1	23.4	24.0	25.8	27.9	--	--	--	--	--
10	19.5	20.1	21.4	21.9	23.7	26.2	29.0	--	30.8	30.2	--
13	16.8	17.4	18.6	19.3	20.8	23.8	--	--	--	--	--

(Cont.)

## K KALIUM

## SOLUBILITY OF POTASSIUM CHLORIDE IN AQUEOUS ETHANOL SOLUTIONS--Cont.

Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	Gms. KCl per 100 gms. solvent										
	0°	5°	10°	15°	20°	25°	30°	35°	40°	50°	60°
15	15.0	15.8	16.9	17.9	19.1	22.1	25.1	--	26.6	25.3	--
18	12.2	13.6	14.6	16.0	16.9	19.8	--	--	--	--	--
20	10.9	12.4	13.4	14.8	15.5	18.5	21.4	--	23.2	21.3	--
30	6.7	7.6	8.9	10.1	10.6	13.3	15.6	--	17.0	15.3	16.9
40	4.3	4.7	5.9	6.9	7.4	9.4	11.1	--	12.5	10.7	11.7
50	2.8	3.3	4.0	4.5	5.3	6.4	7.5	--	8.6	7.6	8.1
60	1.7	2.2	2.5	2.7	3.6	3.9	4.7	--	5.4	5.2	5.6
70	1.0	1.3	1.5	1.3	2.2	2.2	2.5	--	3.0	3.4	3.6
80	0.5	0.6	0.6	0.5	1.1	0.9	1.0	--	1.3	1.7	1.9
85	0.2	0.3	0.3	0.2	0.6	0.5	0.4	0.4	0.7	1.0	1.1
90	0	0	0	0.1	0.2	0.2	0.1	0.2	0.2	0.3	0.4
95	--	--	--	0.05	--	0.07	--	0.1	0.1	--	--
100	--	--	--	0.03	--	0.03	--	0.03	--	--	--

Results on a mole basis  
(See also preceding table)

Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	Moles KCl per liter sat. sol.		
	10.2° (Zeitlin, 1926)	19.9° (Zeitlin, 1926)	25° (McIntosh, 1903)
0	3.712	3.903	4.18
10	--	--	3.21
20	--	--	2.40
25.07	1.607	1.755	--
30	--	--	1.78
40	--	--	1.26
50	0.5860	0.6004	0.84
60	--	--	0.56
70	--	--	0.305
75.03	0.1127	0.1245	--
80	--	--	0.125
90	--	--	0.042
97.3	0.00	0.0052	--
100	--	--	0.011

Results for the solubility of KCl in aqueous ethanol solutions saturated with benzene are given by Barkan, 1955.

0.0016 moles KCl dissolve in a liter of 1 vol. conc. HCl (d. = 1.19) + 5 vols. C<sub>2</sub>H<sub>5</sub>OH (d. = 0.7946) at 20°. (Meier and Treadwell, 1951)

100 gms. of a saturated solution in 50% ethyl alcohol saturated with benzene contains 5.50 gms. KCl at 20°. (Grinberg & Zemlyakova, 1948)

SOLUBILITY OF POTASSIUM CHLORIDE IN AQUEOUS PROPANOL SOLUTIONS  
(Armstrong and Eyre, 1910-11)

Wt. % $C_3H_7OH$ in Solvent	Gms. KCl per 100 gms. sat. sol.:	
	0°	25°
1.00	22.06	26.44
1.48	21.25	25.94
2.91	20.49	25.23
5.66	18.97	23.82

SOLUBILITY OF POTASSIUM CHLORIDE IN AQUEOUS SOLUTIONS OF  
ISO PROPYL ALCOHOL AT 25°  
(Ginnings and Chen, 1931)

Cl

The results locate the binodal curve of the system and include a tie line\* which shows the composition of two layers in contact with each other and the plait point, PP, at which the two liquid layers become homogenous.

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
Iso $C_3H_7OH$	KCl	Iso $C_3H_7OH$	KCl
13.72	17.48*	36.14	9.17
17.64	15.17	37.50	8.93 PP
22.87	12.95	42.56	7.65
29.34	11.04	53.95	5.12

Results at several temperatures:  
(Ferner and Mellon, 1934)

Wt. Percent iso $C_3H_7OH$ in Solvent	Gms. KCl per 100 gms. aq. solvent at:		
	16°	25°	35°
87.7	0.1095	0.1280	0.1494
92.6	0.0286	0.0298	0.0364
96.5	0.0074	0.0084	0.0104
100.0	0.0026	0.0027	0.0029

Additional data for this system are given by Timmermans and Lewin, 1953.

DISTRIBUTION OF POTASSIUM CHLORIDE BETWEEN WATER  
AND BUTYL ALCOHOL AT 25°  
(Alleman, 1928)

Normality of KCl in:			Normality of KCl in:		
$H_2O$ layer (a)	$C_4H_9OH$ layer (b)	(b) (a)	$H_2O$ layer (a)	$C_4H_9OH$ layer (b)	(b) (a)
2.0	0.0182	0.0091	0.25	0.0051	0.0199
1.0	0.0134	0.0135	0.10	0.0020	0.0204
0.50	0.0079	0.0167	0.025	(0.0011)	(0.0455)

## K KALIUM

THE SYSTEM POTASSIUM CHLORIDE - TERTIARY BUTYL  
ALCOHOL - WATER AT 30°  
(Ginning and Robbins, 1930)

The results which were determined by the synthetic method locate the binodal curve of the system and include tie lines\* which show the composition of layers in contact with each other and the plait point, PP, at which the two liquid layers become homogeneous.

	Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
	(CH <sub>3</sub> ) <sub>3</sub> COH	KCl	(CH <sub>3</sub> ) <sub>3</sub> COH	KCl	(CH <sub>3</sub> ) <sub>3</sub> COH	KCl
Cl	--	23.3*	18.2	8.1	39.0	4.2PP
	7.9	15.9	20.5	7.4	43.8	3.3
	9.4	14.6	--	7.1*	50.9	2.6
	10.5	13.3	--	6.7*	53.0	--*
	11.5	12.2	23.9	6.2	57.0	--*
	12.5	11.4	28.3	5.6	58.4	2.0
	16.5	9.0	33.3	4.8	67.3	1.4
			36.6	4.5	90.0	--*

The composition of the plait point, PP, at 25° is 4.5 gms. KCl and 41.0 gms. (CH<sub>3</sub>)<sub>3</sub>COH per 100 gms. sat. solution.  
(Ginnings, Herring and Webb, 1933)

DISTRIBUTION OF POTASSIUM CHLORIDE AT 17°  
(Wosnessensky, 1925)

<u>Water and Amyl Alcohol</u>			<u>Water and Phenol</u>		
Millimols KCl per liter		$\frac{C_1}{C_2^{1.32}}$	Millimols KCl per liter		$\frac{C_1}{C_2}$
H <sub>2</sub> O layer (C <sub>1</sub> )	Alcohol layer (C <sub>2</sub> )		H <sub>2</sub> O layer (C <sub>1</sub> )	Phenol layer (C <sub>2</sub> )	
360.255	0.831	461	64.0	4.5	14.2
512.011	1.050	480	111.5	7.9	14.1
677.507	1.287	486	290.3	20.4	14.2
810.000	1.491	478	324.5	22.8	14.2
921.140	1.648	477			

SOLUBILITY OF POTASSIUM CHLORIDE IN AQUEOUS ACETONE SOLUTIONS  
(Snell, 1898; at 20°; Herz and Knoch, 1904; see also Timmermans and Lewin, 1953)

Wt. (See note) Per cent Acetone in Solvent	At 20°		At 30°		At 40°		At 50°	
	KCl per 100 cc. Solution		Gms. per 100 gms. Solution		Gms. per 100 gms. Solution		Gms. per 100 gms. Solution	
	Millimols		Acetone		Acetone		Acetone	
	Gms.		KCl		KCl		KCl	
0	410.5	30.62	0	27.27	0	28.69	0	30
9.1	351.7	26.23	6.96	23.42	6.79	25.33	--	--
20	286.6	21.38	16.22	18.90	15.75	21.28	--	--
30	223.7	16.69	25.45	15.06	two layers		25.67	14.42
40	166.5	12.42	35.52	11.31	"		36.03	9.93
50	115.4	8.61	45.98	8.04	"		46.46	7.07
60	71.2	5.31	56.91	5.12	"		57.37	4.38
70	38.5	2.87	68.18	2.60	"		68.56	2.22
80	12.9	0.96	79.43	0.76	79.34	0.58	79.25	0.94
90	2	0.15	89.88	0.13	89.84	0.16	±81° sat. sol.	
100	0	0	100	0	100	0		

NOTE: For the 20° results, the per cent acetone in the solvent is in terms of volume instead of weight per cent, and the concentration of the second solution is 10 percent instead of 9.1 which is the weight percent concentration of the solvent for the corresponding results at the other temperatures.

At the temperature 40° and for concentrations of acetone between 20 and 80 percent, the saturated solution separates into two layers having the following compositions:

Lower Layer			Upper Layer		
Gms. per 100 gms. solution			Gms. per 100 gms. solution		
H <sub>2</sub> O	(CH <sub>3</sub> ) <sub>2</sub> CO	KCl	H <sub>2</sub> O	(CH <sub>3</sub> ) <sub>2</sub> CO	KCl
55.2	31.82	12.99	28.14	69.42	2.44
53.27	35.44	11.29	30.96	65.97	3.07
51.23	38.50	10.27	32.64	63.79	3.56
50.34	39.88	9.77	34.07	62.01	3.92
48.02	43.18	8.79	37.44	57.67	4.89
46.49	45.34	8.17	38.68	56.17	5.25
58.99	25.24	15.77	23.66	74.91	1.43

(Plait point approx. 50.5% acetone, 6.5% KCl)

Data for the systems KCl + n-propoxyethanol + H<sub>2</sub>O and KCl + iso-propoxyethanol + H<sub>2</sub>O are given by Timmermans and Lewin 1953.

# K KALIUM

## SOLUBILITY OF POTASSIUM CHLORIDE IN ETHYLENE GLYCOL SOLUTIONS

t °	Density sat. sol.	Gms. per 100 gms. sat. sol.		Author
		C <sub>2</sub> H <sub>4</sub> (OH) <sub>2</sub>	KCl	
25	--	0.0	26.89	Armstrong and Eyre, 1913
	--	1.12	26.43	
	--	4.37	25.26	
30	1.1820	0.0	27.10	Trimble, 1931
	1.1648	15.08	21.97	
	1.1510	33.47	16.53	
	1.1424	52.00	11.84	
	1.1371	73.27	7.75	
Cl	1.1368	94.90	5.00	

## SOLUBILITY OF POTASSIUM CHLORIDE IN AQUEOUS SOLUTIONS OF GLYCEROL AT 25° (Herz and Knoch, 1905)

(Sp. Gr. of Glycerol at 25/4° = 1.2555; Impurity about 1.5%)

Wt. Per cent Glycerol in Solvent	KCl per 100 cc. Solution		Sp. Gr. of Solutions	Wt. Per cent Glycerol in Solvent	KCl per 100 cc. Solution		Sp. Gr. of Solutions
	Millimols	Gms.			Millimols	Gms.	
0	424.5	31.66	1.180	45.36	271.4	20.24	1.211
0.96	--	30.2*	--	54.23	238.5	17.79	1.219
13.28	383.4	28.61	1.185	83.84	149	11.11	1.259
25.98	339.3	25.31	1.194	100	110.6	8.25	1.286

\*Armstrong and Eyre, 1913.

## SOLUBILITY OF POTASSIUM CHLORIDE IN AQUEOUS SOLUTIONS OF DIOXANE AT 25° (Herz and Lorentz, 1929)

Vol. Percent Dioxane in Solvent	Gm. Mol. KCl per liter sat. sol.	Vol. Percent Dioxane in Solvent	Gm. Mol. KCl per liter sat. sol.
10	3.45	55	0.85 (L)*
20	2.80	77	0.14 (U)
33	2.00	80	0.12
50	1.22		

\*Between 51 and 77 vol. percent Dioxane to liquid layers are formed.

(L) = lower liquid layer

(U) = upper liquid layer

SOLUBILITY OF POTASSIUM CHLORIDE IN AQUEOUS  
SOLUTIONS OF PYRIDINE AT 10°  
(Schroeder, 1908)

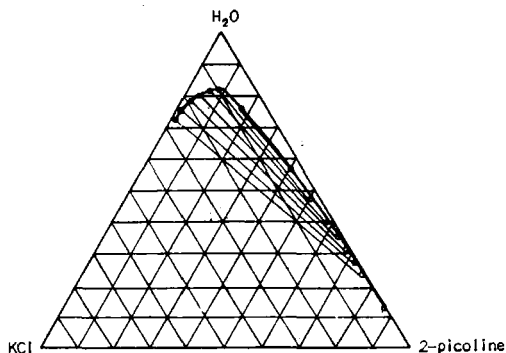
The binodal curve and plait point of the system KCl + Pyridine + H<sub>2</sub>O at 25° has been determined by Ginnings, Webb and Hinohara, 1933, but the authors do not give their experimental results, only the values of a series of arbitrary constants calculated from them by means of empirical equations. Data for this system is also given by Arakawa, Kawaguchi and Kato, 1958.

Aq. Mixture		Gms. KCl per 100 Gms. Sat. Sol.	Aq. Mixture		Gms. KCl per 100 Gms. Sat. Sol.	
cc. H <sub>2</sub> O	cc. Pyridine		cc. H <sub>2</sub> O	cc. Pyridine		
100	0	23.79	40	60	3.33	Cl
90	10	19.76	30	70	1.25	
80	20	16.37	20	80	0.24	
70	30	13.19	10	90	0.04	
60	40	10.05	0	100	0	
50	50	6.34				

Data of Arakawa, Kawaguchi and Kato, 1958 at 30°:

Mole fraction KCl in lower layer ( $\times 10^2$ ):	5.2	6.0	7.0	7.6
Mole fraction pyridine in upper layer ( $\times 10^2$ ):	16	20	25	28

THE SYSTEM POTASSIUM CHLORIDE - 2-PICOLINE - WATER AT 30°  
(Arakawa, Kawaguchi and Kato, 1958)



THE SYSTEM POTASSIUM CHLORIDE - HEPTYLAMINE - WATER AT 20°  
(Arakawa and Kawaguchi, 1958)

Mole fraction KCl							
in lower layer ( $\times 10^2$ ):	0	2	4	5.4	6	8	8.5
Mole fraction heptylamine							
in upper layer ( $\times 10^2$ ):	3.5	6.0	7.9	10	11	15.5	17.5



# K KALIUM

## SOLUBILITY OF POTASSIUM CHLORIDE IN AQUEOUS ACETONE SOLUTIONS AT 20° (Barkan, 1955)

Solvent: Wt. % Acetone	Solvent: Wt. % KCl in Sat. Sol.	Solvent: Wt. % KCl in sat. sol. when system is saturated with benzene
10.8	21.49	21.86
20.0	16.11	18.76
28.0	14.27	15.40
38.0	10.23	11.70
50.0	7.49	9.75
60.0	5.345	8.66
69.0	2.04	8.05

C1

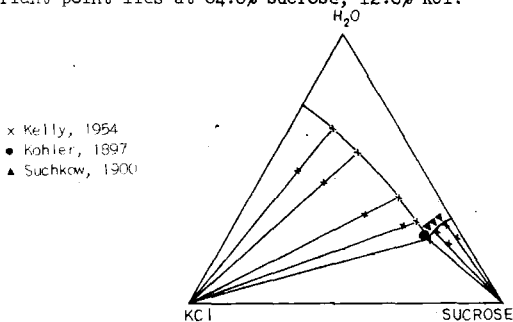
## THE SYSTEM POTASSIUM CHLORIDE - GLUCOSE - WATER AT 25° (Zhdanov and Nigai, 1956)

The early data of Armstrong and Eyre (1910-11) show 1-2% more KCl in the solutions.

Density	Gms. per 100 gms. sat. sol.		Solid Phase	Density	Gms. per 100 gms. sat. sol.		Solid Phase
	KCl	C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>			KCl	C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>	
1.1768	26.16	--	KCl	1.3070	18.31	36.77	KCl
1.1800	25.90	0.86	"	1.3200	17.73	39.72	"
1.1962	25.28	5.44	"	1.3350	16.96	43.46	"
1.2014	24.59	7.68	"	1.3510	16.17	47.94	"
1.2120	23.79	10.61	"	1.3800	15.24	51.31	KCl + C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> ·H <sub>2</sub> O
1.2251	23.24	14.16	"	1.3800	14.89	52.67	" + "
1.2310	22.60	15.26	"	1.3790	13.00	52.64	C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> ·H <sub>2</sub> O
1.2392	21.90	17.59	"	1.3130	9.55	50.94	"
1.2720	20.50	26.92	"	1.2895	6.69	51.40	"
1.2790	20.02	28.79	"	1.2445	3.32	50.06	"
1.2860	19.55	31.19	"	1.2210	--	49.95	"
1.2990	18.98	34.04	"				

## THE SYSTEM POTASSIUM CHLORIDE - SUCROSE - WATER AT 30° (Kelly, 1954; Kohler, 1897; Schukow, 1900)

All the results are summarized in the diagram by Kelly. The invariant point lies at 64.0% sucrose, 12.0% KCl.



SOLUBILITY OF KCl IN MANNITOL SOLUTIONS AT 25°  
(Armstrong and Eyre, 1913)

Solvent: Gms. Mannitol per 100 gms. H <sub>2</sub> O:	0.0	4.553	13.659
Sat. Sol.: Wt. % KCl:	26.89	24.86	24.46

EQUILIBRIUM IN THE SYSTEM POTASSIUM CHLORIDE - UREA - WATER  
(Polosin and Ozolin, 1947)

The system was also studied by Bochovkin and Bochovkina, 1947 with results which differ from those below. According to B. and B. the eutectic solution contains 15.9% KCl and 26.1% urea at -16.9°, and is in equilibrium with ice,  $\alpha$ -KCl and  $\gamma$ -urea. They found only  $\gamma$ -urea to be stable in mixtures which contained excess solid KCl. The results of Zhdanov and Nigai (1956a) at 25° are in reasonable agreement with those given below. [In the original, the results are also given in moles per 1000 moles of water and in moles per 100 moles of dissolved salts.]

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
KCl	CO(NH <sub>2</sub> ) <sub>2</sub>	Solid Phase	KCl	CO(NH <sub>2</sub> ) <sub>2</sub>	Solid Phase
Results at -15°			Results at 0°		
16.00	15.85	Ice + α-KCl	21.65	0.0	α-KCl
15.90	16.80	α-KCl	20.10	8.00	"
14.10	25.75	"	18.40	16.30	"
14.10	28.00	α-KCl + α-CO(NH <sub>2</sub> ) <sub>2</sub>	16.65	24.95	"
13.15	28.05	α-CO(NH <sub>2</sub> ) <sub>2</sub>	15.55	29.10	α-KCl + β-KCl
12.10	28.30	"	14.90	34.10	β-KCl
7.90	29.00	α-CO(NH <sub>2</sub> ) <sub>2</sub> + Ice	14.80	34.40	"
8.50	27.40	Ice	14.60	35.40	β-KCl + α-CO(NH <sub>2</sub> ) <sub>2</sub>
10.40	24.35	"	11.05	36.30	α-CO(NH <sub>2</sub> ) <sub>2</sub>
15.00	17.00	"	4.90	38.40	"
			0.0	40.00	"
Results at 10°			Results at 25°		
23.45	0.0	α-KCl	26.45	0.0	β-KCl
20.10	8.00	"	24.50	7.55	"
18.40	16.30	"	22.30	15.55	"
16.65	24.95	α-KCl + β-KCl	20.10	24.00	"
15.55	29.10	β-KCl	17.70	33.00	"
14.90	34.10	"	16.90	36.60	"
14.80	34.40	"	15.60	42.30	"
14.60	35.40	β-KCl + β-CO(NH <sub>2</sub> ) <sub>2</sub>	14.40	47.80	β-KCl + β-CO(NH <sub>2</sub> ) <sub>2</sub>
11.05	36.30	β-CO(NH <sub>2</sub> ) <sub>2</sub>	9.10	50.00	β-CO(NH <sub>2</sub> ) <sub>2</sub>
4.90	38.40	"	3.80	52.70	"
0.0	40.00	"	0.0	54.60	"

(Cont.)

## K KALIUM

## EQUILIBRIUM IN THE SYSTEM POTASSIUM CHLORIDE - UREA - WATER--Cont.

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
KCl	CO(NH <sub>2</sub> ) <sub>2</sub>	KCl		CO(NH <sub>2</sub> ) <sub>2</sub>			
Results at 30°				Results at 40°			
27.10	0.0	β-KCl		28.30	0.0	β-KCl	
25.20	7.45	"		26.60	7.35	"	
23.05	15.40	"		24.50	15.10	"	
20.80	23.80	"		22.10	23.35	"	
18.30	32.80	"		19.50	32.30	"	
17.50	36.30	"		18.65	35.80	"	
16.00	42.00	"		16.90	41.55	"	
14.60	47.80	"		15.50	47.40	"	
14.30	50.20	β-KCl + β-CO(NH <sub>2</sub> ) <sub>2</sub>		14.00	55.20	β-KCl + β-CO(NH <sub>2</sub> ) <sub>2</sub>	
9.50	52.40	β-CO(NH <sub>2</sub> ) <sub>2</sub>		10.40	57.20	β-CO(NH <sub>2</sub> ) <sub>2</sub>	
3.50	55.60	"		3.10	61.20	γ-CO(NH <sub>2</sub> ) <sub>2</sub>	
0.0	57.40	γ-CO(NH <sub>2</sub> ) <sub>2</sub>		0.0	62.25	"	

Invariant Points

t°	Gms. KCl per 100 gms. Sat. Sol.	Gms. CO(NH <sub>2</sub> ) <sub>2</sub> per 100 gms. Sat. Sol.	Solid Phase
(-10.6)	19.80	0.0	Ice + α-KCl
( 22.1)	26.20	0.0	α-KCl + β-KCl
(-10.9)	0.0	32.90	Ice + α-CO(NH <sub>2</sub> ) <sub>2</sub>
( 1.1)	0.0	40.70	β-CO(NH <sub>2</sub> ) <sub>2</sub> + α-CO(NH <sub>2</sub> ) <sub>2</sub>
( 29.2)	0.0	57.20	β-CO(NH <sub>2</sub> ) <sub>2</sub> + γ-CO(NH <sub>2</sub> ) <sub>2</sub>
(-19.4)	13.45	26.15	Ice + α-KCl + α-CO(NH <sub>2</sub> ) <sub>2</sub>
( - 7.9)	14.50	31.50	α-KCl + β-KCl + α-CO(NH <sub>2</sub> ) <sub>2</sub>
( 8.1)	14.60	39.20	β-KCl + α-CO(NH <sub>2</sub> ) <sub>2</sub> + γ-CO(NH <sub>2</sub> ) <sub>2</sub>

THE SYSTEM POTASSIUM CHLORIDE - URETHAN - WATER AT 25°  
(Palitsch, 1928, 1929)

Gm. mols. per 1000 gms. H <sub>2</sub> O		Solid Phase	Gm. Mols. per 1000 gms. H <sub>2</sub> O		Solid Phase
NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>	KCl		NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>	KCl	
0.0	4.83	KCl	2.597	4.16	KCl + NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>
0.0561	4.81	"	3.972	3.84	Lower liquid layer
0.0786	4.80	"	27.556	2.20	Upper liquid layer
0.2245	4.76	"	28.477	2.0	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>
0.5612	4.66	"	40.88	1.0	"
1.1225	4.49	"	53.09	0.0	"

100 cc. sat. sol. of potassium chloride in ethyl urethan (NH<sub>2</sub>COOC<sub>2</sub>H<sub>5</sub>) contain 0.105 gm. KCl at 60°. (Stuckgold, 1917)

A mixture of equal volumes of ethyl ether and water, when saturated with HCl at 0°, dissolves 0.056 gms. KCl per 100 gms. of mixture.  
(Fischer and Seidel, 1941)

SOLUBILITY OF KCl IN ACETALDEHYDE AND PARALDEHYDE SOLUTIONS AT 25°  
(Armstrong and Eyre, 1913)

	Solvent	Wt. % KCl in Sat. Sol.
Water alone	--	26.89
Acetaldehyde	1.101 gms./100 gms. H <sub>2</sub> O	27.05
Paraldehyde	1.101 "	26.42

100 gms. 95% formic acid dissolve 19.4 gms. KCl at 19.7°. (Achan, 1913)

SOLUBILITY OF POTASSIUM CHLORIDE IN VARIOUS ALCOHOLS

(Larson and Hunt, 1939; Zeitlin, 1926; Turner and Bissett, 1913; Caley and Axelrod, 1942; deBruyn, 1892; Rohland, 1898; Seward and Schumb, 1930; Pavlopoulos and Strehlow, 1954; Kato and Hagiwara, 1950; Ferner and Mellon, 1934; Akerlof and Turck, 1935; Herz and Anders, 1907; Barker and Ali, 1950)

The results of Kirn and Dunlap, 1931 show much smaller solubilities than these and are listed separately in the following table:

	Gms. KCl per 100 gms. of alcohol					
	10°	16°	18°	20°	25°	35°
Methanol	0.486 Z .53 BA		0.5 dBR .49 PS	0.530 Z	0.5391 CH .53 TB .53 PS .527 AT .54 HA	
Ethanol		0.0265 FM	0.034 dBR		0.0294 LH .022 TB .02952SS .0288 FM	0.0325 FM
Propanol-1					0.0061 LH .004 TB	
Propanol-2 (iso)					0.0023 LH	
Butanol-1		0.00038KH			0.0030 LH	
Butanol-2 (iso)					0.00084LH	
2-methyl- propanol-1					0.0020 LH	
Pentanol-1 (amyl)			0.00039 KH		0.0022 LH .0008 TB	
iso-amyl alc.					.0006 TB	
Hexanol-1					0.00004CA	
2-ethyl hexanol					<0.00001CA	

# K KALIUM

## SOLUBILITY OF POTASSIUM CHLORIDE IN SEVERAL ALCOHOLS AT DIFFERENT TEMPERATURES (Kirn and Dunlap, 1931)

[See Table Above]

Gm. Mols. KCl per 100 gms. mols. of:						
t°	Methanol CH <sub>3</sub> OH	Ethanol C <sub>2</sub> H <sub>5</sub> OH	Propanol C <sub>3</sub> H <sub>7</sub> OH	Iso Propanol C <sub>3</sub> H <sub>7</sub> OH	Butanol C <sub>4</sub> H <sub>9</sub> OH	Iso Butanol C <sub>4</sub> H <sub>9</sub> OH
20	0.833	0.1270	0.00700	0.1235	0.00822	0.00326
30	0.729	0.1378	0.00796	0.1300	0.00852	0.00356
35	0.691	0.1443	0.00793	0.1340	--	--
40	0.642	0.1454	0.00773	0.1390	0.00904	0.00400
45	0.528	0.1277	0.00683	0.1295	--	--
50	0.415	0.0845	0.00473	0.1060	0.00925	0.00407

## SOLUBILITY OF POTASSIUM CHLORIDE IN ANHYDROUS ETHYL ALCOHOL SOLUTIONS CONTAINING AMMONIUM NITRATE AT 25° (Seward and Schumb, 1930)

Gm. Mols. NH <sub>4</sub> NO <sub>3</sub> per liter solvent	Gm. Mols. KCl per liter sat. sol.	Gm. Mols. NH <sub>4</sub> NO <sub>3</sub> per liter solvent	Gm. Mols. KCl per liter sat. sol.
0.000	0.003180 (=0.2318 gm.)	0.004807	0.005020
0.000188	0.003125	0.008587	0.007229
0.000466	0.003141	0.01947	0.008827
0.000992	0.003327	0.05129	0.011131
0.002352	0.003716		

## SOLUBILITY OF POTASSIUM CHLORIDE IN ANHYDROUS ACETIC ACID DETERMINED BY THE SYNTHETIC METHOD (Davidson and Chappell, 1938)

t°	Gm. Mols. KCl per 100 gm. mols. KCl + CH <sub>3</sub> COOH	Solid Phase	t°	Gm. Mols. KCl per 100 gm. mols. KCl + CH <sub>3</sub> COOH	Solid Phase
16.45	0.168	CH <sub>3</sub> COOH	59	0.239	KCl
24	0.157	KCl	63	0.257	"
30	0.170	"	70	0.272	"
39	0.188	"	76	0.295	"
47	0.207	"	87	0.336	"
55	0.229	"	93	0.367	"

## SOLUBILITY OF POTASSIUM CHLORIDE IN VARIOUS ORGANIC SOLVENTS

Solvent	t°	Solubility	Author
Acetic acid		See table above.	
Ethylenediamine	25	0.014 gm./100 gm. solvent	(Isbin and Kobe, 1945)
Monoethanolamine	25	0.27	( " " " " )
Ethylene glycol	25	5.18	( " " " " )
Glycerol	15-16	3.72	(Ossendowski, 1907)
Acetone	18	0.000087	(Lannung, 1932)
	37	0.000097	( " " )
Furfurol (C <sub>4</sub> H <sub>3</sub> COOH)	25	0.085 gm./100 cc. sat. sol.	(Walden, 1906)
Formic acid	18	19.1 gm./100 gm. solvent	(Pavlopoulos and Strehlow, 1954)
	25	19.2	( " " )
Acetonitrile	18	0.0024	( " " )
	25	0.0024	( " " )
Methyl acetate	20	0.00385 gm./100 cc. solvent	(Kato and Hagiwara, 1950)
Ethyl acetate	19	0.000057	( " " " " )
Diethyl acetate	19	0.000515	( " " " " )
Butyric acid	20	0.00057	( " " " " )

THE SYSTEM POTASSIUM CHLORIDE - LIQUID AMMONIA  
DETERMINED BY THE SYNTHETIC METHOD  
(Patscheke and Tanne, 1936)

t°	Gms. KCl per 100 gms. sat. sol.	Solid Phase	t°	Gms. KCl per 100 gms. sat. sol.	Solid Phase
-76.6	0.078	NH <sub>3</sub>	-33.9	0.213 (1)	KCl
-76.6	0.115	"	-19.4	0.167	"
-76.7	0.167	"	- 0.6	0.141	"
-76.8	0.193	"	0.0	0.132 (2)	"
-76.9	0.209	"	+15.0	0.115	"
-77.0	0.219	"	25	0.04 (3)	"
-77.2	0.252	NH <sub>3</sub> + KCl	18.9	0.102	"
-57.9	0.219	KCl	31.2	0.089	"
-45.0	0.209	"	44.2	0.078	"
-35.2	0.193	"			

The authors also give results showing that the solubility of KCl in liquid ammonia is increased to almost double by the presence of NaCl or of NH<sub>4</sub>Cl.

- (1) Johnson and Krumboltz, 1933;
- (2) Linhard and Stephan, 1933-1934;
- (3) Hunt, 1932.

# K KALIUM

## SOLUBILITY OF POTASSIUM CHLORIDE IN IODINE MONOCHLORIDE (Cornog and Bauer, 1942)

t°	Gms. KI per 100 gms. ICl	Solid Phase	t°	Gms. KI per 100 gms. ICl	Solid Phase
15	4.70	KCl·2ICl	40	6.80*	KCl·ICl
20	4.90	"	45**	6.95	"
25	5.20	"	50	7.20	"
30	5.55	"	55	7.40	"
35	5.95	"	60	7.70	"
40	6.45	"	65	8.05	"

\* = Metastable.

\*\* = Transition temperature.

## Cl

## SOLUBILITY OF POTASSIUM CHLORIDE IN LIQUID SULFUR DIOXIDE

t°	Solubility	Author
0	0.041 gm. per 100 gm. SO <sub>2</sub>	Jander and Ruppolt, 1937
25	0.0126 gm. per 100 gm. sat. sol.	Shatenstein and Viktorov, 1937

## SOLUBILITY OF POTASSIUM CHLORIDE IN VARIOUS INORGANIC SOLVENTS

Solvent	t°	Solubility	Author
Hydrazine	room	9 gms./100 cc. solvent	Welsh & Brodersen, 1915
Hydroxylamine	17-18	12.3 gms./100 gms. solvent	de Bruyn, 1892
SeOCl <sub>2</sub>	25	2.89 gms./100 gms. sat. sol.	Wise, 1923
SbCl <sub>3</sub>	520-530 (m.p.)	- - -	See Zouravlev, 1939
POCl <sub>3</sub>	20	0.60 gms./liter	Gutmann, 1952

Melting point data are given for the following: (See page 170 for list of authors.)

KCl + AgNO <sub>3</sub> = AgCl + KNO <sub>3</sub>	(28)	KCl + KOH	(4)(59)
KCl + BaCl <sub>2</sub>	(51)	KCl + K <sub>2</sub> SO <sub>4</sub>	(3)(5)(7)(52)
KCl + BaCl <sub>2</sub> + CaCl <sub>2</sub>	(29)	KCl + K <sub>2</sub> SO <sub>4</sub> + K <sub>2</sub> WO <sub>4</sub>	(62)
2KCl + CaF <sub>2</sub> = 2KF + CaCl <sub>2</sub>	(30)	KCl + K <sub>2</sub> SO <sub>4</sub> + NaF	(82)
KCl + CaCl <sub>2</sub> + CaCl	(41)	KCl + K <sub>2</sub> SO <sub>4</sub> + Na <sub>2</sub> CO <sub>3</sub>	(37)
KCl + CaCl <sub>2</sub> + LiCl	(42)	KCl + K <sub>2</sub> SO <sub>4</sub> + K <sub>2</sub> CO <sub>3</sub>	(76)
KCl + CaCl <sub>2</sub> + RbCl	(41)	KCl + KVO <sub>3</sub>	(78)
2KCl + CaSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + CaCl <sub>2</sub>	(58)	KCl + KClO <sub>3</sub>	(79)
2KCl + CdI <sub>2</sub> = 2KI + CdCl <sub>2</sub>	(56)	KCl + KClO <sub>3</sub> + KClO <sub>4</sub>	(81)
KCl + CdCl <sub>2</sub>	(45)	KCl + KNO <sub>3</sub>	(71)(79)
KCl + CdCl <sub>2</sub> + PbCl <sub>2</sub>	(44)	KCl + KNO <sub>3</sub> + KClO <sub>3</sub>	(79)(80)
KCl + CdCl <sub>2</sub> + NaCl	(45)	KCl + KNO <sub>3</sub> + KH <sub>2</sub> PO <sub>4</sub>	(71)
KCl + CsF	(77)	KCl + KPO <sub>3</sub>	(6)
KCl + FeCl <sub>2</sub>	(31)(47)	KCl + K <sub>3</sub> PO <sub>4</sub>	(6)
KCl + Hg <sub>2</sub> Cl <sub>2</sub>	(8)	KCl + K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	(6)
KCl + KI	(1)(2)(3)	KCl + KH <sub>2</sub> PO <sub>4</sub>	(71)

(Cont.)

## Melting point data--Cont.

KCl + K <sub>2</sub> CrO <sub>4</sub>	(5)(25)
KCl + K <sub>2</sub> CrO <sub>4</sub> + NaF	(57)
KCl + K <sub>2</sub> CrO <sub>4</sub> + KF	(60)
KCl + KF	(3)(67)(84)
KCl + KF + K <sub>2</sub> SO <sub>4</sub>	(83)
KCl + K <sub>2</sub> CO <sub>3</sub>	(84)
KCl + K <sub>2</sub> CO <sub>3</sub> + KF	(84)
KCl + K <sub>2</sub> WO <sub>4</sub>	(85)
KCl + K <sub>2</sub> MoO <sub>4</sub>	(70)
KCl + K <sub>2</sub> TiF <sub>6</sub>	(73)
KCl + K <sub>2</sub> TiF <sub>6</sub> + NaCl	(73)
KCl + LiCl	(18)(21)(22)(34)(59)(66)
KCl + LiCl + NaCl	(18)(35)
K, Li, Na, Cl, SO <sub>4</sub> , WO <sub>4</sub>	(62, 65)
K, Li, Na, Cl, SO <sub>4</sub>	(54)(72)
KCl + LiCl + several salts	(75)
KCl + LiOH = KOH + LiCl	(59)
2KCl + Li <sub>2</sub> SO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + 2LiCl	(66)
KCl + MgCl <sub>2</sub>	(16)(17)(48)(51)(86)(87)(88)
KCl + MgCl <sub>2</sub> + NaCl	(89)
2KCl + MgSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + MgCl <sub>2</sub>	(50)
K, Mg, Na, Cl, SO <sub>4</sub>	(63)
KCl + NH <sub>4</sub> Cl	(15)(71)
K, NH <sub>4</sub> , Cl, NO <sub>3</sub> , H <sub>2</sub> PO <sub>4</sub>	(71)
KCl + NH <sub>4</sub> NO <sub>3</sub> = KNO <sub>3</sub> + NH <sub>4</sub> Cl	(14)(49)(71)
KCl + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub> = KH <sub>2</sub> PO <sub>4</sub> + NH <sub>4</sub> Cl	(71)
KCl + NaCl	(3)(8)(11)(12)(26)(34)(43)(74)
KCl + NaCl + Li <sub>2</sub> SO <sub>4</sub>	(61)(68)
KCl + NaCl + CaSO <sub>4</sub>	(38)
KCl + NaCl + TiCl <sub>3</sub>	(39)
KCl + NaCl + ZnCl <sub>2</sub>	(90)
KCl + NaCl + ZnSO <sub>4</sub>	(90)
KCl + Na <sub>2</sub> CO <sub>3</sub> + Na <sub>2</sub> SO <sub>4</sub>	(76)
KCl + Na <sub>2</sub> CO <sub>3</sub> + NaF	(82)
KCl + NaI	(24)
KCl + NaF = KF + NaCl	(64)(67)
2KCl + Na <sub>2</sub> SO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + 2NaCl	(8)(69)
2KCl + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaCl	(70)
KCl + NaSCN = KSCN + NaCl	(33)
KCl + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaCl	(40)
2KCl + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaCl	(55)
KCl + PbCl <sub>2</sub>	(92)
KCl + PbCl <sub>2</sub> + ZnCl <sub>2</sub>	(92)
2KCl + PbI <sub>2</sub> = 2KI + PbCl <sub>2</sub>	(36)
KCl + RbCl	(19)(27)
KCl + RbF	(77)
KCl + SbCl <sub>3</sub>	(20)(23)
KCl + SrCl <sub>2</sub>	(5)(9)(13)
KCl + SrCl <sub>2</sub> + NaCl	(13)
2KCl + Sr(NO <sub>3</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + SrCl <sub>2</sub>	(32)
KCl + TiCl <sub>2</sub>	(46)
KCl + TiCl	(10)
KCl + ZnCl <sub>2</sub>	(88)(92)(93)
2KCl + ZnSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + ZnCl <sub>2</sub>	(53)(87)(90)(91)
KCl + ZrCl <sub>2</sub>	(43)

Cl

Reference list of authors on page 170.



## REFERENCE LIST OF AUTHORS

- (1) Wrzesnewski, 1912; (2) Amadori and Pampanini, 1911; (3) Ruff and Plato, 1903; (4) Scarpa, 1915; (5) Sackur, 1911-12; (6) Amadori, 1912; (7) Janecke, 1912; (8) Sackur, 1913; (9) Vortisch, 1914; (10) Sandonini, 1911; 1914; (11) Schaeffer, 1919; (12) Lautsberry and Page, 1920; (13) Scholich, 1920; (14) Perman and Saunders, 1923; (15) Janecke, 1928; (16) Menge, 1911; (17) Derby, 1918; (18) Richards and Meldrum, 1917; (19) Keitel, 1925; (20) Kendall, Crittenden and Miller, 1923; (21) Elchardus and Laffitte, 1932; (22) Keitel, 1925; (23) Zouravlev, 1939; (24) Waxberg, 1930; (25) Zemczynsky, 1906, 1908; (26) Bunk and Tichelaar, 1953; (27) Hovi, 1950; (28) Lifshitz, 1956; (29) Shul'ga and Bukhalova, 1957; (30) Krauze and Bergman, 1942; (31) Bensman, 1957; (32) Tokareva and Bergman, 1957; (33) Opariva and Dombrovskaya, 1958; (34) Kochergin and Stolyarova, 1956; (35) Akopov, 1956; (36) Il'yasov and Bergman, 1956; (37) Sementsova and Bergman, 1956; (38) Rubleva and Bergman, 1956; (39) Kamenetskii, 1958; (40) Zakharchenko, 1957; (41) Plyushchev and Komissarova, 1956; (42) Plyushchev and Kovalev, 1956; (43) Howell, Sommer and Kellogg, 1957; (44) Il'yasov, Bostandzhiyan and Bergman, 1956; (45) Il'yasov, Bostandzhiyan, Bergman, 1957; (46) Ehrlich and Kuhl, 1957; (47) Pinch and Hirshon, 1957; (48) Markov and Panchenko, 1955; (49) Rutakov, 1948; (50) Chernogorenko, 1956; (51) Kochergin, Garpinenko, Skorniyakova, Minullina, 1956; (52) Bergman and Bakumskaya, 1956; (53) Evseeva and Bergman, 1954; (54) Akopov and Bergman, 1955a, 1957a; (55) Bukhalova and Mateiko, 1956; (56) Bergman and Il'yasov, 1957; (57) Rassonskaya and Bergman, 1953; (58) Golubeva and Bergman, 1956; (59) Unzhakov, 1952; (60) Rassonskaya and Bergman, 1952; (61) Akopov and Bergman, 1954a; (62) Bergman, Kislova, Posypaiko, 1954, 1954b, 1955; (63) Janecke, 1950, 1951; (64) Chretien, Silber, Ishaque, 1951; (65) Bergman, Kislova, Posypaiko, 1954a; (66) Akopov and Bergman, 1954b, 1955b; (67) Sauerwald and Dombois, 1954; (68) Akopov and Bergman, 1954; (69) Akopov and Bergman, 1954c; (70) Bukhalova and Mateiko, 1955; (71) Bergman, Radishchev, Nikonova, Sveshnikova, Shternina and Yatsuk, 1947; (72) Dombrowskaja and Klatchko, 1933; (73) Ono, Hata and Kuriyama, 1954; (74) Barrett and Wallace, 1954; (75) Janz, Solomons, Gardner, Goodkin and Brown, 1958; (76) Bergman and Sementsova, 1958; (77) Link and Wood, 1940; (78) Schmitz-Dumont and Schmitz, 1944; (79) Palkin, 1948; (80) Fedotov, 1941; (81) Harvey, Jr., Edmison, Jones, Seybert and Cato, 1954; (82) Volkov and Bergman, 1940; (83) Mukimov, 1940; (84) Volkov and Bergman, 1940a; (85) Kislova, Posypaiko and Bergman, 1955; (86) Klemm, Beyersdorfer and Oryschkewitsch, 1948; (87) Anosov and Patsukova, 1956; (88) Kochergin, Khalbullina and Potapova, 1956; (89) Imatomi, 1940; (90) Luzhnaya and Vereshemina, 1949; (91) Luzhnaya and Vereshemina, 1954; (92) Ugai and Shatillo, 1949; (93) Nikonova, Pavlenko and Bergman, 1941.

C10 POTASSIUM CHLORATE  $KClO_3$ 

## SOLUBILITY OF POTASSIUM CHLORATE IN WATER

The results of Taylor, 1897; Carlson, 1910; Calzolari, 1912; Bronsted, 1913; Tschugneff and Chlopin, 1914; Toda, 1921, 1922; Iijinski, 1922; Noonan, 1948; Wright, 1927; DiCapua and Scalletti, 1927; Flottmann, 1928; Ricci, 1937, 1938; Nallet, 1955, and Ricci and Yanik, 1937, were plotted and the following average values read from the curve. The results above 100° are from Tilden and Shenstone, 1881; and Benrath, Gfedebo, Schiffers and Wunderlich, 1937. The solid phase is  $KClO_3$  in all cases.

t°	d. of sat. sol.	Gms. KClO <sub>3</sub> per 100 gms. sat. sol.	t°	d. of sat. sol.	Gms. KClO <sub>3</sub> per 100 gms. sat. sol.	t°	d. of sat. sol.	Gms. KClO <sub>3</sub> per 100 gms. sat. sol.
0	1.021	3.2	60	1.115	19.2	180	65.5	
5	--	4.0	70	--	23.2	200	72.0	
10	--	4.9	80	1.165	27.3	220	78.0	
15	(1.0363)	5.7(5.739)*	90	--	31.5	240	83.0	
20	(1.0420)	6.8(6.793)	100	1.219	36.0	260	87.0	
25	(1.0484)	7.9(7.999)	104b.pt.	1.230	37.5	280	91.0	
30	--	9.2	120	--	43.5	300	94.5	
40	1.073	12.2	140	--	52.0	330	96.7	
50	--	15.0	160	--	59.0			

\*The results in parentheses are by Flottmann, 1928.

C10

SOLUBILITY OF POTASSIUM CHLORATE IN DEUTERIUM OXIDE SOLUTIONS AT 5°  
(Noonan, 1948)

Mole % D <sub>2</sub> O	Moles KClO <sub>3</sub> per 100 moles H <sub>2</sub> O + K <sub>2</sub> O
0.0	0.5845
91.43	.5182
100.0	.5120

SOLUBILITY OF POTASSIUM CHLORATE IN AQUEOUS SOLUTIONS OF  
POTASSIUM HYDROXIDE AT 20°  
(Bronsted, 1920a)

Gm. mols. per liter		Gm. mols. per liter		Gm. mols. per liter	
KOH	KClO <sub>3</sub>	KOH	KClO <sub>3</sub>	KOH	KClO <sub>3</sub>
4.71	0.0924	8.60	0.0410	14.02	0.0215
5.06	0.0882	9.41	0.0351	14.85	0.0195
6.35	0.0609	10.95	0.0287	15.02	0.0191
7.95	0.0445	12.19	0.0254		

At 14-15° a saturated solution containing 1.43 wt. % KOH contains 1.47 wt. % KClO<sub>3</sub>. (Blarez, 1911.)

SOLUBILITY OF POTASSIUM CHLORATE IN AQUEOUS SOLUTIONS OF POTASSIUM  
HYDROXIDE, HYDROGEN PEROXIDE, AND MIXTURES OF THE TWO AT 25°  
(Calvert, 1901)

The mixtures were agitated by means of a stream of air. Equilibrium was approached both from above and below 25°.

Composition of Solvent		Mols. KClO <sub>3</sub> dissolved per liter sat. sol.	Mols. KClO <sub>3</sub> dissolved per liter sat. sol.
Water alone		0.675	82.71
Aqueous 0.125 $\frac{n}{n}$ KOH		0.625	76.60
" 0.25 $\frac{n}{n}$ "		0.573	70.23
Aq. H <sub>2</sub> O <sub>2</sub> containing 1.26 mols. H <sub>2</sub> O <sub>2</sub> per l.		0.730	89.45
" " 1.31 " "		0.737	90.33
Aq. 0.25 $\frac{n}{n}$ KOH " 0.015 " "		0.578	70.82
" " 0.276 " "		0.584	71.57
" " 0.954 " "		0.616	75.50
" " 1.073 " "		0.673	82.47

# K KALIUM

## SOLUBILITY OF POTASSIUM CHLORATE IN AMMONIA SOLUTIONS

t°	Solubility	Author
20°	1 liter aqueous 5.2% NH <sub>3</sub> dissolves 52.5 gms. KClO <sub>3</sub>	(Konowalow, 1899b)
25	1 liter 0.5N NH <sub>3</sub> dissolves 20.43 g. KClO <sub>3</sub>	(Rothmund, 1910)

## SOLUBILITY OF POTASSIUM CHLORATE IN AQUEOUS SOLUTIONS OF POTASSIUM BROMIDE AT 13° (Blarez, 1911)

C10	Gms. per 100 gms. solution		Gms. per 100 gms. solution		Gms. per 100 gms. solution	
	KBr	KClO <sub>3</sub>	KBr	KClO <sub>3</sub>	KBr	KClO <sub>3</sub>
	0.20	5.18	1.0	5.04	6.0	3.46
	0.60	5.20	2.0	4.60	8.0	2.80
	0.8	5.06	3.0	4.2	10.0	2.40
			4.0	4.0		

## Results at 14-15° (Blarez, 1911)

Wt. %	{	KBr	3.05	6.10
		KClO <sub>3</sub>	4.49	3.60

## APPROXIMATE SOLUBILITY OF POTASSIUM CHLORATE IN POTASSIUM CARBONATE SOLUTIONS (Alekcceevsky, 1921)

The determinations were made by adding KClO<sub>3</sub> to the aqueous solvent until no more dissolved after a period of 3 hours. The curves drawn from the results are very irregular, thus showing that saturation could not have been reached in all cases.

t°	Gms. KClO <sub>3</sub> per 100 cc. sat. solution in Aqueous					
	5% K <sub>2</sub> CO <sub>3</sub>	10% K <sub>2</sub> CO <sub>3</sub>	20% K <sub>2</sub> CO <sub>3</sub>	30% K <sub>2</sub> CO <sub>3</sub>	40% K <sub>2</sub> CO <sub>3</sub>	50% K <sub>2</sub> CO <sub>3</sub>
20	6.0	5.0	4.0	2.5	2.0	1.0
30	6.5	6.0	5.0	3.5	2.5	2.5
40	8.5	8.0	6.5	4.5	4.5	3.5
50	9.5	9.0	7.5	6.0	6.0	4.0

## SOLUBILITY OF POTASSIUM CHLORATE IN POTASSIUM OXALATE SOLUTIONS AT 14-15° (Blarez, 1911)

Sat. Sol. wt. %	{	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	2.42	4.85
		KClO <sub>3</sub>	4.72	3.93

SOLUBILITY OF POTASSIUM CHLORATE IN POTASSIUM CHLORIDE SOLUTIONS  
 [See also page 119, 120, this volume]

Results at 14-15°  
 (Blarez, 1911)

Wt. %	KCl	1.91	3.82
	KClO <sub>3</sub>	4.45	3.58

Results at 20°  
 (Winteler, 1900)

Sp. Gr. of Solutions	Grams per Liter		Sp. Gr. of Solutions	Grams per liter		ClO
	KCl	KClO <sub>3</sub>		KCl	KClO <sub>3</sub>	
1.050	0	71.1	1.098	120	24.5	
1.050	10	58.0	1.108	140	22.5	
1.050	20	49.0	1.119	160	21.0	
1.054	40	39.5	1.130	180	20.0	
1.064	60	34.0	1.140	200	20.0	
1.075	80	30.0	1.168	250	20.0	
1.086	100	27.0				

Results at 25°  
 (Holluta and Peter, 1929)

Molarity KCl in Solvent	Gms. KClO <sub>3</sub> per liter sat. sol.	Molarity KCl in Solvent	Gms. KClO <sub>3</sub> per liter sat. sol.	Molarity KCl in Solvent	Gms. KClO <sub>3</sub> per liter sat. sol.
0.0	83.030	0.4	64.191	1.0	48.142
0.1	76.653	0.5	60.375	2.0	34.673
0.2	71.484	0.75	54.010	3.0	27.600
0.3	67.793				

THE SYSTEM POTASSIUM CHLORATE - POTASSIUM IODIDE - WATER AT 25°  
 (Ricci, 1937)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	KClO <sub>3</sub>	KI			KClO <sub>3</sub>	KI	
1.047	7.905	0.0	KClO <sub>3</sub>	1.555	1.10	49.94	KClO <sub>3</sub>
1.103	5.04	9.33	"	1.702	0.82	58.34	"
1.178	3.35	18.74	"	1.724	0.83	59.28	" + KI
1.275	2.30	28.72	"	1.724	0.67	59.36	KI
1.400	1.60	39.26	"	1.718	0.0	59.76	"

Data at 14-15°  
 (Blarez, 1911)

Wt. %	KI	4.25	8.51
	KClO <sub>3</sub>	4.59	3.65

# K KALIUM

## THE SYSTEM POTASSIUM CHLORATE - POTASSIUM IODATE - WATER (Ricci, 1938)

	Results at 25°			Results at 50°		
	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	KIO <sub>3</sub>	KClO <sub>3</sub>		KIO <sub>3</sub>	KClO <sub>3</sub>	
d. of sat. sol.						
1.048	0.0	7.90	KClO <sub>3</sub>	0.0	15.78	KClO <sub>3</sub>
1.068	2.92	7.31	"	2.41	15.11	"
1.090	5.43	6.80	" + KIO <sub>3</sub>	5.27	14.31	"
1.082	5.85	5.31	KIO <sub>3</sub>	7.27	13.77	" + KIO <sub>3</sub>
1.070	7.05	2.31	"	8.76	8.58	KIO <sub>3</sub>
1.043	8.45	0.0	"	10.87	3.71	"
				13.21	0.0	"

## THE SYSTEM POTASSIUM CHLORATE - POTASSIUM NITRATE - WATER (14-15° Blarez, 1911; 18.85°, 23.87° Arrhenius, 1893; 25° Toda, 1921a, 1922; also Holluta and Peter, 1929)

At 14-15°		At 19.85°		At 23.87°	
Sat. Sol. wt. %		Grams per Liter		Grams per Liter	
KNO <sub>3</sub>	KClO <sub>3</sub>	KNO <sub>3</sub>	KClO <sub>3</sub>	KNO <sub>3</sub>	KClO <sub>3</sub>
2.59	4.51	0.0	69.88	0.0	79.09
5.18	3.88	12.05	64.86	50.59	63.14
		25.29	60.33		
		101.19	45.85		
		202.38	40.22		

### At 25°

<u>Toda</u>		Solid Phase	<u>H. and P.</u>	
Gms. per 100 gms. sat. sol.			Solvent: Moles KNO <sub>3</sub> per liter	Sat. sol.: Gms. KClO <sub>3</sub> per liter
KNO <sub>3</sub>	KClO <sub>3</sub>			
0.0	7.745	KClO <sub>3</sub>	0.0	83.030
0.68	7.65	KClO <sub>3</sub> ·NO <sub>3</sub>	0.1	77.951
1.55	7.07	"	0.2	75.225
3.59	6.52	"	0.3	72.587
7.12	5.76	"	0.4	70.346
12.81	5.10	"	0.5	68.695
18.97	4.39	"	0.75	63.619
27.14	3.90	"	1.0	61.096
27.14	3.90	KClO <sub>3</sub> + KNO <sub>3</sub>	2.0	53.213
27.21	3.61	KNO <sub>3</sub>	3.0	49.068
27.57	1.63	"		
27.24	0.0	"		

THE SYSTEM POTASSIUM CHLORATE - POTASSIUM SULFATE - WATER  
(Ricci and Yanick, 1937)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	KClO <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>			KClO <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>	
Results at 15°				Results at 25°--Cont.			
1.032	5.676	0.0	KClO <sub>3</sub>	1.099	5.06	8.19	KClO <sub>3</sub>
--	4.71	2.23*	"	1.100	4.96	8.64	KClO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>
--	3.98	4.46*	"	1.099	3.30	9.43	K <sub>2</sub> SO <sub>4</sub>
1.085	3.29	7.86	" + K <sub>2</sub> SO <sub>4</sub>	1.089	1.80	9.93	"
1.076	0.0	9.258	K <sub>2</sub> SO <sub>4</sub>	1.083	0.0	10.76	"
Results at 25° (Also see below)				Results at 45°			
1.048	7.897	0.0	KClO <sub>3</sub>	--	13.90	0.0	KClO <sub>3</sub>
1.063	6.72	2.73	"	--	9.80	9.13	" + K <sub>2</sub> SO <sub>4</sub>
1.080	5.77	5.57	"	--	0.0	13.53	K <sub>2</sub> SO <sub>4</sub>

C10

C10

\*Blarez, 1911

## Results of Holluta and Peter at 25°

Solvent: Equiv. K <sub>2</sub> SO <sub>4</sub> per liter	Sat. Sol.: Gms. KClO <sub>3</sub> per liter	Solvent: Equiv. K <sub>2</sub> SO <sub>4</sub> per liter	Sat. Sol.: Gms. KClO <sub>3</sub> per liter
0.0	83.030	0.3	71.995
0.025	82.570	0.4	69.834
0.05	80.622	0.5	67.004
0.1	79.103	0.75	59.389
0.2	75.387	1.0	54.310

THE SYSTEM POTASSIUM CHLORATE - SODIUM CHLORATE - WATER  
(Nallet, 1955; Nallet and Paris, 1956)

The older results of Muntner and Brown (1943), DiCapua and Scalletti (1927), and Iljinsky (1924) are scattered and less reliable. Data in molarities are given by Holluta and Peter (1929).

[ K = KClO <sub>3</sub>			Na = NaClO <sub>3</sub>	I = Ice]			
Gms. per 100 gms. sat. sol.		Density	Solid Phase	Gms. per 100 gms. sat. sol.		Density	Solid Phase
NaClO <sub>3</sub>	KClO <sub>3</sub>			NaClO <sub>3</sub>	KClO <sub>3</sub>		
At -17.85°							
39.55	0.40	1.356	K + Na + I	41.7	0	1.3685	Na
				41.52	0.579	1.3735	Na + K
At -17.8°							
				35.08	0.578	1.305	K
				25.93	0.604	1.217	K + I
39.74	0	1.355	Na + I	25.40	0.589	1.2115	K (I in?)
				26.43	0	1.215	I

(Cont.)

## K KALIUM

## THE SYSTEM POTASSIUM CHLORATE - SODIUM CHLORATE - WATER—Cont.

[K =  $\text{KClO}_3$ Na =  $\text{NaClO}_3$ 

I = Ice]

ClO	Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
	NaClO <sub>3</sub>	KClO <sub>3</sub>	Density		NaClO <sub>3</sub>	KClO <sub>3</sub>	Density	
	At -4°				At 50°			
	12.63	1.001	1.095	I + K	55.55	0	1.486	Na
					54.31	2.76	1.504	Na
					53.66	4.20	1.510	Na + K
	0	3.01	1.020	I + K	44.53	4.74	1.408	K
					33.56	5.82	1.300	K
					14.17	9.64	1.155	K
					3.91	13.51	1.104	K
					0	15.70	1.089	K
					At 70°			
	46.72	0	1.409	Na	60.05	0	1.526	Na
	46.27	0.665	1.4135	Na	58.48	3	1.543	Na
	46.24	1.25	1.4173	Na + K	56.86	5.84	1.560	Na
	37.52	1.34	1.3253	K	56.6	6.62	1.566	Na + K
	20.71	1.68	1.1659	K	44.75	7.88	1.427	K
	6.28	2.78	1.0628	K	28.49	11.07	1.283	K
	1.809	3.914	1.0381	K	15.04	15.61	1.197	K
	0.712	4.31	1.0333	K	6.87	19.42	1.160	K
	0	4.64	1.0303	K	0	23.49	1.134	K
					At 100°			
					66.74	0	1.595	Na
	51.22	0	1.4473	Na	63.61	5.21	1.625	Na
	50.58	0.965	1.453	Na	60.12	11.52	1.661	Na + K
	50.24	2.435	1.4625	Na + K	45.39	14.36	1.485	K
	41.43	2.7	1.3675	K	25.39	21.21	1.325	K
	25.85	3.57	1.2202	K	0	36.04	1.215	K
	11.62	5.3	1.1141	K				
	7.67	6.25	1.0905	K				
	4.02	7.43	1.0718	K				
	1.58	8.47	1.0609	K				
	0	9.24	1.0552	K				

SOLUBILITY OF  $\text{KClO}_3$  IN  $\text{NaCl}$  AND IN  $\text{Na}_2\text{CO}_3$  SOLUTIONS(Data of Holluta and Peter, 1929 at  $25^\circ$ )

Solvent: Molarity of $\text{NaCl}$	Sat. Sol.: Gms. $\text{KClO}_3$ per liter	Solvent: Molarity of $\text{NaCl}$	Sat. Sol.: Gms. $\text{KClO}_3$ per liter
0.0	83.030	0.5	86.968
0.1	83.233	0.75	88.069
0.2	84.383	1.0	88.924
0.3	85.615	2.0	90.398
0.4	85.998		

(Cont.)

Approximate results of Alekceevsky, 1921

t°	Gms. $\text{KClO}_3$ per 100 cc. sat. solution in Aqueous		
	5 to 7% $\text{Na}_2\text{CO}_3$	5% $\text{NaCl}$	30% $\text{NaCl}$
20	5.0	5.0	5.0
30	5.5	5.5	5.5
40	7.5	7.5	6.5
50	10.5	13.0	11.5

SOLUBILITY OF POTASSIUM CHLORATE IN AQUEOUS ETHANOL  
(Taylor, 1897; Wright, 1927 (20, 100°))

Wt. % Ethanol in Solvent	At 20°	At 30°		At 40°		At 100°	C10
	Gms. $\text{KClO}_3$ per 100 gms. Solution	Gms. $\text{KClO}_3$ per 100 gms.		Gms. $\text{KClO}_3$ per 100 gms.		Gms. $\text{KClO}_3$ per 100 gms. Solution	
		Solution	Water	Solution	Water		
0	--	9.23	10.17	12.23	13.93	--	
5	--	7.72	8.80	10.48	12.33	--	
10	--	6.44	7.65	8.84	10.77	--	
20	--	4.51	5.90	6.40	8.56	--	
30	--	3.21	4.74	4.67	7.00	--	
40	--	2.35	4.00	3.41	5.88	--	
50	1.1	1.64	3.33	2.41	4.94	14.1	
60	--	1.01	2.53	1.41	3.69	--	
70	--	0.54	1.82	0.78	2.63	--	
80	--	0.24	1.22	0.34	1.73	--	
90	--	0.06	0.62	0.12	1.17	--	

SOLUBILITY OF POTASSIUM CHLORATE IN AQUEOUS ACETONE SOLUTIONS  
(Taylor, 1897; Hartley, 1931 (17.6°))

t°	At 17.6°	At 30°		At 40°	
	Gms. $\text{KClO}_3$ per 100 gms. Solution	Gms. $\text{KClO}_3$ per 100 gms.		Gms. $\text{KClO}_3$ per 100 gms.	
		Solution	Water	Solution	Water
0	6.15	9.23	10.17	12.23	13.93
5	5.50	8.32	9.56	11.10	13.11
10	4.90	7.63*	9.09	10.28*	12.60
15	4.33	--	--	--	--
20	--	6.09	8.10	8.27	11.26
30	--	4.93	7.40	6.69	10.24
40	--	3.90	6.76	5.36	9.45
50	--	2.90	5.98	4.03	8.40
60	--	2.03	5.17	2.86	7.35
70	--	1.24	4.18	1.68	5.68
80	--	0.57	2.88	0.79	3.97
90	--	0.18	1.82	0.24	2.45

\*Solvent, 9.09 Wt. percent Acetone.



# K KALIUM

## SOLUBILITY OF POTASSIUM CHLORATE IN AQUEOUS GLYCEROL

t°	d. of Glycerol	Percent Glycerol	Gms. KClO <sub>3</sub> per 100 gms. Glycerol	Authority
15-16	1.256	96.0	3.54	(Ossendowski, 1907)
20	1.2326	86.5	1.32	(Holm, 1921, 1921(a), 1922)
20	1.2645	98.5	1.03	( " " " " )
25	1.249	95.0	1.05	(Schnellbach and Rosin, 1931)

## SOLUBILITY OF POTASSIUM CHLORATE IN AQUEOUS SOLUTIONS OF VARIOUS ORGANIC COMPOUNDS AT 25° (Rothmund, 1910)

Aqueous 0.5 Normal Solution of:	KClO <sub>3</sub> per liter		Aqueous 0.5 Normal Solution of:	KClO <sub>3</sub> per Liter	
	Mols.	Gms.		Mols.	Gms.
Water alone	0.1475	20.44	Ammonia	0.1474	20.43
Methyl Alcohol	0.1402	19.43	Dimethylamine	0.1342	18.60
Ethyl Alcohol	0.1356	18.75	Pyridine	0.1410	19.54
Propyl Alcohol	0.1343	18.61	Urethan	0.1400	19.40
Tertiary Amyl Alcohol	0.1279	17.72	Formamide	0.1539	21.32
Acetone	0.1451	20.11	Acetamide	0.1447	20.05
Ether	0.1336	18.51	Acetic Acid	0.1462	20.26
Glycol	0.1416	19.62	Phenol	0.1362	18.87
Glycerol	0.1404	19.45	Methylal	0.1400	19.40
Urea	0.1510	20.92	Methyl Acetate	0.1429	19.80

## SOLUBILITY OF POTASSIUM CHLORATE IN ORGANIC SOLVENTS AT 25° (Isbin and Kobe, 1945)

Solvent	Gms. KClO <sub>3</sub> per 100 gms. Solvent
Ethylenediamine	0.145
Monoethanolamine	0.30
Ethylene Glycol	1.21

100 gms. liquid ammonia (NH<sub>3</sub>) dissolve 2.52 gms. KClO<sub>3</sub> at 0°.  
(Hunt and Boncyk, 1933)

Melting points in the system KClO<sub>3</sub> + KNO<sub>3</sub> were determined by Palkin, 1948.

## C10 POTASSIUM PERCHLORATE KClO<sub>4</sub>

### SOLUBILITY OF POTASSIUM PERCHLORATE IN WATER

The following values were taken from an average curve constructed from the results of Pierrot, 1921; Hering, 1926; Willard and Smith, 1923; Moser and Ritschel, 1925; Bozarth, 1923; Flottmann, 1928; Cornec and Neumeister, 1929; Platt and Jordan, 1930, 1933; Akerlof and Turck, 1935; and Caven and Bryce, 1934. Above 100° Benrath, Gjedebø, Schiffers and Wunderlich, 1937.

The earlier results of Carlson, 1910; Rosenheim and Weinhaber, 1910-11; and Calzolari, 1912 are too high. Densities in parentheses are from this older work.

The solid phase is  $KClO_4$  throughout.

t°	d. of sat. sol.	Gms. $KClO_4$ per 100 gms. sat. sol.	t°	d. of sat. sol.	Gms. $KClO_4$ per 100 gms. sat. sol.	t°	Gms. $KClO_4$ per 100 gms. sat. sol.
0	1.005	0.75	50	1.017	4.90	120	25
10	—	1.05	60	(1.033)	6.8	140	32.5
15	1.0076	1.33	70	—	9.2	180	46
20	1.0085	1.65	75	1.036	10.36	200	52.5
25	1.0096	2.03	80	(1.053)	11.8	225	60
30	—	2.50	90	—	15.0	250	67
40	(1.022)	3.60	100	1.0681	18.2	265	70

ClO

SOLUBILITY OF POTASSIUM PERCHLORATE IN AQUEOUS  
SOLUTIONS OF HYDROGEN PEROXIDE AT 25°  
(Akerlof and Turck, 1935)

Gms. $H_2O_2$ per 100 gms. aq. solvent	Gms. Mols. $KClO_4$ per 1000 gms. aq. solvent
0.00	0.149
15.72	0.175
31.43	0.199

SOLUBILITY OF POTASSIUM PERCHLORATE IN AQUEOUS AND IN ALCOHOLIC  
SOLUTIONS OF PERCHLORIC ACID AT 25.2°  
(Thin and Cumming, 1915)

In Aq. $HClO_4$ Solutions		In Alcoholic $HClO_4$ Solutions	
Normality of Aq. $HClO_4$	Gms. $KClO_4$ per 100 Gms. Sat. Sol.	Aqueous Solvent	Gms. $KClO_4$ per 100 Gms. Sat. Sol.
0 (= water)	2.085	93.5% Alcohol	0.051
0.01	1.999	" + 0.2% $HClO_4$ *	0.0175
0.10	1.485	98.8% Alcohol +	0.010
1	0.527	" + 2% $HClO_4$ *	0.028

\*The  $HClO_4$  was added as aq. 20%  $HClO_4$  solution hence the concentration of the alcohol was decreased.

# K KALIUM

## THE SYSTEM POTASSIUM PERCHLORATE - POTASSIUM PERMANGANATE - WATER Continuous solid solutions are formed.

Results at 7°  
(Muthmann and Kuntze, 1894; recalculated by Fock, 1897)

	Milligram Mols. per Liter		Gms. per Liter		Mol. percent KMnO <sub>4</sub> in Crystals of Solid Phase
	KMnO <sub>4</sub>	KClO <sub>3</sub>	KMnO <sub>4</sub>	KClO <sub>4</sub>	
ClO	0	63.91	0	8.86	0
	29.37	54.48	4.65	7.55	2.84
	67.73	42.75	10.71	5.93	9.78
	79.04	39.59	12.50	5.49	10.81
	99.81	38.63	15.79	5.36	15.96
	122.24	34.39	19.34	4.77	23.56
	119.21	38.91	18.84	5.39	24.28
	128.08	33.77	20.26	4.68	26.40
	144.46	33.14	22.86	4.59	34.32
	167.81	29.53	26.55	4.09	44.42
	183.09	25.19	28.97	3.49	67.33
	197.82	20.16	31.30	2.80	77.95
	233.75	28.26	36.98	3.92	94.37
	264.27	0	41.81	0	100

Results at 25°  
(Greenberg and Walden, 1940)

The mixtures were heated, and equilibrium was approached from super-saturation. Equilibrium was attained in two weeks, providing the solid phase was ground in an agate mortar a few days after preparation, otherwise 1-1/2 months were required. The solid phases were analyzed by the wet residue method, and the lattice constants were determined by X-Ray analysis.

Gms. per 100 gms. sat. sol.		Wt. % KMnO <sub>4</sub> in Solid Solution	Gms. per 100 gms. sat. sol.		Wt. % KMnO <sub>4</sub> in Solid Solution
KMnO <sub>4</sub>	KClO <sub>4</sub>		KMnO <sub>4</sub>	KClO <sub>4</sub>	
0.4712	1.868	1.2	4.573	0.8434	38.2
2.065	1.381	7.7	4.864	0.7816	44.4
2.651	1.230	11.8	5.698	0.5872	68.0
2.628	1.245	12.0	5.732	0.5548	70.2
4.009	0.9777	26.8	6.333	0.3582	84.5

THE SYSTEM POTASSIUM PERCHLORATE - POTASSIUM NITRATE - WATER AT 25°  
(Karnaukhov, 1957)

For additional data at other temperatures see Cornec and Hering, 1927.

(The solid phase is a solid solution)

Sat. sol. wt. %		Wet residue wt. %		Sat. sol. wt. %		Wet residue wt. %	
KClO <sub>4</sub>	KNO <sub>3</sub>	KClO <sub>4</sub>	KNO <sub>3</sub>	KClO <sub>4</sub>	KNO <sub>3</sub>	KClO <sub>4</sub>	KNO <sub>3</sub>
2.02	0.0	--	--	0.86	19.50	35.78	28.22
2.25	3.07	63.04	4.14	0.87	22.25	39.06	35.34
1.57	5.73	73.88	9.72	1.07	26.87	19.22	53.86
1.00	10.00	58.30	12.29	0.0	27.64	--	--
0.87	15.50	51.02	15.31				

ClO

THE SYSTEM KClO<sub>4</sub> + NH<sub>4</sub>NO<sub>3</sub> = KNO<sub>3</sub> + NH<sub>4</sub>ClO<sub>4</sub> AT 25°  
(Karnaukhov, 1957)

Sat. soln. wt. %					Solid Phase
KNO <sub>3</sub>	NH <sub>4</sub> NO <sub>3</sub>	NH <sub>4</sub> ClO <sub>4</sub>	KClO <sub>4</sub>	H <sub>2</sub> O	
16.63	51.07	2.74	--	29.56	3:1 + NH <sub>4</sub> NO <sub>3</sub>
16.62	51.56	2.90	--	28.92	3:1 + NH <sub>4</sub> NO <sub>3</sub> + mKClO <sub>4</sub> ·nNH <sub>4</sub> ClO <sub>4</sub>
11.39	55.29	2.54	--	30.78	NH <sub>4</sub> NO <sub>3</sub> + mKClO <sub>4</sub> ·nNH <sub>4</sub> ClO <sub>4</sub>
4.14	47.82	3.33	--	47.71	" "
2.15	38.69	4.91	--	54.25	" "
--	19.69	4.04	1.25	75.02	" "
--	19.87	5.19	1.25	73.69	" "
--	14.42	7.99	0.95	76.64	" "
--	5.60	15.60	0.24	78.56	" "
--	0.77	18.50	0.07	80.66	" "
2.22	--	0.09	1.69	96.00	mKClO <sub>4</sub> ·nKNO <sub>3</sub> + mKClO <sub>4</sub> ·nNH <sub>4</sub> ClO <sub>4</sub>
4.58	0.80	--	1.17	93.45	" "
4.95	2.49	--	0.49	92.07	" "
5.00	4.22	--	0.48	90.30	" "
8.57	9.24	--	1.03	81.16	" "
22.47	34.73	--	1.71	41.09	" "
22.61	34.41	--	1.67	41.31	" " + 3:1
20.33	40.00	--	1.71	37.96	mKClO <sub>4</sub> ·nNH <sub>4</sub> ClO <sub>4</sub> + 3:1
22.06	45.42	2.37	--	30.25	" "
21.93	35.55	--	0.58	41.94	mKClO <sub>4</sub> ·nKNO <sub>3</sub> + 3:1

3:1 = 3KNO<sub>3</sub>·NH<sub>4</sub>NO<sub>3</sub>

SOLUBILITY OF POTASSIUM PERCHLORATE IN AQUEOUS  
SOLUTIONS OF ALUMINUM PERCHLORATE AT 30°  
(Craven and Bryce, 1934)

Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
Al(ClO <sub>4</sub> ) <sub>3</sub>	KClO <sub>4</sub>		Al(ClO <sub>4</sub> ) <sub>3</sub>	KClO <sub>4</sub>	
0.0	2.528	KClO <sub>4</sub>	4.956	1.028	KClO <sub>4</sub>
2.652	1.462	"	8.158	0.7041	"
3.043	1.357	"	34.56	0.2115	"

## K KALIUM

THE SYSTEM  $\text{KClO}_4 - \text{NH}_4\text{ClO}_4 - \text{H}_2\text{O}$  AT  $25^\circ$   
(Kernaikhov, 1957)

Sat. sol. wt. %		Solid Phase	Sat. sol. wt. %		Solid Phase
$\text{KClO}_4$	$\text{NH}_4\text{ClO}_4$		$\text{KClO}_4$	$\text{NH}_4\text{ClO}_4$	
2.02	0.0	$\text{KClO}_4$	1.47	15.54 (Av.)	S.S. I + S.S. II
1.59	4.20	Solid Soln. I	0.49	17.81	Solid Soln. II
1.46	8.31	"	0.32	19.57	"
1.03	11.27	"	0.0	19.68	$\text{NH}_4\text{ClO}_4$
1.39	14.16	"			

C10

THE SYSTEM POTASSIUM PERCHLORATE - SODIUM PERCHLORATE - WATER  
(Kernaikhov and Makin, 1957)

The salts form limited solid solutions at  $0^\circ$ , but only the pure solids were found at  $25^\circ$ .

Results at $0^\circ$					Results at $25^\circ$		
Sat. sol. wt. %		Wet solid wt. %		Solid Phase	Sat. sol. wt. %		Solid Phase
$\text{KClO}_4$	$\text{NaClO}_4$	$\text{KClO}_4$	$\text{NaClO}_4$		$\text{KClO}_4$	$\text{NaClO}_4$	
0.75	—	—	—	K	2.30	—	K
0.63	5.15	75.90	0.74	K	2.18	2.38	K
0.55	6.94	77.27	0.92	K	2.21	4.11	K
0.45	9.23	73.18	1.59	K	2.03	6.52	K
0.49	11.71	73.61	2.87	K	1.36	10.00	K
0.48	11.85	72.51	2.92	K	1.34	11.95	K
0.51	19.54	77.76	4.19	K	1.60	16.74	K
0.50	21.56	75.00	5.26	K	1.60	18.39	K
0.49	31.82	73.49	8.12	K	1.62	26.08	K
0.45	36.58	74.22	9.21	K	1.45	32.38	K
0.46	41.24	73.00	11.55	K	1.30	40.82	K
0.51	50.00	65.35	17.54	K	1.26	49.94	K
0.52	55.37	62.29	26.47	K + Na	1.33	58.37	K
0.51	55.32	51.15	41.48	K + Na	1.34	63.26	K
0.51	55.35	34.12	58.75	K + Na	0.47	66.32	Na
0.54	55.32	24.69	69.55	K + Na	—	67.82	Na
0.42	58.23	19.26	76.56	K, Na			
0.28	60.15	13.39	82.39	K, Na			
0.16	61.46	5.47	91.47	K, Na			
—	62.89	—	—	Na			

K =  $\text{KClO}_4$ Na =  $\text{NaClO}_4 \cdot \text{H}_2\text{O}$ 

K, Na = Solid Solution

THE SYSTEM  $\text{KClO}_4 + \text{NaNO}_3 \rightleftharpoons \text{KNO}_3 + \text{NaClO}_4$  (+  $\text{H}_2\text{O}$ )  
(Hering, 1926)

t°	d. of sat. sol.	Gms. per 100 gms. $\text{H}_2\text{O}$				Solid Phase
		$\text{KClO}_4$	$\text{NaClO}_4$	$\text{NaNO}_3$	$\text{KNO}_3$	
25	1.013	2.07	--	--	--	$\text{KClO}_4$
"	1.684	--	211.0	--	--	$\text{NaClO}_4 \cdot \text{H}_2\text{O}$
"	1.392	--	--	91.7	--	$\text{NaNO}_3$
"	1.189	--	--	--	38.3	$\text{KNO}_3$
"	1.684	0.87	210.0	--	--	$\text{KClO}_4 + \text{NaClO}_4 \cdot \text{H}_2\text{O}$
"	1.732	--	209.0	41.7	--	$\text{NaClO}_4 + \text{NaNO}_3$
"	1.512	--	--	97.7	49.2	$\text{KNO}_3 + \text{NaNO}_3$
"	1.195	0.96	--	--	38.8	$\text{KClO}_4 + \text{KNO}_3$
"	1.733	1.91	208.0	41.2	--	" + $\text{NaNO}_3 + \text{NaClO}_4 \cdot \text{H}_2\text{O}$
"	1.419	7.24	--	94.4	--	" + $\text{NaNO}_3$
"	1.515	1.92	--	97.7	49.1	" + " + $\text{KNO}_3$
100	1.070	22.1	--	--	--	"
"	1.758	--	329.0	--	--	$\text{NaClO}_4$
"	1.507	--	--	175.1	--	$\text{NaNO}_3$
"	1.569	--	--	--	244.0	$\text{KNO}_3$
"	1.770	9.0	333.0	--	--	$\text{KClO}_4 + \text{NaClO}_4$
"	1.825	--	333.0	114.0	--	$\text{NaClO}_4 + \text{NaNO}_3$
"	1.786	--	--	234.0	328.0	$\text{KNO}_3 + \text{NaNO}_3$
"	1.609	22.0	--	--	255.0	$\text{KClO}_4 + \text{KNO}_3$
"	1.837	11.6	331.0	116.0	--	" + $\text{NaNO}_3 + \text{NaClO}_4$
"	1.578	38.6	--	186.0	--	" + "
"	1.803	22.6	--	242.0	332.0	" + " + $\text{KNO}_3$

THE SYSTEM  $\text{KClO}_4 + \text{NaCl} + \text{H}_2\text{O}$  (PSEUDO-BINARY)  
(Cornec and Neumeister, 1929)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	KClO <sub>4</sub>	NaNO <sub>3</sub>			KClO <sub>4</sub>	NaNO <sub>3</sub>	
Results at 0°				Results at 75°			
1.005	0.75	0.0	KClO <sub>4</sub>	1.036	10.36	0.0	KClO <sub>4</sub>
1.214	0.74	26.2	" + NaCl	1.207	6.18	27.5	" + NaCl
1.209	0.0	26.4	NaCl	1.176	0.0	27.5	NaCl
Results at 25°				Results at 100°			
1.013	2.03	0.0	KClO <sub>4</sub>	1.068	18.17	0.0	KClO <sub>4</sub>
1.207	1.61	25.9	" + NaCl	1.116	15.32	8.1	"
1.198	0.0	26.6	NaCl	1.153	12.72	15.0	"
				1.190	10.85	21.0	"
				1.216	9.49	25.1	" + NaCl
				1.201	6.85	36.0	NaCl
1.017	4.71	0.0	KClO <sub>4</sub>	1.183	3.54	27.0	"
1.205	3.19	25.9	" + NaCl	1.164	0.0	28.6	"
1.85	0.0	26.9	NaCl				
Results at 50°							

## K KALIUM

THE SYSTEM  $\text{KClO}_4 + \text{NaNO}_3 + \text{H}_2\text{O}$  (PSEUDO-BINARY)  
(Cornec and Neumeister, 1929)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase		
	KClO <sub>4</sub>	NaNO <sub>3</sub>			KClO <sub>4</sub>	NaNO <sub>3</sub>			
Results at 0°				Results at 75°					
C10	1.005	0.75	0.0	KClO <sub>4</sub>	1.036	10.36	0.0	KClO <sub>4</sub>	
	1.136	1.43	16.4	"	1.187	10.81	19.8	"	
	1.237	1.70	28.1	"	1.312	10.28	34.0	"	
	1.317	1.82	36.8	"	1.407	9.61	43.5	"	
	1.368	1.88	41.8	" + NaNO <sub>3</sub>	1.461	9.11	48.9	"	
	1.352	0.0	42.3	NaNO <sub>3</sub>	1.523	8.61	54.4	" + NaNO <sub>3</sub>	
Results at 25°				1.509	6.11	55.7	NaNO <sub>3</sub>		
	1.013	2.03	0.0	KClO <sub>4</sub>	1.501	5.42	56.0	"	
	1.155	2.25	24.0	"	1.492	3.92	56.7	"	
	1.265	3.52	48.3	"	1.488	3.20	57.1	"	
	1.352	3.60	40.4	"	1.486	2.80	57.3	"	
	1.419	3.59	46.8	" + NaNO <sub>3</sub>	1.469	0.0	58.7	"	
	1.404	1.82	47.3	NaNO <sub>3</sub>	Results at 100°				
	1.392	0.0	47.8	"		1.068	18.17	0.0	KClO <sub>4</sub>
	Results at 50°					1.241	16.39	22.7	"
1.017	4.91	0.0	KClO <sub>4</sub>	1.370		14.81	37.1	"	
1.158	6.10	18.2	"	1.472		13.41	47.4	"	
1.264	6.29	30.6	"	1.535		12.44	53.6	"	
1.349	6.23	39.6	"	1.578		11.89	57.3	" + NaNO <sub>3</sub>	
1.417	5.99	46.2	"	1.554		8.21	59.4	NaNO <sub>3</sub>	
1.468	5.73	51.0	" + NaNO <sub>3</sub>	1.540		5.17	61.0	"	
1.454	3.56	52.0	NaNO <sub>3</sub>	1.507		0.0	63.7	"	
1.441	1.85	52.6	"						
1.427	0.0	53.2	"						

THE SYSTEM  $\text{KClO}_4 + \text{NaCl} + \text{NaNO}_3 + \text{H}_2\text{O}$   
(Cornec and Neumeister, 1929)

t°	d. of sat. sol.	Gms. per 100 gms. sat. sol.			Solid Phase
		$\text{KClO}_4$	$\text{NaCl}$	$\text{NaNO}_3$	
0	1.342	1.15	16.4	23.4	$\text{KClO}_4 + \text{NaCl} + \text{NaNO}_3$
25	1.404	3.19	4.1	41.7	" + $\text{NaNO}_3$
"	1.395	2.84	8.4	36.9	" + "
"	1.388	2.55	12.3	32.5	" + " + $\text{NaCl}$
"	1.332	2.31	16.0	23.4	" + $\text{NaCl}$
"	1.274	2.00	20.5	13.0	" + "
"	1.378	1.28	12.8	32.3	" + $\text{NaNO}_3$
50	1.445	4.76	8.6	41.3	$\text{KClO}_4 + \text{NaCl} + \text{NaNO}_3$
"	1.398	4.60	11.1	34.6	" + "
"	1.341	4.34	14.6	25.7	" + "
"	1.277	3.84	19.6	14.3	" + "

(Cont.)

THE SYSTEM  $\text{KClO}_4 + \text{NaCl} + \text{NaNO}_3 + \text{H}_2\text{O}$ —Cont.

t°	d. of sat. sol.	Gms. per 100 gms. sat. sol.			Solid Phase
		$\text{KClO}_4$	$\text{NaCl}$	$\text{NaNO}_3$	
75	1.509	7.69	5.9	48.3	$\text{KClO}_4 + \text{NaCl} + \text{NaNO}_3$
"	1.454	7.67	8.1	41.5	" + "
"	1.384	7.51	11.7	31.5	" + "
"	1.305	6.92	17.1	18.6	" + "
100	1.578	11.54	2.20	55.1	$\text{KClO}_4 + \text{NaNO}_3$
"	1.538	5.86	4.79	55.5	$\text{NaCl} + "$
"	1.573	10.80	4.23	53.6	" + " + $\text{KClO}_4$
"	1.518	11.52	5.73	47.0	" + $\text{KClO}_4$
"	1.440	11.72	8.84	37.0	" + "
"	1.340	11.34	14.71	22.1	" + "

ClO

SOLUBILITY OF POTASSIUM PERCHLORATE IN VARIOUS SALT SOLUTIONS AT 25°  
(Bozorth, 1923)

Saturation was obtained by constant agitation, and approaching equilibrium from above and from below. The salt content of the solvents was determined by evaporation and drying the residue at 200°. The salt content of the saturated solutions was determined in the same manner and the difference ascribed to dissolve perchlorate.

Salt	Gm. Equiv. Salt per 1000 gms. $\text{H}_2\text{O}$	Gms. Equiv. $\text{KClO}_4$ per 1000 gms. $\text{H}_2\text{O}$
None = $\text{H}_2\text{O}$	0.0	0.1491 (=20.67 gms.)
$\text{KCl}$	0.0491	0.1267*
"	0.0982	0.1110*
"	0.0983	0.1136
"	0.2994	0.0757
"	0.6089	0.0535
$\text{KNO}_3$	0.0971	0.1174
"	0.2954	0.0846
"	0.6686	0.0642
$\text{NaClO}_4$	0.1026	0.1122
"	0.3090	0.0752
"	0.6273	0.0533
$\text{NaCl}^\dagger$	0.1007	0.1567
"	0.2994	0.1558
"	0.5903	0.1732
$\text{NaNO}_3$	0.1008	0.1611
"	0.3139	0.1790
"	0.6220	0.1994
$\text{K}_2\text{SO}_4$	0.0491	0.1299*
"	0.0981	0.1166*
"	0.0998	0.1194
"	0.3025	0.0857
"	0.6008	0.0644
$\text{Na}_2\text{SO}_4$	0.1047	0.1633
"	0.3210	0.1800
"	0.6610	0.1957
$\text{BaCl}_2^\dagger$	0.0991	0.1569
"	0.2974	0.1638
"	0.5995	0.1693
$\text{Ba}(\text{NO}_3)_2^\dagger$	0.0990	0.1605
"	0.3019	0.1747
"	0.6075	0.1902

\*Noyes and Boggs, 1911.

†For further data see Hagenmuller, 1951.



## K KALIUM

SOLUBILITY OF POTASSIUM PERCHLORATE IN AQUEOUS ETHANOL SOLUTIONS  
(Pierrat, 1921)Results at 15°

Saturation was obtained by constant agitation for several hours. The saturated solution was evaporated to dryness in a current of air and the residue dissolved in enough water to yield the original volume of the solution. The salt content of this solution was then determined by electrolytic conductivity measurement.

	Wt. percent C <sub>2</sub> H <sub>5</sub> OH in solvent	Gms. KClO <sub>4</sub> per liter sat. sol.	Wt. percent C <sub>2</sub> H <sub>5</sub> OH in solvent	Gms. KClO <sub>4</sub> per liter sat. sol.
C10	0.0	12.4	42.4	3.9
	7.1	9.2	58.5	2.6
	13.2	7.8	94.7	0.15
	27.3	5.7		

Results at 25°

(Flatt, 1933; Flatt and Jordan, 1930, 1933;  
Thin and Cumming, 1915; Wenzel, 1891)

Solvent: Vol. % C <sub>2</sub> H <sub>5</sub> OH	Solubility
0	2.065 g./100 g. sat. sol.
50	0.790 "
(T.C.) 51.2 (d. = .9319)	0.749 "
( " 75	0.313 "
(T.C.) 93.5 (d. = .8219)	0.051 "
(T.C.) 98.8 (d. = .7998)	0.019 "

Solvent: Wt. % C <sub>2</sub> H <sub>5</sub> OH	Solubility
(W.) 90	0.036 g./100 g. sat. sol.
(W.) 97.2	0.0156 "

Results at 40°

(Flatt)

Vol. % C <sub>2</sub> H <sub>5</sub> OH in solvent	50	75
Gms. KClO <sub>4</sub> per 100 gm. sat. sol.	1.422	0.548

For solubilities of KClO<sub>4</sub> in aqueous nitromethane solutions see Hagen and Friedman, 1956.

## SOLUBILITY OF POTASSIUM PERCHLORATE IN VARIOUS ORGANIC SOLVENTS AT 25°

Solvent	d. of sat. sol.		Solubility	
	(Seward and Schumb, 1930)			
Ethyl Alcohol	--	0.0078	gms. $KClO_4$ /100 cc. sat. sol.	
	(Willard and Smith, 1923)			
Ethyl Alcohol	0.7852	0.012	gms. $KClO_4$ /100 gms. sat. sol.	
Methyl Alcohol	0.7878	0.105	" "	
n-Propyl Alcohol	0.8011	0.010	" "	
n-Butyl Alcohol	0.8060	0.0045*	" "	
iso- " "	0.7981	0.005	" "	
Acetone	0.7868	0.155	" "	
	(Miravittles Mille, 1945)			C10
Acetone	--	0.183(20°)	gms. $KClO_4$ /100 gms. sat. sol.	
"	--	0.207(15°)	" "	
	(Willard and Smith, 1923)			
Ethyl acetate	0.8945	0.0015	gms. $KClO_4$ /100 gms. sat. sol.	
	(Smith, 1925)			
Ethyl acetate	--	0.0013	gms. $KClO_4$ /100 cc. sat. sol.	
	(Isbin and Kobe, 1945)			
Ethylenediamine	--	2.81	gms. $KClO_4$ /100 gms. solvent	
Monocethanolamine	--	1.36	" "	
Ethylene Glycol	--	1.03	" "	
	(Seward and Hamblet, 1932)			
Acetic Acid	--	0.00272	gms. $KClO_4$ /100 cc. sat. sol.	

\*Also see below.

## SOLUBILITY OF POTASSIUM PERCHLORATE IN NORMAL BUTYL ALCOHOL

SOLUTIONS AT 25 ± 3°

(Smith, 1923a)

Composition of solvent			Milligrams $KClO_4$ per 100 cc. sat. sol.
Percent Pure n Butyl alcohol	Percent $HC10_4 \cdot 2H_2O$	Percent $H_2O$	
100	0.0	0.0	1.35
99.75	0.25	0.0	1.00
99.5	0.5	0.0	1.00
99.0	1.0	0.0	1.9
98.0	1.0	1.0	1.4
99.0	0.0	1.0	2.0
97.0	0.0	3.0	3.8
96.0	1.0	3.0	1.6
96.5	0.5	3.0	1.2
94.0	1.0	5.0	2.3

# K KALIUM

## SOLUBILITY OF POTASSIUM PERCHLORATE AND ABSOLUTE ETHYL ALCOHOL SOLUTION OF AMMONIUM SALTS AT 25° (Seward and Schumb, 1930)

Results for  $C_2H_5OH$  ( $d = 0.7852$ ) Solutions of:

C10	Ammonium Nitrate		Ammonium Perchlorate		Ammonium Iodide	
	Gm. Mols. per liter		Gm. mols. per liter		Gm. Mols. per liter	
	$NH_4NO_3$	$KClO_4$	$NH_4ClO_4$	$KClO_4$	$NH_4I$	$KClO_4$
	0.000000	0.0005654	0.000000	0.0005654	0.000495	0.0006148
	0.000254	0.0005986	0.000222	0.0004979	0.000856	0.0006493
	0.000488	0.0006233	0.000514	0.0004087	0.001141	0.0006784
	0.000971	0.0006773	0.001004	0.0003251	0.001518	0.0007068
	0.001858	0.0007283	0.001742	0.0002536	0.001765	0.0007156
	0.004345	0.0008396			0.002343	0.0007462

## SOLUBILITY OF POTASSIUM PERCHLORATE IN MIXTURES OF ETHYL ACETATE AND ALCOHOLS AT 25° (Smith, 1925)

Composition of solvent		Gms. $KClO_4$ per 100 gms. sat. sol.
90 Vol. % $CH_3COOC_2H_5$	+ 10 Vol. % $CH_3OH$	0.35
85 " "	+ 15 " "	0.52
80 " "	+ 20 " "	0.55
90 " "	+ 10 " $C_2H_5OH$	0.16
85 " "	+ 15 " "	0.26
80 " "	+ 20 " "	0.33
90 " "	+ 10 " of 93% $C_2H_5OH$	0.28
85 " "	+ 15 " "	0.44
80 " "	+ 20 " "	0.50
90 " "	+ 10 " n Butyl alcohol	0.24
85 " "	+ 15 " "	0.20
80 " "	+ 20 " "	0.25

## SOLUBILITY OF POTASSIUM PERCHLORATE IN ANHYDROUS ACETIC ACID SOLUTIONS OF VARIOUS SALTS AT 25° (Seward and Hamblet, 1932; Scholl and Hutchinson and Chandlee, 1933)

Results for  $CH_3COOH$  ( $d_{25} = 1.044$ ) solutions of:

Lithium Chloride		Magnesium Chloride		Ammonium Perchlorate	
Gm. Mols. per liter		Gm. Mols. per liter		Gm. Mols. per liter	
$LiCl$	$KClO_4$	$MgCl_2$	$KClO_4$	$NH_4ClO_4$	$KClO_4$
0.00000	0.000196	0.0000042	0.000228	0.000198	0.000194
0.00070	0.000293	0.0000115	0.000250	0.000316	0.000176
0.00141	0.000360	0.0000314	0.000276	0.000378	0.000190
0.00285	0.000524	0.0000420	0.000297	0.000509	0.000171
0.00641	0.000701	0.0000829	0.000336	0.000765	0.000155
0.00943	0.000767	0.0001440	0.000347	0.000983	0.000155
0.02870	0.001265	0.0002820	0.000394	0.001306	0.000139
		0.0005390	0.000475	0.002093	0.000141

Results for  $\text{CH}_3\text{COOH}$  ( $d_{25} = 1.044$ ) solutions of:--Cont.

Sodium Bromide		Sodium Bromide		Sodium Nitrate	
Gm. Mols. per liter		Gm. Mols. per liter		Gm. Mols. per liter	
NaBr	KClO <sub>4</sub>	NaBr	KClO <sub>4</sub>	NaNO <sub>3</sub>	KClO <sub>4</sub>
0.000078	0.000233	0.00000	0.000195	0.00000	0.000195
0.000120	0.000247	0.000078	0.000235	0.000168	0.000253
0.000192	0.000288	0.000120	0.000270	0.000346	0.000305
0.000210	0.000314	0.000192	0.000290	0.000633	0.000357
0.000278	0.000329	0.000210	0.000288	0.001009	0.000413
0.000590	0.000387	0.000278	0.000310	0.001550	0.000483
0.000700	0.000409	0.000590	0.000379	0.001825	0.000522

# POTASSIUM CHROMATE $\text{K}_2\text{CrO}_4$

CrO

THE SYSTEM POTASSIUM OXIDE - CHROMIC OXIDE - WATER  
(Koppel and Blumenthal, 1907; Schreinemakers, 1906(\*))

Results at 0°		Results at 30°		Results at 60°		Solid Phase at each Temp.
Gms. per 100 Gms. Sat. Sol.		Gms. per 100 Gms. Sat. Sol.		Gms. per 100 Gms. Sat. Sol.		
K <sub>2</sub> O	CrO <sub>3</sub>	K <sub>2</sub> O	CrO <sub>3</sub>	K <sub>2</sub> O	CrO <sub>3</sub>	
31.18	--	46.8	--	50	--	KOH·2H <sub>2</sub> O
26.06	0.54	26.89	0.94	32.98	0.53	K <sub>2</sub> CrO <sub>4</sub>
19.31	4.27	22.25	3.06	21.05	9.15	"
17.06	11.77	18.65	13.72	20.25	14.43	"
17.62	18.71	19.12	20.30	20.70	21.97	"
17.73	19.04	19.35	21.00	20.61	23.61	" + K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
		(19.17	20.67)*			" + "
10.90	11.93	15.04	16.85	14.53	20.82	K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
1.87	3.13	11.20	13.11	10.01	21.21	"
0.78	22.38	2.42	28.21	6.86	39.64	"
1.47	42.95	2.50	44.50	7.06	49.84	" + K <sub>2</sub> Cr <sub>3</sub> O <sub>10</sub>
		( 3.24	44.46)*			" + "
1.25	44.52	( 2.82	46.37)*	4.06	54.73	K <sub>2</sub> Cr <sub>3</sub> O <sub>10</sub>
1.17	46.84	--	--	2.00	60.69	"
1.37	47.40	2.35	49.95	--	--	" + K <sub>2</sub> Cr <sub>4</sub> O <sub>13</sub>
		( 2.35	49.36)*			" + "
1.24	48.23	1.35	53.39	--	--	K <sub>2</sub> Cr <sub>4</sub> O <sub>13</sub>
1.16	56.93	( 0.80	62.55)*	--	--	"
0.64	61.79	0.69	62.81	1.27	65.77	" + CrO <sub>3</sub>
		( 0.62	63.00)*			" + "
0	61.54	--	62.52	0	65.12	CrO <sub>3</sub>

## K. KALIUM

## Freezing point data:

The points were determined by adding a sat. solution of  $K_2Cr_2O_7$  successive 1 to 2 gm. portions of chromic acid and ascertaining the freezing-point and composition of the solution. At the point of appearance of a new solid phase an additional amount of chromic acid does not change the f.-pt. since the added  $CrO_3$  goes into the solid phase. This relation also holds at the points where the solution is simultaneously saturated with  $K_2Cr_2O_7$  and  $K_2Cr_2O_{10}$  or  $K_2Cr_2O_{10}$  and  $K_2Cr_4O_{13}$ .

	t° of Equilibrium of Sat. Sol. with Ice	Gms. per 100 Gms. Sat. Solution		Solid Phase in Equilibrium with Sat. Sol. and Ice
		K <sub>2</sub> O	CrO <sub>3</sub>	
CrO	-25	20	5.70	K <sub>2</sub> CrO <sub>4</sub>
	-13	17.52	13.89	"
	-11.37	17.12	18.18	"
	-11.50	17.18	18.11	" + K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
	- 5	8.27	8.01	K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
	- 0.63	1.38	2.93	"
	- 1.78	not det.	6.81	"
	- 5.5	"	16.05	"
	- 6.43	0.48	17.25	"
	10.25	0.45	23.63	"
	-13.22	not det.	27.26	"
	-14.50	"	28.85	"
	-22.10	"	35.92	"
	-22.11	0.47	36.14	"
	-26.77	0.88	39.86	"
	-30.20	1.18	42.31	" + K <sub>2</sub> Cr <sub>3</sub> O <sub>10</sub>
	-34.01	0.95	43.45	K <sub>2</sub> Cr <sub>3</sub> O <sub>10</sub>
	-39	0.79	45.66	" + K <sub>2</sub> Cr <sub>4</sub> O <sub>13</sub>
	-49	not det.	49.11	K <sub>2</sub> Cr <sub>4</sub> O <sub>13</sub>
	-61.5	0.61	53.57	"

The viscosity of the solutions at the lower temperatures increased so much that the cryohydrate points could not be determined. By graphic extrapolation the cryohydrate temperature of chromic acid and of chromic acid + potassium tetra-chromate is near -80° and the CrO<sub>3</sub> content is 59 gms. per 100 gms. sat. solution.

Data for boiling points in the system K<sub>2</sub>O + CrO<sub>3</sub>·H<sub>2</sub>O determined by means of the Beckmann apparatus are also given.

## SOLUBILITY OF POTASSIUM CHROMATE IN WATER

There has been considerable disagreement among the several determinations, perhaps caused by lack of control of the pH. The following table shows the magnitude of the variations which are encountered. Etard's data are consistently low and have been omitted from the average curve.

SOLUBILITY OF POTASSIUM CHROMATE IN WATER--Cont.  
 gms  $K_2CrO_4$  per 100 gms  $H_2O$

t°	Etard 1894	Alluard 1864	Nordenskjöld and Lindström 1869	Koppel and Blumenthal 1907	Flott- mann 1928	Hart- ford 1949	Average Curve	
- 0.99(Ice)--	--	--	--	4.53	--	--	--	
- 1.2 " --	--	--	--	6.12	--	--	--	
- 4.3 " --	--	--	--	26.99	--	--	--	
- 7.12 " --	--	--	--	42.04	--	--	--	
-10.35 " --	--	--	--	52.41	--	--	--	
-11.35(Eutectic)	--	--	--	54.54	--	--	--	
0	58.2	59.3	60.2	57.11	--	--	58.8	CrO
1	--	--	--	--	--	59.3	--	
10	60.0	61.2	62.5	--	--	--	61.5	
15	--	--	--	--	62.6	--	62.7	
20	61.7	63.2	64.5	--	63.7	--	63.9	
24	--	--	--	--	--	65.0	--	
25	62.5	64.2	64.5	--	64.9	65.8†	65.1	
30	63.4	65.2	66.5	65.1	--	--	66.0	
40	65.2	67.0	68.6	--	--	--	68.0	
50	66.8	69.0	70.6	--	--	--	70.1	
60	68.6	71.0	72.7	74.6	--	--	72.2	
70	70.4	73.0	74.8	--	--	--	74.2	
80	72.1	75.0	76.9	--	--	77.3	76.3	
90	73.9	77.0	79.0	--	--	--	77.2	
100	75.6	79.0	82.2	--	--	78.5*	80.1	
105.8(b.pt.)--	--	--	--	88.8	--	--	--	
125	79.0	--	--	--	--	--	--	
150	83.0	--	--	--	--	89.3*	--	

†Linke, 1954

\*Benrath, see below.

SOLUBILITY OF POTASSIUM CHROMATE IN WATER  
 AT TEMPERATURES ABOVE 100°  
 (Benrath, Gjedebo, Schiffers and Wunderlich, 1937)

The authors' results were plotted and the following values taken from the average curve.

t°	Gms. $K_2CrO_4$ per 100 gms. sat. sol.	t°	Gms. $K_2CrO_4$ per 100 gms. sat. sol.	t°	Gms. $K_2CrO_4$ per 100 gms. sat. sol.
100	44.0	180	48.5	260	52.6
120	45.5	200	49.6	280	53.6
140	46.5	220	50.6	300	54.6
160	47.8	240	51.6	320	55.7

# K KALIUM

## THE SYSTEM POTASSIUM CHROMATE - POTASSIUM NITRATE - WATER (Ravich and Frolova, 1944)

t°	Gms. KNO <sub>3</sub> per 100	Gms. K <sub>2</sub> CrO <sub>4</sub> per 100	Solid Phase
	Gms. Sat. Sol.	Gms. Sat. Sol.	
-12.1	2.31	35.34	Ice + KNO <sub>3</sub> + K <sub>2</sub> CrO <sub>4</sub>
- 6.2	5.73	18.87	KNO <sub>3</sub> + Ice
- 5.8	5.57	18.33	Ice
- 4.6	4.62	15.23	"
- 2.6	2.64	8.71	"
- 4.8	5.93	19.53	KNO <sub>3</sub>
- 1.8	6.52	21.48	"
+ 2.0	7.24	23.83	"
4.4	7.58	24.97	"
CrO	0	9.20	"
		6.94	"
		5.50	"
		4.72	KNO <sub>3</sub> + K <sub>2</sub> CrO <sub>4</sub>
		3.01	K <sub>2</sub> CrO <sub>4</sub>
25	22.26	8.25	KNO <sub>3</sub>
	17.79	17.76	"
	12.54	29.32	"
	10.28	32.31	KNO <sub>3</sub> + K <sub>2</sub> CrO <sub>4</sub>
	6.01	35.32	K <sub>2</sub> CrO <sub>4</sub>
50	40.45	6.39	KNO <sub>3</sub>
	34.17	13.92	"
	25.48	26.46	KNO <sub>3</sub> + K <sub>2</sub> CrO <sub>4</sub>
	14.44	32.77	K <sub>2</sub> CrO <sub>4</sub>
	7.23	36.82	"
96.5	56.43	10.64	KNO <sub>3</sub> + K <sub>2</sub> CrO <sub>4</sub>
116	71.15	5.49	"

## THE SYSTEM POTASSIUM CHROMATE - POTASSIUM MOLYBDATE - WATER AT 25° (Amadori, 1912a)

Gms. per 100 Gms. H <sub>2</sub> O		Gms. per 100 Gms. H <sub>2</sub> O		Gms. per 100 Gms. H <sub>2</sub> O	
K <sub>2</sub> CrO <sub>4</sub>	K <sub>2</sub> MoO <sub>4</sub>	K <sub>2</sub> CrO <sub>4</sub>	K <sub>2</sub> MoO <sub>4</sub>	K <sub>2</sub> CrO <sub>4</sub>	K <sub>2</sub> MoO <sub>4</sub>
64.62	0	14.13	98.72	4.92	165.4
49.59	15.37	10.07	118.8	2.14	180.8
38.90	38.79	10.24	119.9	1.70	183.0
33.21	50.96	7.12	137.8	0	184.6
		6.37	157.2		

## THE SYSTEM POTASSIUM CHROMATE - POTASSIUM SULFATE - WATER AT 25°

[Continuous solid solutions are formed]

Results of Makarov and Druzhinin, 1937

Gms. per 100 gms. Sat. Sol.		Gms. per 100 gms. Solid	
K <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> CrO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> CrO <sub>4</sub>
0.0	39.52	0.0	100.0
1.11	36.18	12.60	87.40
1.51	33.91	32.50	67.50
1.88	30.91	45.00	55.00
2.66	25.75	66.90	33.10
3.49	23.20	91.50	8.50
5.47	15.53	99.20	0.80
8.75	4.95	99.80	0.20
10.76	0.0	100.0	0.0

CrO

Results of Fock, 1897

Grams per Liter		Mol. percent K <sub>2</sub> SO <sub>4</sub> in Solution	Sp. Gr. of Solution	Mol. percent K <sub>2</sub> SO <sub>4</sub> in Solid Phase
K <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> CrO <sub>4</sub>			
107.7	0.00	100.0	1.083	100.0
106.0	20.02	85.51	1.092	99.65
59.46	134.5	33.01	1.141	97.30
30.47	290.5	10.50	1.231	91.97
19.30	490.5	4.21	1.356	28.43
17.54	522.3	3.60	1.377	2.41
0.0	553.5	0.00	1.398	0.00
127.9	0.0	100.0	1.0863	100.0
107.6	20.1	85.65	1.0934	99.78
80.72	88.0	55.55	1.1235	98.49
48.64	184.4	22.72	1.1700	96.07
26.68	285.6	9.41	1.2255	85.77
51.61	521.2	21.09	1.3688	25.73
0.00	527.8	0.00	1.3781	0.00

Results of Amadori, 1912a

Gms. per 100 Gms. H <sub>2</sub> O		Gms. per 100 Gms. H <sub>2</sub> O		Gms. per 100 Gms. H <sub>2</sub> O	
K <sub>2</sub> CrO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> CrO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> CrO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>
63.09	0.76	40.93	3.33	7.81	8.98
61.39	1.17	27.36	4.82	4.36	10.25
58.40	1.84	20.83	5.72	1.94	10.86
51.81	2.36	14.65	7.12	0	12.10

Data for the reciprocal salt pair  $\text{K}_2\text{CrO}_4 + \text{Na}_2\text{SO}_4 \rightleftharpoons \text{K}_2\text{SO}_4 + \text{Na}_2\text{CrO}_4$  in water at 25° are given by Druzhinin, 1938. The compounds  $2\text{K}_2\text{CrO}_4 \cdot \text{Na}_2\text{CrO}_4$  and  $2\text{K}_2\text{SO}_4 \cdot \text{Na}_2\text{SO}_4$  are isomorphous.



# K KALIUM

## THE SYSTEM AMMONIUM CHROMATE + POTASSIUM CHROMATE + WATER AT 25° (Araki, 1925)

	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. aol.		Solid Phase
	K <sub>2</sub> CrO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> CrO <sub>4</sub>		K <sub>2</sub> CrO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> CrO <sub>4</sub>	
CrO	39.35	0.00	K <sub>2</sub> CrO <sub>4</sub>	15.82	19.98	Mixtures of the two series of solid solutions
	36.77	1.41		15.20	20.18	
	34.38	3.25		14.55	20.36	
	29.36	6.75	Series of solid solutions of (NH <sub>4</sub> ) <sub>2</sub> CrO <sub>4</sub> in K <sub>2</sub> CrO <sub>4</sub>	14.47	20.40	Series of solid solutions of K <sub>2</sub> CrO <sub>4</sub> in (NH <sub>4</sub> ) <sub>2</sub> CrO <sub>4</sub>
	25.89	10.01		14.14	20.70	
	22.35	12.85		11.69	21.30	
	18.64	16.51		10.63	21.94	
	16.07	19.10		7.08	22.88	
	15.84	19.95		4.53	23.43	

## A STUDY OF THE RECIPROCAL SALT PAIR [(NH<sub>4</sub>)<sub>2</sub>K<sub>2</sub>]-[CrO<sub>4</sub>,SO<sub>4</sub>] AT 25° (Ishikawa, 1926)

Previous experiments have shown that K<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>CrO<sub>4</sub> and also (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>SO<sub>4</sub> each form a complete series of solid solutions with no gap, while (NH<sub>4</sub>)<sub>2</sub>CrO<sub>4</sub> + (NH<sub>4</sub>)<sub>2</sub>CrO<sub>4</sub> + K<sub>2</sub>CrO<sub>4</sub> each form a series of solid solutions with gaps respectively at 2.90 to 21.51 and 16.75 to 55.50 molar percentages of ammonium chromate. The present experiments were made by adding to a solution in equilibrium with two kinds of solid solutions of two salts having a common ion, another salt in different proportion, in such a manner that when equilibrium is attained, two or three solid phases remained as residue. The mixtures were rotated in a thermostat for at least two days. The results of the analyses are given in a table and plotted in the Janecke square diagram.

## THE SYSTEM POTASSIUM CHROMATE - SODIUM CHROMATE - WATER AT 25° (Makarov and Druzhinin, 1937)

The results are also reported on a mole basis.

Gms. per 100 gms. Sat. Sol.		Gms. per 100 gms. Solid	
Na <sub>2</sub> CrO <sub>4</sub>	K <sub>2</sub> CrO <sub>4</sub>	Na <sub>2</sub> CrO <sub>4</sub>	K <sub>2</sub> CrO <sub>4</sub>
45.76	0.0	60.0	0.0
41.49	5.49		
35.00	11.75		
34.35	13.20		
27.21	14.92		
25.15	15.27		
22.97	16.86		
16.49	21.40		
12.33	25.62		
9.46	30.00		
8.24	30.82	21.00	79.00
8.08	32.04		
4.25	35.77		
0.0	39.52		
		0.0	100.0

SOLUBILITY OF POTASSIUM CHROMATE IN AQUEOUS SOLUTIONS  
OF SEVERAL SALTS (SEPARATELY) AT 25°  
(Herz and Hiebenthal, 1929)

Results for Aqueous Solutions of:

<u>Potassium Bromide</u>		<u>Potassium Chloride</u>		<u>Magnesium Chloride</u>		CrO
Gm. Mol. per liter		Gm. Mol. per liter		Gm. Mol. per liter		
KBr	1/6 K <sub>2</sub> CrO <sub>4</sub>	KCl	1/6 K <sub>2</sub> CrO <sub>4</sub>	1/2 MgCl <sub>2</sub>	1/6 K <sub>2</sub> CrO <sub>4</sub>	
0.00	8.35	0.0	8.35	0.0	8.35	
0.41	7.56	0.40	7.76	0.42	7.58	
0.82	6.91	0.46	7.69	0.86	6.11	
1.24	6.26	1.31	6.48	1.73	4.30	
1.78	5.50	1.72	5.89	2.27	2.74	
2.19	5.00	2.18	5.24	2.76	1.30	
2.70	4.38	+2.70	4.75	3.26	1.04	

<u>Sodium Chloride</u>		<u>Ammonium Chloride</u>	
Gm. Mol. per liter		Gm. Mol. per liter	
NaCl	1/6 K <sub>2</sub> CrO <sub>4</sub>	NH <sub>4</sub> Cl	1/6 K <sub>2</sub> CrO <sub>4</sub>
0.42	8.22	0.45	7.68
0.86	7.71	0.83	6.92
1.73	6.51	1.81	5.58
2.59	5.46	2.34	5.00
3.30	4.79	2.93	4.43
3.40	4.57	3.76	3.49
+4.25	4.49	4.51	2.87

SOLUBILITY OF POTASSIUM CHROMATE IN VARIOUS SOLVENTS

Methanol 10° 0.38 gms./liter (Barber and Ali, 1950)  
Ethanol, aq. 25° (Linke, 1954)

Solvent	Saturated Soln.			Solvent	Saturated Soln.		
	Vol. %	Wt. %	Density		Vol. %	Wt. %	Density
C <sub>2</sub> H <sub>5</sub> OH		K <sub>2</sub> CrO <sub>4</sub>		C <sub>2</sub> H <sub>5</sub> OH		K <sub>2</sub> CrO <sub>4</sub>	
0	39.67	1.387	60.0	1.238	0.905		
10.00	30.69	1.263	75.0	0.160	.863		
20.00	21.70	1.152	85.0	.035	.834		
30.00	13.50	1.062	95.0	.021	.801		
40.00	7.19	0.992	100	.005	.786		
50.00	3.214	.942					

Dioxane, aq. 25° (Herz and Lorentz, 1929)  
 Solvent Vol. % C<sub>4</sub>H<sub>8</sub>O<sub>2</sub> Moles K<sub>2</sub>CrO<sub>4</sub> per liter sat. sol.  
 5.0 1.21  
 9.0 1.08 L  
 55.0 0.05 U  
 80 0.02

L = Lower Liquid Layer

U = Upper Liquid Layer

(Cont.)

## K KALIUM

## SOLUBILITY OF POTASSIUM CHROMATE IN VARIOUS SOLVENTS--Cont.

Glycol, aq. ( $C_2H_4(OH)_2 \cdot H_2O$ )	15.4°	1.7 gms. $K_2CrO_4$ per 100 gms. sat. sol.	(de Coninck, 1905)
Urethan, aq.	25°		(Palitsch, 1928, 1929)
	Gm. Mols. per 1000 gms. $H_2O$		
	$K_2CrO_4$	$NH_2COOC_2H_5$	Solid Phase
	3.23	0.0	$K_2CrO_4$
	0.1	49.61	Upper liquid layer
	3.0	0.396	Lower liquid layer
Hydrazine (anhyd.)	Room t°	1 gm. per 100 cc. (Welsh and Broderson, 1915) hydrazine	

Melting point data are given for:

$K_2CrO_4 + K_2Cr_2O_7$	(Groschuff, 1908)
$K_2CrO_4 + K_2MoO_4$	(Amadori, 1913)
$K_2CrO_4 + K_2WO_4$	(Amadori, 1913; Kislova, Posypaiko and Bergmann, 1955)
$K_2CrO_4 + K_2SO_4$	( " ; Groschuff, 1908; Rasson- skaya and Bergman, 1953a)
$K_2CrO_4 + KNO_3$	(Kitrov, 1949)
$K_2CrO_4 + 2NaOH \rightleftharpoons 2KOH + Na_2CrO_4$	(Bergman and Khitrov, 1954)
$K_2CrO_4 + 2NaF \rightleftharpoons 2KF + Na_2CrO_4$	(Dergunov and Bergman, 1952)
$K_2CrO_4 + 2LiOH \rightleftharpoons 2KOH + Li_2CrO_4$	(Reshetnikov and Diogenov, 1952)
$K_2CrO_4 + KOH$	(Reshetnikov and Vilutis, 1958; Reshetnikov and Diogenov, 1952)
$K_2CrO_4 + Li_2CrO_4$	(Reshetnikov and Diogenov, 1952)
$K_2CrO_4 + KF + KCl$	(Rassonskaya and Bergman, 1952)
$K_2CrO_4 + NaF$	( " " " " )
$K_2CrO_4 + KF$	( " " " " )
$K_2CrO_4 + KCl$	( " " " " )
$K_2CrO_4 + KNO_3 + K_2SO_4$	(Rassonskaya and Bergman, 1953a)
$K_2CrO_4 + NaCl + NaF$	( " " " " , 1953)
$K_2CrO_4 + 2NaNO_3 \rightleftharpoons 2KNO_3 + Na_2CrO_4$	(Bergman and Voksberg, 1948)
$K_2CrO_4 + Li_2SO_4 \rightleftharpoons K_2SO_4 + Li_2CrO_4$	(Volkov and Dubinskaya, 1953)
$K_2CrO_4 + KI$	(Gromakov, 1952)
$K_2CrO_4 + Na_2CrO_4$	(Bergman and Bartbaronov, 1957b)

CrO POTASSIUM DICHROMATE  $K_2Cr_2O_7$ 

## SOLUBILITY IN WATER

Averages of the very closely agreeing results of Sherrill and Eaton (1907), LeBlanc and Schmandt (1911), Greenish and Smith (1901), Koppell and Blumenthal (1907), Flottmann (1928), Rakowski (1931), Noonan (1948), Bogoyavlenskii (1949, 1952), Robertson (1924), Konopkina (1956). Above 60° there is less data, and the average of results of Alluard (1864), Kremens (1854), and Tilden and Shenstone (1884) is given. The data of Etard (1894) at higher temperatures are too low.

SOLID PHASE  $K_2Cr_2O_7$  THROUGHOUT

t°	Gms. $K_2Cr_2O_7$ per 100 gms. $H_2O$	t°	Gms. $K_2Cr_2O_7$ per 100 gms. $H_2O$	t°	Gms. $K_2Cr_2O_7$ per 100 gms. $H_2O$
0	4.6	30	18.0	70	58
5	5.8	35	21.6	80	70
10	6.6	40	26.0	90	82
15	9.8	45	31.6	100	97 (100*)
20	12.2	50	37.2	125	145
25	15.0	60	46.5	150	205

\*Rakowski and Babajewa, 1931

CrO

SOLUBILITY OF POTASSIUM DICHROMATE IN DEUTERIUM OXIDE SOLUTIONS  
(Noonan, 1948)

t°	Mole % $D_2O$	Moles $K_2Cr_2O_7$ per 100 moles $H_2O + D_2O$	t°	Mole % $D_2O$	Moles $K_2Cr_2O_7$ per 100 moles $H_2O + D_2O$
5	0.0	0.3645	25	0.0	0.9136
	91.83	.2525		48.5	.788
	100.0	.2425		91.8	.6903
15	0.0	.5977		98.0	.6781
	91.56	.4286		100.0	.6720
	100.0	.4130	35	0.0	1.3252
				91.83	1.0454
				100.0	1.0205

Results for the solubility of  $K_2Cr_2O_7$  in 27 mixtures of  $H_2O + D_2O$  are given by Chang and Chang (1955). The solubilities are:

- $$S_n = 0.5024 - 0.1467n + 0.0174n^2$$

where {  $S_n$  = moles  $K_2Cr_2O_7$  per 55.51 moles solvent  
 $n$  = mole fraction  $D_2O$  in solvent
- $$S_x = 0.1478 - 0.0540x + 0.0049x^2$$

where {  $S_x$  = gms.  $K_2Cr_2O_7$  per gm. solvent  
 $x$  = wt. fraction  $D_2O$  in solvent

THE SYSTEM  $K_2Cr_2O_7 - KCl - H_2O$   
(Data of Robertson, 1924)

Results at 25°		Results at 50°		Results at 100°		Solid Phase at each temperature
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
KCl	$K_2Cr_2O_7$	KCl	$K_2Cr_2O_7$	KCl	$K_2Cr_2O_7$	
2.1	10.0	2.4	25.8	0.0	47.2	$K_2Cr_2O_7$
4.3	8.3	4.6	21.3	3.5	42.1	"
6.32	6.53	6.6	18.9	7.2	37.1	"
8.2	5.5	8.6	16.7	11.4	32.2	"
10.0	4.55	10.6	14.9	15.6	27.6	"
11.6	3.9	11.9	13.2	22.1	20.6	"

(Cont.)

## K KALIUM

THE SYSTEM  $K_2Cr_2O_7 - KCl - H_2O$ —Cont.

	Results at 25°		Results at 50°		Results at 100°		Solid Phase at each temperature
	Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
	KCl	K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	KCl	K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	KCl	K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	
	13.0	3.36	13.3	12.4	24.9	18.2	
	15.7	2.6	14.8	11.0	--	--	
	18.6	2.2	18.1	8.8	--	--	
CrO	21.2	1.7	21.4	6.8	--	--	
	23.0	1.57	24.0	5.7	--	--	
	26.0	1.2	28.9	4.1	27.6	16.2	
	--	--	29.0	3.7	29.6	11.6	
	26.1	1.05	29.8	1.9	31.9	6.4	
	26.3	0.0	30.6	0.0	35.9	0.0	

(Data of Palkin and Bogoyavlenskii, 1941, Bogoyavlenskii, 1949)

Cr = K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>				Cl = KCl				Solid Phase
0°		10°		20°		40°		
Wt. %		Wt. %		Wt. %		Wt. %		
Cr	Cl	Cr	Cl	Cr	Cl	Cr	Cl	
4.43	0.0	7.5	0.0	11.1	0.0	20.6	0.0	
0.34	21.4	0.45	23.4	0.90	25.4	2.28	27.25	Cr + Cl
0.0	21.9	0.0	23.8	0.0	25.5	0.0	28.7	Cl

THE SYSTEM  $K_2Cr_2O_7 - KNO_3 - H_2O$   
(Palkin and Bogoyavlenskii, 1941; Bogoyavlenskii, 1949)

Cr = K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>				N = KNO <sub>3</sub>				Solid Phase
0°		10°		20°		40°		
Wt. %		Wt. %		Wt. %		Wt. %		
Cr	N	Cr	N	Cr	N	Cr	N	
4.43	0.0	7.5	0.0	11.1	0.0	20.6	0.0	Cr
1.68	11.56	2.70	16.60	4.61	22.54	8.65	38.17	Cr + N
0.0	11.5	0.0	17.7	0.0	24.1	0.0	39.1	N

THE SYSTEM  $K_2Cr_2O_7 - K_2SO_4 - H_2O$   
(Bogoyavlenskii, 1952)

Cr =  $K_2Cr_2O_7$ S =  $K_2SO_4$ 

Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
Cr		S		Cr		S		Cr		S	
Results at 20°				Results at 25°—Cont.				Results at 40°			
11.1	--	Cr		6.15	8.80	S		20.6	--	Cr	
10.16	1.02	"		4.03	9.60	"		19.45	1.17	"	
9.91	1.40	"		3.13	9.92	"		18.94	1.80	"	
9.53	1.87	"		2.28	10.10	"		17.65	3.54	"	CrO
8.56	3.38	"		1.19	10.50	"		16.89	4.40	"	
7.80	4.42	"		0.74	10.70	"		15.98	5.53	"	
6.92	6.41	"		--	10.80	"		15.24	6.63	"	
6.24	8.23	Cr + S		Results at 30°				14.61	7.76	"	
5.42	8.48	S						14.40	8.20	Cr + S	
4.20	8.89	"						11.66	8.88	S	
3.08	9.43	"		15.4	--	Cr		9.90	9.60	"	
1.98	9.64	"		13.16	2.86	"		8.30	10.05	"	
0.45	9.90	"		12.20	4.66	"		6.88	10.44	"	
--	10.0	"		11.39	5.95	"		5.60	10.80	"	
Results at 25°				10.15	7.75	"		4.45	11.43	"	
13.08	--	Cr		9.75	8.66	"		3.71	11.85	"	
12.09	1.56	"		9.41	9.07	Cr + S		2.70	12.20	"	
11.14	2.95	"		6.80	9.75	S		2.46	12.36	"	
10.12	4.15	"		4.54	10.15	"		1.84	12.46	"	
9.15	5.80	"		3.48	10.40	"		1.34	12.76	"	
7.70	8.01	"		2.94	10.74	"		0.34	12.94	"	
7.43	8.33	Cr + S		1.76	11.15	"		--	13.1	"	
6.69	8.65	S		1.01	11.28	"					
				--	11.48	"					

Data for the distribution of Th, B, and Ra isotopes in the liquid and solid phases of the systems

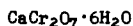
$K_2CrO_4 - K_2SO_4 - H_2O$

$PbSO_4 - K_2SO_4 - H_2O$

$RaSO_4 - K_2SO_4 - H_2O$

are given by Merkulova, Potapova, Shevelkina and Chastukhina, 1957.

## K KALIUM

THE SYSTEM  $K_2Cr_2O_7 - CaCr_2O_7 - H_2O$   
(Konopkina, 1956)

Results at 0°				Results at 25°				Results at 50°			
Sat. Sol. Wt. %		Solid Phase		Sat. Sol. Wt. %		Solid Phase		Sat. Sol. Wt. %		Solid Phase	
Ca	K			Ca	K			Ca	K		
53.47	--	Ca <sub>6</sub>		58.96	--	Ca <sub>5</sub>		64.35	--	Ca <sub>4</sub>	
52.69	0.46	"		57.70	1.19	"		63.47	1.17	"	
52.01	1.5	"		57.00	2.18	"		63.07	1.80	"	
51.57	2.45	Ca + K		56.49	3.71	Ca <sub>5</sub> + K		62.68	3.08	"	
46.86	2.47	K		43.00	4.21	K		61.92	3.72	"	
36.41	2.60	"		35.72	5.22	"		61.60	4.25	"	
23.96	3.26	"		23.77	6.74	"		61.60	4.73	"	
12.12	3.35	"		12.21	9.26	"		61.24	5.69	Ca <sub>4</sub> + K	
--	4.58	"		--	13.13	"		59.91	5.91	K	
								56.61	6.88	"	
								52.93	7.37	"	
								44.28	8.57	"	
								34.57	10.57	"	
								20.96	15.92	"	
								10.74	20.06	"	
								--	25.82	"	

THE SYSTEM  $K_2Cr_2O_7 - Na_2Cr_2O_7 - H_2O$   
(Robertson, 1924)

The mixtures of the two salts were dissolved in water at a higher temperature than that of the isotherm and the flasks then placed in a thermostat at the desired temperature. Constant agitation is not mentioned.

Results at 25°		Results at 50°		Results at 100°		Solid Phase at each temperature
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	
0.0	13.1	0.0	27.4	0.0	47.2	K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
4.38	12.2	6.5	24.2	6.3	42.1	"
16.1	8.68	16.3	19.3	14.1	36.5	"
20.0	8.97	21.0	17.8	23.0	29.0	"
26.9	7.70	29.3	13.6	29.6	24.2	"
33.6	6.52	43.6	11.3	44.4	16.4	"
43.2	5.46	48.5	9.47	56.1	13.4	"
55.5	5.16	52.5	9.36	60.6	12.4	"
61.4	5.25	63.3	7.92	70.8	9.96	"Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
65.5	0.0	70.3	0.0	80.1	0.0	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>

SOLUBILITY OF POTASSIUM DICHROMATE IN AQUEOUS SOLUTIONS  
OF SEVERAL SALTS (EACH DETERMINED SEPARATELY AT 25°  
(Herz and Hiebenthal, 1929)

Results for Aqueous Solutions of:

<u>Calcium Chloride</u>		<u>Magnesium Chloride</u>		<u>Strontium Chloride</u>		CrO
Gm. Mols. per liter		Gm. Mols. per liter		Gm. Mols. per liter		
$1/2\text{-CaCl}_2$	$1/6\text{-K}_2\text{Cr}_2\text{O}_7$	$1/2\text{-MgCl}_2$	$1/6\text{-K}_2\text{Cr}_2\text{O}_7$	$1/2\text{-SrCl}_2$	$1/6\text{-K}_2\text{Cr}_2\text{O}_7$	
0.24	2.88	0.0	2.89	0.0	2.89	
0.45	2.91	0.45	2.78	0.51	2.89	
0.92	2.84	0.93	2.64	1.00	2.91	
1.41	2.69	1.84	2.24	2.02	2.73	
1.64	2.62	2.31	2.07	2.23	2.69	
1.87	2.56	2.74	1.91	2.84	2.62	
11.42	1.88	3.15	1.76	3.47	2.38	

<u>Lithium Chloride</u>		<u>Sodium Chloride</u>		<u>Ammonium Chloride</u>	
Gm. Mols. per liter		Gm. Mols. per liter		Gm. Mols. per liter	
LiCl	$1/6\text{-K}_2\text{Cr}_2\text{O}_7$	NaCl	$1/6\text{-K}_2\text{Cr}_2\text{O}_7$	$\text{NH}_4\text{Cl}$	$1/6\text{-K}_2\text{Cr}_2\text{O}_7$
0.0	2.89	0.47	2.91	0.0	2.89
0.49	2.73	0.94	2.98	0.73	2.52
0.92	2.55	1.91	2.79	1.79	2.54
1.78	2.26	2.84	2.62	2.59	2.32
2.78	1.85	3.80	2.33	3.10	2.16
3.61	1.57	4.21	2.24	4.00	1.83
4.49	1.32	5.03	2.06	5.32	0.91

SOLUBILITY OF POTASSIUM DICHROMATE IN DIFFERENT SOLVENTS

<u>Dioxane, aq.</u>	25°	(Herz and Lorentz, 1929)	
	cc. Dioxane (C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> ) per 100 cc. aq. solvent	Gm. Mols. K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> per liter sat. sol.	
	10	0.41	
	33	0.25	
	50	0.15	
	60	0.01	

<u>Glycol, aq.</u> (C <sub>2</sub> H <sub>4</sub> (OH) <sub>2</sub> ·H <sub>2</sub> O	14.6°	6 gms. K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> per 100 gms. sat. sol.	(de Coninck, 1905)
------------------------------------------------------------------------------------------	-------	--------------------------------------------------------------------------------	--------------------

<u>Hydrazine</u> (anhyd.)	Room t°	1 gm. K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> per 100 cc. hydrazine	(Welsh and Broderson, 1915)
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# K KALIUM

Melting point data are given for:

$K_2Cr_2O_7 + K_2Mo_2O_7$	(Amadori, 1913)
$K_2Cr_2O_7 + K_2W_2O_7$	(Amadori, 1913)
$K_2Cr_2O_7 + Na_2Cr_2O_7$	(Evdokimova and Bergman, 1945; Lehrman, Selditch and Skell, 1936)
$K_2Cr_2O_7 + 2NaNO_3 \rightleftharpoons Na_2Cr_2O_7 + 2KNO_3$	(Evdokimova and Bergman, 1945)
$K_2Cr_2O_7 + 2NaCl \rightleftharpoons Na_2Cr_2O_7 + 2KCl$	( " " " " )
$K_2Cr_2O_7 + KNO_3$	(Belyaev, 1953)

## F POTASSIUM FLUORIDE KF

### SOLUBILITY OF POTASSIUM FLUORIDE IN WATER (Jatlov and Poljakova, 1938)

t°	Gms. KF per 100 gms. sat. sol.	Solid Phase	t°	Gms. KF per 100 gms. sat. sol.	Solid Phase
- 3.2	5.0	Ice	0	44.30 <sup>1</sup>	KF·2H <sub>2</sub> O
- 6.5	10.0	"	17.5	47.52*	"
-12.2	15.0	"	18	48.0 <sup>2</sup>	"
-19.5	20.0	"	20	48.70 <sup>1</sup>	"
-21.8 (Eutec.)	21.5	" + KF·4H <sub>2</sub> O	25	50.41	"
-20.0	22.7	KF·4H <sub>2</sub> O	30	51.95	"
0	30.90	"	35	54.65	"
10	34.87	"	40.2	58.08 <sup>1</sup>	" + KF
15	38.13	"	45	58.62	KF
17.5	41.52	"	60	58.72	"
17.7	47.7	" + KF·2H <sub>2</sub> O	80	60.01	"

\*Metastable

<sup>1</sup>At 0°, 20°, 40°, Tananaev (1938) found 42.77, 47.75, 56.36 wt. % KF in solutions saturated with KF·2H<sub>2</sub>O.

<sup>2</sup>Mylius and Funk, 1897; d. = 1.502.

### THE SYSTEM POTASSIUM FLUORIDE - HYDROGEN FLUORIDE - WATER (Tananaev, 1938)

The earlier data of Ditte, 1896 at 21° are in good agreement with these.

At 0°		At 20°		At 40°		Solid Phase
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
KF	HF	KF	HF	KF	HF	
42.77	0.0	47.75	0.0	56.36	0.0	KF·2H <sub>2</sub> O
--	--	47.80	0.27	58.50	0.30	"
44.15	0.36	47.90	0.72	59.20	1.37	KF·2H <sub>2</sub> O + KF·HF
41.00	0.38	38.30	0.82	39.70	1.50	KF·HF
39.66	0.43	35.47	1.12	37.28	1.89	"
29.75	0.71	31.00	1.46	32.28	2.95	"

(Cont.)

## THE SYSTEM POTASSIUM FLUORIDE - HYDROGEN FLUORIDE - WATER--Cont.

At 0°		At 20°		At 40°		Solid Phase
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
KF	HF	KF	HF	KF	HF	
27.33	0.95	21.53	5.05	29.72	4.23	KF·HF
24.08	1.25	20.50	6.88	27.60	7.24	"
22.86	1.41	21.47	10.04	27.10	9.26	"
20.12	1.89	26.70	17.97	29.12	14.22	"
17.85	2.40	27.70	18.34	30.75	17.55	"
14.72	4.15	38.00	28.38	38.40	23.80	"
14.08	5.23	40.67	29.84	46.07	30.00	"
14.63	6.43	41.57	30.55	47.80	31.95	"
16.30	10.43	42.94	31.36	48.83	32.72	"
21.50	17.71	43.41	31.68	50.71	34.41	"
25.23	21.27	--	--	52.60	35.22	"
27.89	24.07	--	--	--	--	"
31.60	26.87	--	--	--	--	"
--	--	--	--	52.80	35.68	KF·HF + KF·2HF
30.72	27.57	41.70	33.05	50.74	36.57	KF·2HF
29.86	29.20	42.80	32.25	48.87	38.60	"
29.81	32.33	41.68	33.14	49.15	39.40	"
29.40	34.83	40.55	34.00	48.92	40.53	"
27.95	37.14	39.77	36.54	--	--	"
--	--	40.37	38.82	--	--	"
27.29	38.52	37.62	40.18	--	--	"
26.77	40.35	35.37	41.90	46.24	42.98	2KF·5HF
26.66	42.10	34.42	44.20	44.70	44.46	"
26.42	44.30	--	--	43.40	46.21	"
26.82	45.83	--	--	42.75	48.03	"
25.59	45.09	34.00	45.27	--	--	"
24.02	45.42	31.00	47.55	38.17	50.54	KF·3HF
22.85	46.75	30.56	47.77	37.41	51.38	"
22.38	47.50	29.64	48.68	37.05	52.04	"
22.30	48.16	28.86	49.50	36.98	52.50	"
20.98	50.74	28.75	50.01	--	--	"
20.56	50.82	28.64	50.26	--	--	"
19.46	51.30	26.04	51.81	34.21	54.20	KF·4HF
18.00	52.08	21.36	55.30	31.46	55.76	"
15.87	54.01	18.67	58.58	29.68	56.74	"
12.50	57.60	17.64	62.23	27.74	58.07	"
10.68	60.57	17.45	64.12	26.25	60.54	"
9.86	64.13	18.36	66.60	--	--	"
10.30	68.10	19.20	67.15	--	--	"
12.01	69.80	--	--	--	--	"
14.17	71.57	--	--	--	--	"
15.85	72.42	--	--	--	--	"
19.84	73.27	--	--	--	--	"
23.62	74.60	--	--	--	--	"

# K KALIUM

## F POTASSIUM BIFLUORIDE $\text{KHF}_2$

### SOLUBILITY OF POTASSIUM ACID FLUORIDE IN WATER (Jutlov and Poljokova, 1938)

t°	Gms. $\text{KHF}_2$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{KHF}_2$ per 100 gms. sat. sol.	Solid Phase
- 2.9	5.0	Ice	20	28.15	$\text{KHF}_2$
- 4.9	10.0	"	45	38.03	"
- 7.6	16.5	" + $\text{KHF}_2$	60	44.08	"
0	19.7	$\text{KHF}_2$	80	53.28	"
+10	23.14	"			

### THE SYSTEM POTASSIUM FLUORIDE - POTASSIUM IODIDE - WATER AT 25° (Taft and Krishnan, 1954)

The concentrations were measured by conductance measurements. Continuous solid solutions are probably formed.

Sat. sol. mole %		Sat. sol. mole %		Sat. sol. mole %	
KI	KF	KI	KF	KI	KF
13.92	0.0	9.42	4.74	3.78	12.25
12.58	1.34	7.49	7.10	2.22	15.30
10.08	4.34	6.22	8.81	1.21	18.97
9.44	4.69	5.19	10.53	0.0	23.92

### THE SYSTEM POTASSIUM FLUORIDE - AMMONIUM FLUORIDE - WATER AT 25° (Haendler and Jacke, 1950)

(Selected data)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{NH}_4\text{F}$	KF		$\text{NH}_4\text{F}$	KF	
0	48.96	$\text{KF} \cdot 2\text{H}_2\text{O}$	13.77	41.26	$\text{NH}_4\text{F}$
1.70	48.76	"	16.88	35.43	"
3.49	48.63	"	20.37	29.92	"
6.53	48.15	"	26.44	23.76	"
8.04	48.42	"	31.59	16.85	"
10.08	47.88	"	36.03	10.69	"
10.77	47.93	$\text{NH}_4\text{F}$	41.27	4.57	"
11.09	47.39	"	42.92	1.48	"
12.14	45.09	"	44.85	0.00	"

THE SYSTEM POTASSIUM FLUORIDE - NICKEL FLUORIDE - WATER  
(Kurtenacker, Finger and Hey, 1933)

Results at 20°

Results at 50°

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
NiF <sub>2</sub>	KF		NiF <sub>2</sub>	KF	
1.98	1.21	MC*	2.01	1.18	MC
1.20	3.52	"	1.12	4.30	"
0.80	6.32	"	0.26	9.25	"
0.52	9.64	"	0.03	15.4	"
0.40	12.9	"	0.01	19.2	"
0.01	16.8	"	--	22.1	"
--	20.2	"	--	25.0	"
--	25.5	"	--	27.7	"
--	28.1	"	--	31.3	"
--	33.0	"	--	36.8	"
--	37.5	"	--	41.3	"

\*MC = A series of mixed crystals (solid solutions) varying in composition from 0.8 to 1.4 mols. KF per 1 mol. of NiF<sub>2</sub>.

Data for the System  $\text{KF} + \text{VO}_2(\text{NO}_3)_2 \rightleftharpoons 2\text{KNO}_3 + \text{VO}_2\text{F}_2$  in H<sub>2</sub>O at 20° are given in graphical form by Groenweghe, 1954.

THE SYSTEM POTASSIUM FLUORIDE - ETHANOL - WATER AT 23-26°  
(Frankforter and Frary, 1913)

The authors determined the binodal curve, the quadruple points and two tie lines.

Gms. per 100 Gms. Upper Layer			Gms. per 100 Gms. Lower Layer		
KF	C <sub>2</sub> H <sub>5</sub> OH	H <sub>2</sub> O	KF	C <sub>2</sub> H <sub>5</sub> OH	H <sub>2</sub> O
1.23	92.67	6.07*	45.33	0.67	54.00*
--	--	--	37.82	1.70	60.49
1.16	83.30	15.54	--	--	--
--	--	--	28.68	4.7	66.85
2.86	65.81	31.33	--	--	--
4.47	57.4	38.13	20.90	11.9	67.2†
5.47	53.04	41.49	--	--	--
--	--	--	18.55	15.6	65.85
6.93	47.52	45.55	--	--	--
8.84	41.28	49.88	15.7	21.8	62.5†
9.55	38.66	51.79	--	--	--
--	--	--	13.57	27.27	59.15
10.52	35.91	53.57	--	--	--
--	--	--	11.43	33.23	54.34
11	30	59	11	30	59†

\*Quad. points.

†Tie line.

‡Plait point approx.

A method for the determination of alcohol in unknown mixtures, based upon the above data, is described by the authors.

## K KALIUM

THE SYSTEM POTASSIUM FLUORIDE - PROPYL ALCOHOL - WATER AT 25-26°  
(Frankforter and Fray, 1913)

One tie line was determined. In this case the upper layer contained 78.91%  $C_3H_7OH$  and 0.31% KF, and the lower layer contained 9.67% KF.

In this system, the effect of change in temperature is more marked than in the preceding one in which ethyl alcohol is present.

## Points on the Binodal Curve

F	Gms. per 100 Gms. Homogeneous Liquid			Gms. per 100 Gms. Homogeneous Liquid		
	KF	$C_3H_7OH$	$H_2O$	KF	$C_3H_7OH$	$H_2O$
	0.17	96.78	3.05*	8.15	7.49	84.36
	0.31	78.91	21.19	10.00	5.97	84.03
	0.62	66.29	33.09	12.21	4.39	83.41
	0.81	59.97	39.22	14.18	3.45	82.37
	1.29	47.46	51.21	18.75	1.89	79.35
	1.77	35.40	62.83	25.83	0.74	73.43
	2.50	19.05	78.45	35.38	0.23	64.38
	5.32	10.64	84.04	47.62	0.039	52.34*

\*Quad point.

## THE SYSTEM POTASSIUM FLUORIDE - ISOPROPYL ALCOHOL - WATER

Data of Frankforter and Temple, 1915 At 20°

## Points on the Binodal Curve

Results in terms of gms. per 100 gms. of solvent, alcohol + water.

Gms. per 100 Gms. Solvent			Gms. per 100 Gms. Solvent		
KF	$CH_3CHOHCH_3$	$H_2O$	KF	$CH_3CHOHCH_3$	$H_2O$
51.826	1.555	98.445	12.385	21.438	78.562
38.748	2.965	97.035	5.071	59.339	40.661
26.039	6.525	93.475	3.973	65.455	34.545
17.812	12.215	87.785	1.705	82.750	17.250

Data of Ginnings and Chen, 1931 at 25°

The results locate the binodal curve of the system, including a tie line,\* which shows the composition of two liquid layers in contact with each other and, the plait, PP, at which the two liquid layers become homogeneous.

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
$C_3H_7OH$	KF	$C_3H_7OH$	KF
0.16	46.75	23.40	6.40
2.20	25.00	36.80	4.3 PP
4.45	18.68	39.20	4.0
7.70	14.30	65.80	1.0 *
15.10	9.30		

THE SYSTEM POTASSIUM FLUORIDE - TERTIARY BUTYL ALCOHOL - WATER AT 30°  
(Ginnings and Robbins, 1930)

The points on the binodal curve of this system were determined by observing the appearance or disappearance of clouding in a mixture of weighed amounts of KF and one of the two liquids, upon addition of a weighed amount of the other. Conjugate points representing the lines \* located by determining KF in two liquid layers in contact with each other. The plait point, PP, was found by plotting.

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		F
(CH <sub>3</sub> ) <sub>3</sub> COH	KF	(CH <sub>3</sub> ) <sub>3</sub> COH	KF	(CH <sub>3</sub> ) <sub>3</sub> COH	KF	
0.2	51.9	8.2	10.0	--	3.4*	
0.7	29.8*	8.7	9.6	24.1	3.3	
1.2	24.6	9.7	8.8	28.6	2.8	
1.6	22.2	12.5	7.0	34.1	2.3	
1.9	20.7	14.9	5.7	36.0	2.2 PP	
2.4	19.7	15.4	5.6	48.3	1.4	
2.8	18.7	16.6	5.1	55.0	--*	
3.8	16.9	17.7	4.5	60.0	--*	
5.6	14.0	--	4.3*	60.6	0.8	
6.3	12.7	--	4.1*	64.0	--*	
7.7	10.9	20.4	3.7	99.0	--*	

The binodal curve and plait point of the systems  $\text{KF} + (\text{CH}_3)_2\text{COH} + \text{H}_2\text{O}$  at 25° and of  $\text{KF} + \text{Pyridine} + \text{H}_2\text{O}$  at 25° have been determined respectively by Ginnings, Herring and Webb, 1933 and Ginnings, Webb and Hinohara, 1933, but the authors do not give their experimental results but only the values of a series of arbitrary constants calculated from them by means of empirical equations.

THE SYSTEM POTASSIUM FLUORIDE - ALLYL ALCOHOL - WATER AT 20°  
(Frankforter and Temple, 1915)

The results are given in terms of grams per 100 gms. Alcohol + Water instead of gms. per 100 gms. of the homogeneous mixture. Points on the Binodal Curve:

Gms. per 100 Gms. Solvent			Gms. per 100 Gms. Solvent		
KF	CH <sub>2</sub> :CHCH <sub>2</sub> OH	H <sub>2</sub> O	KF	CH <sub>2</sub> :CHCH <sub>2</sub> OH	H <sub>2</sub> O
45.707	2.270	97.730	7.508	35.390	64.610
38.076	3.983	96.017	6.024	42.011	57.989
30.675	5.879	94.121	4.813	47.550	52.450
24.341	7.129	92.871	3.631	54.211	45.789
20.580	9.691	90.309	2.236	59.948	36.443
17.371	11.491	88.509	1.031	65.630	34.370
13.184	17.764	82.236	1.635	68.845	31.155
10.880	22.537	77.463	1.368	71.395	28.605
8.873	29.529	70.471	1.066	75.377	24.223

A solution containing 2.42% KF and 65.85% allyl alcohol has a lower consolute temperature of 17° and an upper consolute of 69.5°. When the salt concentration is raised to 2.66% KF the upper temperature is 73.0°.  
(Timmermans and Lewin, 1953)

# K KALIUM

## THE SYSTEM POTASSIUM FLUORIDE - ACETONE - WATER AT 20° (Frankforter and Cohen, 1914)

Several points on the binodal curves at temperatures between 0° and 35° are also given.

A discussion, with examples, is given of the applicability of the above data to the determination of acetone in unknown mixtures.

Gms. per 100 Gms. Homogeneous Mixture			Gms. per 100 Gms. Homogeneous Mixture		
KF	(CH <sub>3</sub> ) <sub>2</sub> CO	H <sub>2</sub> O	KF	(CH <sub>3</sub> ) <sub>2</sub> CO	H <sub>2</sub> O
F 46.3	trace	53.7*	9.17	23.53	67.30
44.24	0.24	55.52	5.00	38.72	56.28
33.34	1.00	65.66	3.06	47.89	46.84
29.86	1.60	68.54	1.38	58.06	40.55
25.74	3.02	71.24	0.979	62.60	36.42
20.28	5.90	73.80	0.75	65.41	33.84
16.31	9.72	73.97	0.50	69.58	29.92
12.40	15.59	72.01	0	98	2*

\*Quad. point.

### Tie Line Data

Wt. % KF	in aqueous layer:	23.12	14.78	10.94	1.63
	in acetone layer:	0.05	0.56	1.63	3.36

## THE SYSTEM POTASSIUM FLUORIDE - METHYL ETHYL KETONE - WATER AT 20° (Frankforter and Cohen, 1916)

Points on the binodal curve

Gms. per 100 Gms. Homogeneous Mixture			Gms. per 100 Gms. Homogeneous Mixture		
KF	CH <sub>3</sub> ·CO·C <sub>2</sub> H <sub>5</sub>	H <sub>2</sub> O	KF	CH <sub>3</sub> ·CO·C <sub>2</sub> H <sub>5</sub>	H <sub>2</sub> O
34.38	0.17	65.45	10.50	4.87	84.63
23.63	0.50	75.87	5.70	9.93	84.37
18.62	1.49	79.89	3.96	12.42	83.61
15.91	2.19	81.90	0.84	21.23	77.93
13.80	2.98	83.22	0.34	23.55	76.11

Systems by Timmermans and Lewin, 1953:

KF + Ethoxy-ethanol + H <sub>2</sub> O				KF + Propoxy-ethanol + H <sub>2</sub> O			
% Ethoxy-ethanol	% KF	Critical mixing t°		% Propoxy-ethanol	% KF	Critical mixing t°	
		Lower	Upper			Lower	Upper
38.62	9.70	91.8	--	36.87	4.52	45.7	--
	10.0	79.8	--		5.20	33.2	--
	10.40	69.2	--		7.07	8	--
	11.52	46.2	--		11.45	< 0	--
35.05	10.80	--	136	34.60	3.50	101	--
	11.31	90.5	182		3.65	87.6	115
	12.08	66.2	--		3.83	76.2	--
	14.40	27.8	--		5.0	45.6	--
	15.40	16.7	--		5.65	33.3	--

## SOLUBILITY OF POTASSIUM FLUORIDE IN ANHYDROUS ORGANIC SOLVENTS

Solvent	t°	Solubility
(Pavlopoulos and Strehlow, 1954)		
Methanol	18	10.0 gms. per 100 gms. CH <sub>3</sub> OH (d. = 0.864)
	25	10.2 " (d. = 0.865)
(Germuth, 1931)		
Methanol	20	0.192 gms. per 100 gms. sat. sol.
	30	0.168 "
	40	0.150 "
	50	0.125 "
	55	0.092 "
Ethanol	20	0.106 "
	30	0.096 "
	40	0.068 "
	50	0.023 "
	55	0.016 "
(Frankforter and Frary, 1913)		
Propanol (99.6%)	Room t°	0.34 gm. per 100 gms. sat. sol.
(Lannung, 1932)		
Acetone	18	0.00022 gms. per 1000 gms. acetone
	37	0.00025 "
(Pavlopoulos and Strehlow, 1954)		
Acetonitrile	18	0.0036 gms. per 100 gms. acetonitrile
	25	0.0024 "



## K KALIUM

THE SYSTEM POTASSIUM FLUORIDE - HYDROGEN FLUORIDE  
(Cady, 1934)

A thermocouple thermometer was used and the freezing, eutectic and transition points were determined by cooling curves. Data for vapor pressure are also given.

	Mol. Fraction HF in Solution	Solid Phase	t°	Mol. Fraction HF in Solution	Solid Phase	
F	-83.7	1.000	HF	64.0	0.7173	KF·5HF
	-85.2	0.9875	"	(64.3)	(0.714)	"
	-86.9	0.9732	"	64.3	0.7115	"
	-89.5	0.9580	"	63.4	0.7040	"
	-92.8	0.9466	"	61.8	0.6969	" + KF·2HF
	-97.0	0.9311	" + KF·4HF	62.4	0.6932	KF·2HF
	-45.0	0.9143	KF·4HF	70.0	0.6777	"
	8.0	0.8884	"	71.7	0.6670	"
	48.0	0.8572	"	71.1	0.6606	"
	63.2	0.8355	"	68.3	(0.649)	" + $\alpha$ KF·HF
	67.7	0.8241	"	84.	0.6435	$\alpha$ KF·HF
	71.8	0.8086	"	128	0.6197	"
	(72.0)	(6.8000)	"	148	0.6014	"
	72.0	0.7993	"	175	0.5695	"
	71.0	0.7901	"	189	0.5488	"
	67.8	0.7783	"	195	0.5382	" + $\beta$ KF·HF
	(63.6)	(0.771)	" + KF·3HF	217	0.5218	$\beta$ KF·HF
	64.4	0.7676	KF·3HF	231	0.5103	"
	65.4	0.7583	"	234	0.5075	"
	(65.8)	(0.7500)	"	236.8	0.5032	"
	65.8	0.7490	"	(239.0)	(0.5000)	"
A	65.5	0.7438	"	238.8	0.4996	"
	64.5	0.7342	"	236	0.4847	"
	62.6	0.7278	"	229.5	0.4860	" + KF
	62.4	(0.727)	" + 2KF·5HF	292	0.4775	KF
	62.7	0.725	KF·5HF	346	0.4646	"

100 cc. sat. solution of Potassium Fluoride in liquid hydrofluoric acid contain 38.0 gms. KF at 0°. (Fredenhagen 1930, 1933; Fredenhagen and Cadenback, 1931.)

100 gms. liquid Sulfur Dioxide dissolve 0.018 gm. KF at 0°. (Jander and Wickert, 1936; Jander and Ruppolt, 1937.)

SOLUBILITY OF POTASSIUM FLUORIDE IN BROMINE TRIFLUORIDE  
(Sheft, Hyman and Katz, 1953)

t°	Solubility		
25	4.73 gms. K (= 7.03 gms. KF)	per 100 gms. sat. sol.	
70	5.38 " (= 8.00 " )	"	"

At 20°, the solubility of KF in phosphorus oxychloride is 0.40 gms./liter. (Gutmann, 1952)

Melting point data are given for:

- KF + NaF (Saverwald and Dombois, 1954; Platonov, 1946; Bergman and Dergunov, 1945, 1941a; Kurnakow and Zemcznyy, 1907; Sholokhovich, 1955; Bergman and Nagorny, 1943; Silber and Ishaqur, 1951)
- KF + MgF<sub>2</sub> (Dergunov and Bergman, 1948; Bergman and Dergunov, 1945; Remy and Hansen, 1956; Remy and Seeman, 1940)
- KF + BeF<sub>2</sub> (Borzenkova, Novoselova, Simanov, Chernykh and Yaremash, 1956)
- KF + RbF (Dergunov and Bergman, 1948)
- KF + LaF<sub>3</sub> (Dergunov, 1948)
- KF + YF<sub>3</sub> (Dergunov, 1948)
- KF + KVO<sub>3</sub> (Schmitz-Dumont and Schmitz, 1944)
- KF + LiF (Bergman and Dergunov, 1941a) F
- KF + ThF<sub>4</sub> (Dergunov and Bergman, 1948a; Zachariasen, 1948; Asker, Segnit, and Wylie, 1952)
- KF + ThF<sub>4</sub> + RbF (Dergunov and Bergman, 1948a)
- KF + MgF<sub>2</sub> + RbF (Dergunov and Bergman, 1948)
- KF + MgF<sub>2</sub> + NaF (Bergman and Dergunov, 1945, 1941; Bergman and Pavlenko, 1941)
- KF + NaF + LiF (Bergman and Dergunov, 1941a)
- KF + K<sub>2</sub>SO<sub>4</sub> (Karandeev, 1909; Gladushchenko and Bergman, 1956)
- KF + KOH (Scarpa, 1915)
- KF + KPO<sub>3</sub> (Amadori, 1912)
- KF + K<sub>4</sub>P<sub>2</sub>O<sub>7</sub> ( " " )
- KF + K<sub>3</sub>PO<sub>4</sub> ( " " )
- KF + K<sub>4</sub>P<sub>2</sub>O<sub>7</sub> (Sholokhovich and Belyaev, 1954)
- KF + K<sub>2</sub>Mo<sub>4</sub>O<sub>13</sub> (Schmitz-Dumont and Oppenhoff, 1954)
- KF + K<sub>2</sub>MoO<sub>4</sub> (Schmitz-Dumont and Weeg, 1951; Mateiko and Bukalova, 1955)
- 2KF + Na<sub>2</sub>MoO<sub>4</sub> = K<sub>2</sub>MoO<sub>4</sub> + 2NaF (Mateiko and Bukalova, 1955)
- KF + NiF<sub>2</sub> (Wagner and Balz, 1952)
- KF + KNO<sub>3</sub> (Nyankovska and Bergman, 1952)
- KF + NaNO<sub>3</sub> = KNO<sub>3</sub> + NaF (Nyankovska and Bergman, 1952)
- KF + MgF<sub>2</sub> (DeVries and Roy, 1953)
- KF + UF<sub>4</sub> (Zachariasen, 1948)
- KF + LaF<sub>3</sub> (Zachariasen, 1948)
- KF + MoO<sub>3</sub> (Schmitz-Dumont and Heckmann, 1952)
- KF + WO<sub>3</sub> (Schmitz-Dumont, Bruns, and Heckmann, 1953)
- KF + PbF<sub>2</sub> (Gladushchenko and Bergman, 1956)
- 2KF + PbSO<sub>4</sub> = K<sub>2</sub>SO<sub>4</sub> + PbF<sub>2</sub> (Gladushchenko and Bergman, 1956; Schmitz-Dumont, Bergerhoff, and Hartet, 1956)
- 2KF + Na<sub>2</sub>WO<sub>4</sub> = K<sub>2</sub>WO<sub>4</sub> + 2NaF (Mateiko and Bukhalova, 1957)
- KF + NaVO<sub>3</sub> = KVO<sub>3</sub> + NaF (Zakharchenko and Bergman, 1957)
- KF + K<sub>2</sub>SiO<sub>3</sub> (Bergman, Nesterova and Bychkova, 1955)
- 2KF + Li<sub>2</sub>SiO<sub>3</sub> = 2LiF + K<sub>2</sub>SiO<sub>3</sub> (Bergman and Bychkova-Shul'ga, 1957)
- KF + K<sub>2</sub>WO<sub>4</sub> (Schmitz-Dumont and Weeg, 1951; Kislova, Posypaiko, and Bergman, 1955)
- KF + K<sub>2</sub>CrO<sub>4</sub> (Schmitz-Dumont and Weeg, 1951)
- KF + ErF<sub>3</sub> (Dergunov, 1952)
- KF + SmF<sub>3</sub> ( " " )
- KF + PrF<sub>3</sub> ( " " )
- KF + CaF<sub>2</sub> + SiO<sub>2</sub> (Ershova and Ol'shanskii, 1958)
- KF + MgF<sub>2</sub> + SiO<sub>2</sub> ( " " " )
- KF + K<sub>2</sub>Ti<sub>2</sub>O<sub>5</sub> (Schmitz-Dumont and Schulz, 1952)
- KF + K<sub>2</sub>TiO<sub>3</sub> (Sholokhovich, 1955)
- 2KF + Na<sub>2</sub>TiO<sub>3</sub> = K<sub>2</sub>TiO<sub>3</sub> + 2NaF (Sholokhovich, 1955)

## K KALIUM

The reactions in the solid state below the melting points were studied for the following pairs of salts by Link and Wood, 1939.

KF + RbCl	KF + CsBr	KF + LiI
KF + RbBr	KF + CaI	KF + NaCl
KF + RbI	KF + LiCl	KF + NaBr
KF + CsCl	KF + LiBr	KF + NaI

## F POTASSIUM BERYLLIUM FLUORIDE $K_2BeF_4$

THE SYSTEM  $K_2BeF_4 - H_2O$   
(Vorob'eva and Tamm, 1956)

When an equimolar mixture of  $K_2CO_3$  and  $BeCH_2$  is dissolved in HF solution, colorless hexagonal prisms of  $K_2BeF_4$  precipitate. The salt dissolves slowly (20 hrs.), and then the concentration in solution slowly decreases over 2 months, indicating that the original phase was metastable.

t°	Gms. $K_2BeF_4$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $K_2BeF_4$ per 100 gms. sat. sol.	Solid Phase
-0.15	0.38	Ice	25	1.52	$K_2BeF_4$
-0.30	0.77	"		(1.97)*	"
-0.38	0.94	" + $K_2BeF_4$	50	2.42	"
0.0	1.04 (1.23)*	$K_2BeF_4$	75	3.36	"

\*metastable modification.

Phase equilibria in the system  $K_2BeF_4 - K_2SO_4$  were studied by Levina, Novoselova, Simanov, and Bakina, 1956.

## POTASSIUM GERMANIUM FLUORIDE $K_2GeF_6$

SOLUBILITY IN WATER

18°	100°		
173.98	34.07 gms. per 100 gms. $H_2O$		(Winkler, 1887)
184.61	38.76 " "	"	(Kruss and Nilson, 1887)

## POTASSIUM HAFNIUM FLUORIDE $K_2HfF_6$

100 gms. sat. solution of Potassium Hafnium Fluoride in Water contain 3.0 gms.  $K_2HfF_6$  at 20°. (v. Hevesy, 1923.)

## F POTASSIUM NIOBIUM FLUORIDES $K_2NbF_7$ , $KNbF_6$ , $K_2NbOF_5$

The System  $KNbF_6 - HF - H_2O$  AT 25°  
(Savchenko and Tansnaev, 1946)

Saturated Solution Wt. %		Solid Phase	Saturated Solution Wt. %		Solid Phase
HF	$KNbF_6$		HF	$KNbF_6$	
40.90	15.79	$KNbF_6$	54.00	15.14	$KNbF_6$
45.00	15.55	"	57.30	14.78	"
47.50	15.50	"	59.00	14.72	"

THE SYSTEM  $K_2NbF_7$  - HF -  $H_2O$ 

Results at 25°  
(Savchenko and Tananaev, 1946)

Saturated Solution Wt. %			Saturated Solution Wt. %		
HF	$K_2NbF_7$	Solid Phase	HF	$K_2NbF_7$	Solid Phase
1.51	10.44	$K_2NbOF_5 \cdot H_2O$	9.35	11.58	$K_2NbF_7$
3.61	11.63	"	12.20	8.69	"
4.12	11.76	"	16.34	5.80	"
5.20	12.33	"	19.18	6.19	"
5.30	12.78	"	20.50	6.16	"
6.30	13.14	"	21.60	5.71	"
6.60	13.70	"	27.40	5.71	"
6.94	13.75	$K_2NbF_7$	31.58	8.11	"
7.16	13.80	"	37.87	12.64	"
7.20	14.16	"	40.32*	--	"
8.00	13.85	"			

\*Above 40.3% HF, the solid phase is  $KNbF_6$  and the ratio  $KF:NbF_5$  in solution increases sharply.

Results at 75°  
(Savchenko and Tananaev, 1947)

Saturated Solution				Solid Phase
Wt. % HF	Wt. % $NbF_5$	Wt. % KF	Mol. KF Mol. $NbF_5$	
2.70	7.45	--	--	$K_2NbOF_5 \cdot H_2O$
5.00	23.77	14.38	2.00	$K_2NbOF_5 \cdot H_2O + K_2NbF_7$
6.00	22.52	15.28	2.20	$K_2NbF_7$
9.60	18.60	--	--	"
11.40	16.50	9.58	1.90	"
15.00	13.80	--	--	"
20.20	11.00	6.80	2.00	"
20.70	11.25	7.19	2.06	"
29.00	11.70	7.12	2.00	"
32.10	13.24	7.87	1.95	"
33.60	17.00	--	--	"

Earlier data of Ruff and Schiller, 1911 at 16°, 80°, 85°

The determinations were made in platinum vessels. The mixtures were shaken for 3 hour periods at constant temperature and the saturated solutions filtered through platinum funnels.

Solvent	t°	Gms. per 100 Gms. Sat. Sol.			Solid Phase
		$NbF_5$	KF	HF	
Water	16	5.19	2.98	0.35	$K_2NbOF_5 \cdot H_2O$
"	16	7.07	5.33	4.35	$K_2NbOF_5 \cdot H_2O + K_2NbF_7$
Aq. 10.95% HF	16	4.33	2.32	10.43	$K_2NbF_7$
" 7.41% KF	16	1.16	5.54	0.13	$K_2NbOF_5 \cdot H_2O$
" 7.39% KF	16	2.67	6.04	5.39	$K_2NbOF_5 \cdot H_2O + K_2NbF_7$
Water	85	30.39	14.68	0.35	$K_2NbOF_5 \cdot H_2O(?)$
Aq. 4.81% KF	80	11.66	10.08	1.53	"

# K KALIUM

Some data for the quaternary systems  $K_2NbF_7 - KF - HF - H_2O$  and  $K_2NbF_7 - K_2TaF_7 - HF - H_2O$  at 25° are also given by Savchenko and Tananaev, 1946.

## SOLUBILITY OF $K_2NbOF_5 \cdot H_2O$ IN 1% HF SOLUTION (Meerson, Zverev, and Zubkova, 1939)

Temperature °	20	40	60	75
% $K_2NbOF_5 \cdot H_2O$ :	10	19	33	46

Data for the system  $K_2NbOF_5 \cdot H_2O - K_2TaF_7 - H_2O$  (+ 1% HF) at 20° and 60° are also given.

## F POTASSIUM PLATINUM FLUORIDE $K_2PtF_6$

At 25° 100 ml. sat. solution contains 0.750 gms.  $K_2PtF_6$ . (Wheeler, Perros and Naeser, 1955.)

## POTASSIUM TANTALUM FLUORIDES $K_2TaF_7$ , $KTaF_6$

### SOLUBILITY OF POTASSIUM TANTALUM FLUORIDE IN HYDROFLUORIC ACID SOLUTIONS

(The System  $K_2TaF_7 - HF - H_2O$ )

(Babaeva and Klatchko-Gourvitch, 1935 at 0°, 20°, 80°; Savchenko and Tananaev, 1946 at 25°, 1947 at 75°)

At high concentrations of HF the reaction  $2KTaF_6 \rightleftharpoons K_2TaF_7 + TaF_5$  proceeds to the left and the solid phase becomes  $KTaF_6$ . (The ratio  $KF:TaF_5$  in solution increases sharply.) At 25° for example, this occurs above 45.3% HF, and the new curve ( $KTaF_6$ ) was followed up to 69% HF.

Results at 0°			Results at 20°			Results at 80°		
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$H_2F_2$	$K_2TaF_7$		$H_2F_2$	$K_2TaF_7$		$H_2F_2$	$K_2TaF_7$	
0.105	0.114	$K_2TaF_7 + X$	0.214	0.226	$K_2TaF_7 + X$	2.170	3.367	$K_2TaF_7$
0.610	0.246	$K_2TaF_7$	0.288	0.319	$K_2TaF_7$	5.023	3.843	"
1.757	0.287	"	1.520	0.620	"	7.550	4.305	"
3.750	0.364	"	4.234	0.783	"	10.230	4.863	"
6.545	0.454	"	9.859	1.015	"	16.690	6.331	"
11.207	0.579	"	16.520	1.440	"	24.233	8.820	"
17.273	0.815	"	19.047	1.609	"	32.610	11.444	"
24.099	1.326	"	25.420	2.368	"			
34.366	4.500	"	32.025	3.825	"			
			38.157	6.345				

(Cont.)

The System  $K_2TaF_7$  - HF -  $H_2O$ —Cont.

## Results at 25°

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. aat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
HF	$K_2TaF_7$		HF	$K_2TaF_7$		HF	$KTaF_6$	
1.97	0.95	$K_2TaF_7$	39.49	6.63	$K_2TaF_7$	42.40	16.88	$KTaF_6$
9.51	1.26	"	40.90	8.88	"	50.00	16.06	"
19.54	2.00	"	42.64	10.16	"	53.15	15.93	"
28.20	3.30	"	42.80	10.55	"	56.00	15.93	"
32.82	3.95	"	44.00	11.28	"	59.90	16.53	"
33.86	4.16	"	44.56	12.56	"	63.85	17.21	"
36.14	4.85	"	44.64	12.77	"	65.50	17.40	"
37.26	5.71	"	45.29	14.90	"			

## Results at 75°

## Saturated Solution

Wt. % HF	Wt. % $TaF_5$	Wt. % KF	Mol. KF Mol. $TaF_5$	Solid Phase
2.70	3.20	1.52	2.25	$K_2TaF_7$
4.86	3.05	1.37	2.11	"
7.12	3.25	--	--	"
11.80	3.48	1.65	2.18	"
21.52	5.15	--	--	"
30.00	6.74	--	--	"
35.50	10.87	4.69	2.08	"

SOLUBILITY OF  $K_2TaF_7$  IN 1% HF SOLUTION  
(Meerson, Zverev, and Zubkova, 1939)

Temperature°	20	40	60	75
% $K_2TaF_7$ :	0.8	1.6	3.1	4.2

POTASSIUM THORIUM FLUORIDE  $K_2ThF_6 \cdot H_2O$ 

F

100 gms. sat. solution of Potassium Thorium Fluoride in Water contain 0.000064 gm.  $K_2ThF_6$  at 25°. (Spicín, 1917)

POTASSIUM TITANIUM FLUORIDE  $K_2TiF_6 \cdot H_2O$ SOLUBILITY OF POTASSIUM TITANIUM FLUORIDE IN WATER  
(Merignac, 1866)

T°	0°	3°	6°	10°	14°	20°
Gms. $K_2TiF_6$ per 100 gms. $H_2O$	0.55	0.67	0.77	0.91	1.04	1.28

# K KALIUM

## SOLUBILITY OF POTASSIUM TITANIUM FLUORIDE IN WATER AND IN 98 PERCENT ETHYL ALCOHOL (Ginsberg, 1932)

Results for Water			Results for 98% C <sub>2</sub> H <sub>5</sub> OH		
t°	Gms. K <sub>2</sub> TiF <sub>6</sub> per 100 cc. sat. sol.	Solid Phase	t°	Gms. K <sub>2</sub> TiF <sub>6</sub> per 100 cc. sat. sol.	Solid Phase
20-22	1.3	K <sub>2</sub> TiF <sub>6</sub> ·H <sub>2</sub> O	20-22	0.005	K <sub>2</sub> TiF <sub>6</sub> ·H <sub>2</sub> O
"	1.2	K <sub>2</sub> TiF <sub>6</sub>	"	0.0045	"

# F POTASSIUM ZIRCONIUM FLUORIDE K<sub>2</sub>ZrF<sub>6</sub> (See also Zirconium Salts)

## SOLUBILITY OF POTASSIUM ZIRCONIUM FLUORIDE IN WATER (Missenden, 1922)

No information is given as to how the determinations were made and no explanation of the column heading "No. of parts of water". Presumably this is the grams of water required to dissolve one gram of the salt.

t°	No. of parts water	t°	No. of parts water	t°	No. of parts water
10	81.75	40	42.25	80	14.50
20	64.50*	50	34.00	90	9.00
30	52.00	60	26.25	100	4.25
		70	19.75		

\*100 gms. sat. solution of Potassium Zirconium Fluoride in water contain 2.6 gms. K<sub>2</sub>ZrF<sub>6</sub> at 20°. (v. Hevesy, 1923)

# I POTASSIUM IODIDE KI

## SOLUBILITY IN WATER

(Averages of the closely agreeing results of Mulder; deCoppet, 1883; Etard, 1894; Meusser, 1905; see also Tilden and Shenstone, 1884; Schreinemakers, 1892; Kremann and Kershbaum, 1907; Scott and Frazier, 1927; Scott and Durham 1930; Hill, Willson and Bishop, 1933; and Hering, 1936, and others)

Gms. KI per 100 gms.			Density	Gms. KI per 100 gms.			Density
t°	H <sub>2</sub> O	sat. sol.		t°	H <sub>2</sub> O	sat. sol.	
Solid phase ICE				Solid phase KI			
- 5	25.7	22.5	--	-10	115.1	59.5	--
- 7	42.6	29.9	--	- 5	119.8	54.5	--
- 9.5	51.5	34.0	--	- 1	122.2	55.0	--
-11.5	64.7	39.3	--	0	127.5	56.0	1.667
-14	75.8	42.7	--	10	136	57.6	--
-20	92.3	48.0	--	20	144	59.0	1.716
-23.2	107.8	51.9	(Eutectic)				

(Cont.)

t°	Gms. KI per 100 gms.		Density	t°	Gms. KI per 100 gms.	
	H <sub>2</sub> O	sat. sol.			H <sub>2</sub> O	sat. sol.
	Solid phase KI				Solid phase KI	
25	148	59.7	1.721	160	255.0	71.8
30	152	60.4	--	170	263.7	72.5
40	160	61.6	1.747	180	272.9	73.2
50	168	62.8	1.760	190	282.6	73.9
60	176	63.8	1.773	200	292.9	74.6
70	184	64.8	--	210	303.4	75.2
80	192	65.7	1.795	220	314.3	75.8
90	200	66.6	--	230	326.0	76.6
100	208	67.4	1.819	240	338.4	77.2
100	206.4	67.3	--	275	376	79.1
110	214.3	68.2	--	300	525	84.0
120	222.3	69.0	--	350	558	84.8
130	230.3	69.8	--	400	614	86.0
140	238.5	70.5	--	450	809	89.0
150	246.7	71.2	--			

I

SOLUBILITY OF POTASSIUM IODIDE IN WATER AND DEUTERIUM OXIDE  
(Eddy and Menzies, 1940)

t°	Gms. KI per 100 gms. H <sub>2</sub> O	t°	Gms. KI per 100 gms. D <sub>2</sub> O	t°	Gms. KI per 100 gms. D <sub>2</sub> O	t°	Gms. KI per 100 gms. D <sub>2</sub> O
6.2	132.7	0	97.3	55	143.1	105	180
11.2	136.7	5	102.2	60	146.9	110	183.5
56.7	173	10	107.0	65	150.5	115	187
		15	111.7	70	154.3	120	190.5
		20	116.1	75	158	125	194
		25	120.4	80	161.5	130	198
		30	124.5	85	165	135	202
		35	128.4	90	169	140	205
		40	132.1	95	172.5	145	209
		45	135.8	100	176	150	213
		50	139.4				

For references to the solubility of KI at the critical temperature see Booth and Bidwell, 1948. Data for the change in critical temperature as a function of concentration are given by Schroer, 1927.



# K KALIUM

## SOLUBILITY OF POTASSIUM IODIDE IN POTASSIUM HYDROXIDE SOLUTIONS AT 20° (Kirschman and Pomeroy, 1943)

The data differ from those of Bronsted, below, whose values are all higher. The KOH contained about 1%  $K_2CO_3$ , which was expressed as KOH in the data below.

	Gm. moles KOH per liter sat. sol.	Gm. moles KI per liter sat. sol.	Density	Gm. moles KOH per liter sat. sol.	Gm. moles KI per liter sat. sol.	Density
I	14.35	0.556	1.593	5.853	2.634	1.540 <sup>1</sup>
	13.28	.651	1.576	4.753	3.146	1.556 <sup>1</sup>
	12.51	.759	1.562 <sup>1</sup>	4.111	3.485	1.569 <sup>1</sup>
	11.05	.981	1.538 <sup>1</sup>	4.000	3.525	1.571 <sup>1</sup>
	10.53	1.107	1.533 <sup>1</sup>	2.405	4.454	1.616 <sup>1</sup>
	8.814	1.541	1.524 <sup>1</sup>	1.860	4.818	1.635 <sup>1</sup>
	8.161	1.733	1.524 <sup>1</sup>	1.358	5.132	1.654 <sup>1</sup>
	7.050	2.171	1.529 <sup>1</sup>	0.783	5.539	1.677 <sup>1</sup>
	6.624	2.292	1.532 <sup>1</sup>	0.0	6.089	--
	6.453	2.369*	1.534 <sup>1</sup>			

<sup>1</sup>Estimated by plotting the data given by the authors.

\*Contained 0.40 N  $K_2CO_3$

## Earlier results of Bronsted, 1920a

Gm. Mols. per liter sat. sol.		Gm. Mols. per liter sat. sol.	
KOH	KI	KOH	KI
9.41	1.72	12.92	0.824
10.95	1.23	14.02	0.672
11.10	1.176	15.01	0.558
12.19	0.933		

## SOLUBILITY OF POTASSIUM IODIDE IN SODIUM HYDROXIDE SOLUTIONS AT 20° (Kirschman and Pomeroy, 1944)

Moles NaOH per liter of sat. sol.	Moles KI per liter of sat. sol.	Density	Moles NaOH per liter of sat. sol.	Moles KI per liter of sat. sol.	Density
0.0	6.09	1.716	6.78	2.75	1.543
0.95	5.48	1.674	7.77	2.42	1.532
1.34	5.26	1.661	8.68	2.18	1.531
2.57	4.58	1.624	10.06	1.81	1.526
3.60	4.06	1.597	10.80	1.67	1.530
4.77	3.53	1.573	13.45	1.29	1.540
5.04	3.44	1.568	16.22	1.03	1.569
5.20	3.35	1.564	16.50	1.03	1.583

The distribution of iodide ions at 25° between solid and liquid phases in the systems  $KBr - KI - H_2O$  and  $KCl - KI - H_2O$  in solutions containing small amounts of iodide was studied by Cirkov and Schnee, 1939a.

THE SYSTEM POTASSIUM IODIDE - POTASSIUM IODATE - WATER AT 25°  
(Ricci, 1937)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	KIO <sub>3</sub>	KI			KIO <sub>3</sub>	KI	
1.718	0.0	59.76	KI	1.451	2.54	41.10	KIO <sub>3</sub>
1.731	1.10	59.14	"	1.227	3.27	22.38	"
--	2.25	58.62	"	--	4.33	12.04	"
1.751	2.35	58.51	" + KIO <sub>3</sub>	1.053	7.15	2.40	"
1.722	2.35	57.02	KIO <sub>3</sub>	1.071	8.449	0.0	"

THE SYSTEM POTASSIUM IODIDE - POTASSIUM SULFATE - WATER AT 25°  
(Ricci, 1938)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	K <sub>2</sub> SO <sub>4</sub>	KI			K <sub>2</sub> SO <sub>4</sub>	KI	
1.718	0.0	59.76	KI	1.273	1.70	28.81	K <sub>2</sub> SO <sub>4</sub>
1.722	0.08	59.60	" + K <sub>2</sub> SO <sub>4</sub>	1.185	3.57	18.57	"
1.701	0.10	58.70	K <sub>2</sub> SO <sub>4</sub>	1.127	6.57	9.13	"
1.399	0.69	39.57	"	1.083	10.76	0.0	"

EQUILIBRIUM IN THE SYSTEM POTASSIUM IODIDE - IODINE - WATER  
(Briggs, Glack, Ballard, and Sassaman, 1940)

See also Vol. I, p. 1257-9

The authors' data confirm the findings of Grace and of Foote and Chalker, which indicated the existence of two polyiodide compounds in the system. The older work of Parsons and Whittemore, who thought the system to be simple, is shown to have been incorrectly interpreted by those authors.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
KI	I		KI	I	
Results at 0°					
55.86	0.0	KI	30.63	55.58	KI <sub>3</sub> ·2H <sub>2</sub> O
51.43	10.21	"	29.60	57.18	"
46.01	23.10	"	28.95	58.32	"
40.34	35.23	"	28.20	59.60	"
35.96	45.62	"	27.55	60.34	KI <sub>3</sub> ·2H <sub>2</sub> O + I
35.20	47.50	"	27.09	58.76	I
34.92	48.62	"	27.19	56.79	"
34.81	48.76	KI + KI <sub>3</sub> ·2H <sub>2</sub> O	26.63	52.99	"
34.27	49.39	KI <sub>3</sub> ·2H <sub>2</sub> O	25.36	42.28	"
33.51	50.75	"	21.84	29.56	"
32.77	52.12	"	18.40	21.12	"
31.64	53.77	"	13.22	13.39	"

(Cont.)

## K KALIUM

## EQUILIBRIUM IN THE SYSTEM POTASSIUM IODIDE - IODINE - WATER--Cont.

Results at 25°

	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	KI	I		KI	I	
	60.15	0.0	KI	26.98	66.57	KI <sub>7</sub> ·H <sub>2</sub> O
	56.91	6.59	"	26.67	66.83	"
	46.56	26.76	"	26.22	67.31	"
	36.95	46.94	"	25.96	67.53	"
	32.54	57.05	"	25.80	67.71	"
	30.84	60.89	"	25.75	67.80	"
I	30.12	61.97	"	25.64	67.76	KI <sub>7</sub> ·H <sub>2</sub> O + I
	30.08	62.28	KI + KI <sub>3</sub> ·H <sub>2</sub> O	25.57	67.68	I
	30.03	63.02	KI <sub>3</sub> ·H <sub>2</sub> O	25.28	67.26	"
	29.12	63.80	"	25.01	65.94	"
	28.90	64.18	"	24.89	57.03	"
	28.50	64.51	"	19.13	25.37	"
	27.33	66.42	"	10.87	10.49	"
	27.24	66.51	KI <sub>3</sub> ·H <sub>2</sub> O + KI <sub>7</sub> ·H <sub>2</sub> O	2.09	1.62	"

The authors also studied the system from the eutectic to about 60°, and present tables and diagrams of the polythermal data. It was found that KI<sub>3</sub>·2H<sub>2</sub>O can exist in two modifications, but no other compounds were formed.

INVARIANT POINTS IN THE POLYTHERMAL SYSTEM KI + I + H<sub>2</sub>O

t°	Gms. per 100 gms. sat. sol.		Solid Phase
	I	KI	
-22.7	0.0	52.2	Ice + KI
0	trace	0.0	Ice + I
80.8	85.3	14.7	KI + I
-23.7	44.1	19.4	Ice + α-KI <sub>3</sub> ·2H <sub>2</sub> O + KI
~ 1.0	48.7	35.0	KI + α-KI <sub>3</sub> ·2H <sub>2</sub> O + β-KI <sub>3</sub> ·2H <sub>2</sub> O
12.3	54.9	32.8	KI <sub>3</sub> ·H <sub>2</sub> O + KI + β-KI <sub>3</sub> ·2H <sub>2</sub> O
30.0	67.4	26.5	KI <sub>3</sub> ·H <sub>2</sub> O + KI + KI <sub>7</sub> ·H <sub>2</sub> O
38.0	70.9	24.4	KI <sub>7</sub> ·H <sub>2</sub> O + KI + I
3.0	60.3	28.5	β-KI <sub>3</sub> ·2H <sub>2</sub> O + KI <sub>3</sub> ·H <sub>2</sub> O + KI <sub>7</sub> ·H <sub>2</sub> O
~ 1.0	59.8	28.4	α-KI <sub>3</sub> ·2H <sub>2</sub> O + β-KI <sub>3</sub> ·2H <sub>2</sub> O + KI <sub>7</sub> ·H <sub>2</sub> O
- 4.9	59.0	28.2	α-KI <sub>3</sub> ·2H <sub>2</sub> O + KI <sub>7</sub> ·H <sub>2</sub> O + I
-19.6	51.5	28.5	Ice + α-KI <sub>3</sub> ·2H <sub>2</sub> O + I

THE SYSTEM POTASSIUM IODIDE - SILVER IODIDE - WATER  
(Van Dam and Donk, 1911)

Results at 0°		Results at 30°		Results at 50°		Solid Phase in Each Case
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
AgI	KI	AgI	KI	AgI	KI	
0	56.1	0	60.35	0	62.6	KI
9.0	53.0	16.0	55.5	10.7	59.1	"
18.0	51.2	35.8	46.9	22.8	55.5	"
31.3	46.6	42.8	43.9	45.0	43.2	"
37.9	44.0	44.1	43.2	53.4	37.6	" + AgI·KI
37.6	42.7	47.7	40.9	53.5	37.1	AgI·KI
38.0	41.3	49.7	38.6	53.5	36.6	" + AgI
28.1	36.4	42.8	38.8	53.5	36.5	AgI
26.6	34.6	29.4	37.6	39.0	38.1	"
6.5	26.1	10.0	31.4	28.0	36.7	"
1.5	20.5	--	--	16.0	33.8	"
0.2	9.8	0.1	10.2	2.5	24.8	"
27.5	48.7	--	--	--	--	AgI·2KI + KI
21.0	50.3	--	--	--	--	AgI·2KI

THE SYSTEM POTASSIUM IODIDE - SODIUM IODIDE - WATER  
(Hill, Willson and Bishop, 1933)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
KI	NaI	Solid Phase	KI	NaI	Solid Phase
Results at 8°			Results at 25°		
57.33	0.0	KI	59.78	0.0	KI
37.54	19.97	"	50.32	9.29	"
19.20	40.55	"	42.08	17.60	"
8.36	55.58	"	29.79	30.55	"
7.44	57.13	" + NaI·2H <sub>2</sub> O	21.43	40.11	"
5.82	58.23	NaI·2H <sub>2</sub> O	15.90	46.91	"
0.0	62.49	"	10.60	54.49	"
Results at 40°			7.59	59.35	KI + NaI·2H <sub>2</sub> O
			7.06	59.71	NaI·2H <sub>2</sub> O
61.73	0.0	KI	6.80	59.97	"
48.04	13.47	"	5.44	60.74	"
35.55	26.20	"	4.78	61.35	"
21.33	42.04	"	2.17	63.15	"
9.68	57.85	"	0.0	64.72	"
7.23	62.34	" + NaI·2H <sub>2</sub> O			
4.81	63.92	NaI·2H <sub>2</sub> O			
0.0	67.35	"			

## K KALIUM

## THE SYSTEM POTASSIUM IODIDE - LEAD IODIDE - WATER

In the case of the determinations by Burrage, constant agitation in a thermostat was employed. At low concentration of  $\text{PbI}_2$  the lead was determined colorimetrically. For the determinations by Demassieux the solutions were simply shaken by hand several times a day and the temperature held constant to within  $0.5^\circ$ . Van Klooster and Balon, 1934 give data at  $25^\circ$  in excellent agreement with those of Burrage.

	K = KI		D = PbI <sub>2</sub> ·KI·2H <sub>2</sub> O				P = PbI <sub>2</sub>		
	Results at 0°		Results at 13°		Results at 25°		Results at 50°		
	(Van Klooster and Balon, 1934)		(Demassieux, 1923)		(Burrage, 1926)		(Demassieux, 1923)		
	Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
	KI	PbI <sub>2</sub>	KI	PbI <sub>2</sub>	KI	PbI <sub>2</sub>	KI	PbI <sub>2</sub>	Solid Phase
	0.0	0.043	0.0	0.05	0.083	0.0234	2.84	0.002	P
	0.166	0.003	2.21	0.001	0.166	0.0092	9.33	0.02	"
	2.21	0.001	4.18	0.001	0.332	0.0040	14.48	0.02	"
	4.55	0.002	9.09	0.002	0.664	0.0020	17.36	0.12	"
	7.26	0.012	--	--	0.830	0.0019	18.77	0.14	"
	10.35	0.030	--	--	1.661	0.0016	19.50	0.15	"
	--	--	--	--	3.320	0.0020	21.00	0.27	"
	--	--	--	--	8.307	0.0073	29.43	1.74	"
	--	--	--	--	13.61	0.0316	29.51	1.82	"
	--	--	--	--	14.90	0.0578	30.47	2.45	"
	--	--	--	--	19.45	0.253	30.57	2.52	"
	11.42	0.037	16.02	0.05	21.32	0.428 <sup>1</sup>	31.77	3.11	" , D
	15.26	0.044	17.26	0.02	26.82	0.553	32.12	3.10	D
	19.60	0.074	21.32	0.19	36.73	1.221	36.18	3.99	"
	25.56	0.146	34.45	0.68	43.80	2.249	38.44	4.23	"
	29.72	0.263	37.25	0.77	49.43	3.712	42.28	5.64	"
	35.20	0.445	45.17	1.47	51.61	4.654	51.93	9.59	"
	40.56	0.724	52.14	2.91	54.60	5.876	53.96	11.74	"
	46.20	1.30	--	--	--	--	--	--	"
	53.10	2.41	--	--	--	--	--	--	"
	55.10	3.10	56.55	4.54	56.59	7.421 <sup>2</sup>	56.41	14.14	" , K
	55.28	2.00	57.66	0.0	57.82	5.235	58.49	9.72	K
	55.65	1.23	--	--	59.13	5.49	60.28	5.55	"
	56.07	0.0	--	--	59.72	0.00	61.98	1.52	"
							62.02	1.48	"
							62.39	0.0	"

<sup>1</sup>Van Klooster and Balon, 1934 give 21.29, 0.422<sup>2</sup>Van Klooster and Balon, 1934 give 56.60, 7.30

(Cont.)

Compositions of the invariant solutions at different temperatures:

(Ditte, 1881; Schreinemakers, 1892)

Ordinary solubility method used for temperatures below boiling-point of the solution and sealed tube (with constriction in middle) method used for temperatures above boiling point.

t°	Gms. per 1000 gms. H <sub>2</sub> O		Solid Phase
	PbI <sub>2</sub>	KI	
5	--	163	Double Salt + PbI <sub>2</sub>
20	9	260	"
28	25	325	" I
39	45	449	"
67	255	751	"
80	731	1186	"
80	569.9	976.4	"
104.5	1411	1521	"
120	2151	1812	"
137	2874	2097	"
175	5603	2947	"
189	--	3339	"
9	96.6	1352	Double Salt + KI
13	114.3	1384	"
23	186.3	1510	"
50	526.7	1906	"
64	789.3	2161	"
83.5	1108.6	2434	"
92	1273	2566	"
137	2382	3278	"
165	4187	4227	"
218	10,303	--	"
241	12,803	7998	"
242	12,749	--	"
250	15,264	--	"
157	5,218	gms. PbI <sub>2</sub> ·2KI	PbI <sub>2</sub> ·2KI·2½H <sub>2</sub> O
172	6,489	"	"
186	7,903	"	"
194	9,266	"	"
201	11,320	"	"

THE SYSTEM POTASSIUM IODIDE - ANTIMONY IODIDE - WATER  
(Francois, 1935; Francois and Delwaulle, 1936)

The authors give a diagram but no numerical results. The following approximate values for the triple points were estimated from the diagram.

Results at 16°		Results at 32°		Results at 48°		Solid Phase at each temperature
Gms. per 100 gms. H <sub>2</sub> O		Gms. per 100 gms. H <sub>2</sub> O		Gms. per 100 gms. H <sub>2</sub> O		
KI	SbI <sub>3</sub>	KI	SbI <sub>3</sub>	KI	SbI <sub>3</sub>	
195	105	220	130	245	155	KI + 2KI·SbI <sub>3</sub> ·H <sub>2</sub> O
160	125	200	155	218	200	SbI <sub>3</sub> + "

# K KALIUM

## SOLUBILITY OF POTASSIUM IODIDE IN AQUEOUS METHANOL SOLUTIONS

Results at 10°, 20°  
(Zeitlin, 1926)

Solvent	Gm. mols. KI dissolved per liter at	
	10.2°	19.9°
H <sub>2</sub> O	5.863	6.110
Aq. 25.96 wt. % CH <sub>3</sub> OH	4.169	4.308
" 45.13 " "	3.089	3.25
" 74.88 " "	1.632	1.693
" 100.00 " "	0.7519	0.7350

I

Results at 25°  
(Herz and Anders, 1907; Akerlof and Turck, 1935)

Solvent		Sat. Solution	
$d_{25}^4$	Wt. percent CH <sub>3</sub> OH	$d_{25}^4$	Wt. percent KI
0.9971	0	1.7213	59.7
--	0	--	59.8
0.9791	10.6	1.634	56.3
--	20.0	--	52.9
0.9481	30.8	1.460	49.0
--	40.82	--	44.6
0.9180	47.1	1.325	41.9
--	60.21	--	35.6
0.8820	64.0	1.185	34.0
--	72.39	--	29.1
0.8489	78.1	1.066	26.3
--	80.03	--	24.6
--	89.79	--	19.0
0.8167	93.9	0.9700	19.3
--	94.76	--	16.5
0.7881	100	0.9018	14.7
--	100.00	--	13.8

## SOLUBILITY OF POTASSIUM IODIDE IN AQUEOUS ETHANOL SOLUTIONS

t°	Solvent	Solubility
(Gerardin, 1865)		
8	40 wt. % alc.	67.4 gm. KI per 100 gm. solvent
(Zeitlin, 1926)		
10.2	H <sub>2</sub> O	5.863 moles KI per liter
	25.07 wt. % alc.	3.970 " " "
	50.01 " "	2.419 " " "
	75.03 " "	1.120 " " "
13	40 wt. %	(Gerardin, 1865)
		69.2 gms KI per 100 gms solvent
(Greenish and Smith, 1901)		
15	87.3 wt. % alc.	8.83 gms. per 100 cc. sat. sol. (d.=0.8989)
(de Bruyn, 1892)		
17	94 wt. % alc.	3.99 gms. per 100 gms. solvent

(Cont.)

## SOLUBILITY OF POTASSIUM IODIDE IN AQUEOUS ETHANOL SOLUTIONS—Cont.

t°	Solvent	Solubility	
		(Gerardin, 1865)	
18	5.2 wt. % alc.	(d.=0.9904)	130.5 gms. per 100 gm. solvent
	9.8 "	(d.=0.9851)	119.4 "
	23.0 "	(d.=0.9726)	100.1 "
	29.0 "	(d.=0.9665)	89.9 "
	38.0 "	(d.=0.9528)	76.9 "
	45 "	(d.=0.9390)	66.4 "
	59 "	(d.=0.9088)	48.2 "
	86 "	(d.=0.8464)	11.4 "
	91 "	(d.=0.8322)	6.2 "
		(Zeitlin, 1926)	
19.9	H <sub>2</sub> O	6.110	moles KI per liter
	25.07 wt. % alc.	4.083	"
	50.01 "	2.612	"
	75.03 "	1.142	"
	97.30 "	0.0428	"
		(Armstrong, Eyre, Hussey, and Paddison, 1907)	
25	H <sub>2</sub> O	59.80 wt. % KI	(d. = 1.7268)
	1.14 wt. % alc.	59.41 "	(d. = 1.7154)
	2.25 "	58.95 "	(d. = 1.7042)
	4.41 "	58.08 "	(d. = 1.6833)
	12.14 "	54.93 "	(d. = 1.6063)
	18.73 "	52.08 "	(d. = 1.5420)
		(Gerardin, 1865)	
25	40 wt. % alc.	75.1	gms. KI per 100 gms. solvent
46	40 "	84.7	"
55	40 "	87.5	"
65	40 "	90.2	"

Additional data at higher temperatures are given by Gerardin, 1865.

THE SYSTEM POTASSIUM IODIDE - t-BUTANOL - WATER AT 30°  
(Ginnings and Robbins, 1930)

The points of the binodal curve of this system were determined by observing the appearance or disappearance of clouding in mixtures of weighed amounts of KI in one of the liquids upon addition of weighed amounts of the other. Tie lines, \*, connecting conjugate points were located by determination of KI in liquid layers in contact with each other and from these the plait point, PP, was found by plotting.

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
(CH <sub>3</sub> ) <sub>3</sub> COH	KI	(CH <sub>3</sub> ) <sub>3</sub> COH	KI	(CH <sub>3</sub> ) <sub>3</sub> COH	KI
3.3	54.7*	17.9	39.6	45.0	—*
4.0	52.9	19.9	38.6	46.5	23.4
5.2	49.8	22.1	37.0	49.2	22.1
7.2	47.3	24.2	35.6	50.0	—*
—	47.1*	26.0	34.6 PP	52.0	20.9
8.4	46.1	27.6	33.4	57.7	18.5
9.6	45.4*	30.6	31.9	60.3	16.9
11.3	44.0	35.1	29.5	62.8	15.5
13.9	42.3	39.2	27.0	63.0	—
15.1	41.1	42.0	25.5		
16.6	40.3	44.3	24.6		

(Cont.)



# K KALIUM

(cont'd:)

The composition of the plait point PP at 25° is 38.4 gms. KI + 22.2 gms. (CH<sub>3</sub>)<sub>2</sub>COH per 100 gms. sat. solution. (Ginnings, Herring and Webb, 1933.)

## DISTRIBUTION OF POTASSIUM IODIDE AT 17° BETWEEN WATER AND AMYL ALCOHOL (Wosnessensky, 1925)

Millimols KI per liter of		C <sub>1</sub>
H <sub>2</sub> O layer (C <sub>1</sub> )	Alcohol layer (C <sub>2</sub> )	C <sub>2</sub> <sup>0.53</sup>
105.5	0.27	207
228.5	1.20	208
336.75	2.25	218
I 485.5	5.00	217

## SOLUBILITY OF POTASSIUM IODIDE IN AQUEOUS SOLUTIONS OF ETHYLENE GLYCOL AT 30° (Ginnings and Robbins, 1930)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		d. of sat. sol.	Gms. per 100 gms. sat. sol.	
	CH <sub>2</sub> OH·CH <sub>2</sub> OH	KI		CH <sub>2</sub> OH·CH <sub>2</sub> OH	KI
1.7302	0.0	60.31	1.5395	32.27	45.38
1.6655	8.96	55.90	1.4687	51.57	38.27
1.6031	19.26	50.98	1.4272	66.41	33.59

## SOLUBILITY OF POTASSIUM IODIDE IN AQUEOUS GLYCEROL SOLUTIONS AT 20° (Holm, 1921, 1921a, 1922)

100 gms. glycerol of d. = 1.2326 (= 86.5%) dissolve 58.3 gms. KI  
 " " " d. = 1.2645 (= 98.5%) " 50.6 " "

## THE SYSTEM POTASSIUM IODIDE - ETHYL ETHER - WATER AT 20° (Dunningham, 1914)

Gms. per 100 Gms. Upper Layer			Gms. per 100 Gms. Lower Layer			Solid Phase
KI	H <sub>2</sub> O	(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	KI	H <sub>2</sub> O	(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	
--	--	---	59.2	40.8	---	KI
0	3.9	96.1	0	93.0	7.0	None
0.4	0.4	99.2	55.6	40.7	3.7	KI
0.1	2.2	97.7	25	72.1	2.9	None

(Cont.)

## DISTRIBUTION OF POTASSIUM IODIDE BETWEEN WATER AND:

NITROBENZENE AT 18°  
(Dawson, 1908)PHENOL AT ROOM TEMPERATURE  
(Riesenfeld, 1902)

Mols. KI per Liter		Dist. Ratio	Gms. KI per 100 cc.		Dist. Ratio
C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub> Layer	H <sub>2</sub> O Layer		C <sub>6</sub> H <sub>5</sub> OH Layer	Aq. Layer	
0.00114	6.05	5300	0.052	0.725	13.2
0.00108	6.05	5600	0.197	2.42	12.3
			2.09	30.7	14.7

THE SYSTEM POTASSIUM IODIDE - URETHAN - WATER AT 25°  
(Palitzsch, 1928, 1929)

I

Gm. Mols. per 1000 gms. H <sub>2</sub> O		Solid Phase
NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>	KI	
0.0	9.0355	KI
1.1225	8.979	"
20.79	8.73	"
46.72	9.66	" + NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>
53.09	0.0	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>

THE SYSTEM POTASSIUM IODIDE - CAFFEINE - WATER  
(Chambon and Duron, 1937)

Results at 2°		Results at 35°		Results at 90°		Solid Phase at each temperature
Gms. per 100 gms. H <sub>2</sub> O		Gms. per 100 gms. H <sub>2</sub> O		Gms. per 100 gms. H <sub>2</sub> O		
Caffeine (anhyd.)	KI	Caffeine (anhyd.)	KI	Caffeine (anhyd.)	KI	
0.735	0.0	3.52	0.0	83.5	0.0	Caffeine
--	--	--	--	70.2	5.0	"
--	--	--	--	41.0	167.0	"
18.2	133.1	25.0	156.0	43.0	199.0	" + KI
0.0	130.1	0.0	156.0	0.0	196.6	KI

100 gms. sat. solution in hydrated lanolin (containing 30% emulsified water) contain 42.5 gms. KI at 45° (Klose, 1907) KI is insoluble in anhydrous lanolin.

## K KALIUM

## SOLUBILITY OF POTASSIUM IODIDE IN VARIOUS ALCOHOLS

Alcohol	t°	Solubility (gms. per 100 gms. alc.)	Author
I Methanol	0	14.9 (d. = 0.8964)	Walden, 1906
	11.4	13.5	Timofeiew, 1894
	12.2	14.6	"
	13.5	16	"
	15	14.50	Tyrer, 1910
	18	16.4 (d. = 0.900)	Pavlopoulos and Strehlow, 1954
	20.5	16.5	de Bruyn, 1892
	25	17.6	Walden, 1906
	25	18.04	Turner and Bissett, 1913
	25	17.04 (d. = 0.8982)	Larson and Hunt, 1939
	25	19	Semenchenko and Shakparonov, 1948
	25	17.0 (d. = 0.898)	Pavlopoulos and Strehlow, 1954
	30	16.20	Tyrer, 1910
	50	18.9	"
	80	22.5	"
	100	25	"
	120	27.2	"
	140	29.2	"
	160	30.6	"
	180	30.7	"
	200	29.1	"
	220	27.5	"
	240	24.8	"
	245	22.6	"
	247	21	"
	250	13.8	"
	252.5*	7.6	"
Ethanol	0	1.50 (d. = 0.8085)	Walden, 1906
	13.6	1.63	Timofeiew, 1894
	20.5	1.75	de Bruyn, 1892
	25	1.96 (d. = 0.7908)	Walden, 1906
	25	1.585 g. per 100 cc. sat. solution	Laurie, 1912
	25	2.16	Turner and Bissett, 1913
	25	1.88 (d. = 0.7977)	Larson and Hunt, 1939
	25	1.8	Semenchenko and Shakparonov, 1948
1-propanol	12.2	0.731	Timofeiew, 1894
	15-20	0.46	Rohland, 1898
	25	0.43	Turner and Bissett, 1913
	25	0.444 (d. = 0.8035)	Larson and Hunt, 1939
1-butanol	25	0.201 (d. = 0.8071)	"
2-propanol	25	0.177 (d. = 0.7821)	"
2-methyl- 1-propanol	25	0.0955 (d. = 0.7986)	"
1-pentanol	25	0.0894 (d. = 0.8112)	"
	25	0.098	Turner and Bissett, 1913
2-butanol	25	0.0582 (d. = 0.8026)	Larson and Hunt, 1939

\*Crit. temp.

SOLUBILITY OF POTASSIUM IODIDE IN VAPOR OF METHYL ALCOHOL ABOVE  
THE CRITICAL POINT  
(Tyrer, 1910a)

Data for this system are also given by Centnerszwer (1910). This author gives the crit. temp. as 266° and the corresponding concentration as 8.64 gms. KI per 100 gms. of the sat. solution.

Solvent Gms. CH <sub>3</sub> OH per 1 cc. Vapor	Gms. KI Dissolved per 100 Gms. Solvent at:				
	252°	270°	280°	290°	300°
0.1	0.3	—	—	—	—
0.2	1.0	1.0	1.0	1.0	1.0
0.3	3.7	3.5	3.4	3.4	3.3
0.36	7.6	7.4	7.3	7.2	7.0
0.4	11.8	11.5	11.3	11.0	—
0.45	18.1	—	—	—	—

SOLUBILITY OF POTASSIUM IODIDE IN MIXTURES OF ALCOHOLS AT 25°  
(Herz and Kuhn, 1908)

In Methyl + Ethyl Alcohol			In Methyl + Propyl Alcohol		
Percent CH <sub>3</sub> OH in Solvent	$d_{25}^{25}$ of Sat. Sol.	Gms. KI per 100 cc. Sat. Sol.	Percent C <sub>3</sub> H <sub>7</sub> OH in Solvent	$d_{25}^{25}$ of Sat. Sol.	Gms. KI per 100 cc. Sat. Sol.
0	0.8015	1.55	0	0.9018	13.16
4.37	0.8041	1.91	11.11	0.8823	10.96
10.4	0.8071	2.25	23.8	0.8629	8.54
41.02	0.8295	4.94	65.2	0.8187	2.62
80.69	0.8794	10.13	91.8	0.8045	0.60
84.77	0.8795	10.72	96.6	0.8041	0.58
91.25	0.8908	11.84	100	0.8041	0.43
100	0.9018	13.16			

In Ethyl + Propyl Alcohol		
Percent C <sub>3</sub> H <sub>7</sub> OH in Solvent	$d_{25}^{25}$ of Sat. Sol.	Gms. KI per 100 cc. Sat. Sol.
0	0.8015	1.55
8.1	0.7983	1.46
17.85	0.7991	1.37
56.6	0.7988	0.75
88.6	0.8022	0.52
91.2	0.8027	0.49
95.2	0.8029	0.44
100	0.8041	0.43

## K KALIUM

## SOLUBILITY OF POTASSIUM IODIDE IN VARIOUS ORGANIC SOLVENTS

Solvent	t°	Solubility (gms. KI per 100 gms. sat. sol.)	Author
I Acetone	-78.5	4.15	Livingston and Halverson, 1946
	-64.4	6.84	"
	-58.5	9.0	"
	-57.6	9.79	"
	-57.0	9.79	"
	-56.4	9.2	"
	-44.8	6.08	"
	-26.3	3.87	"
	-2.5	2.99	von Laszcynski, 1894
	0	2.105 (d. = 0.8227)	Walden, 1906
	4.62	2.02	Livingston and Halverson, 1946
	18	1.00 (d. = 0.799)	Lannung, 1932
	22	2.32	von Laszcynski, 1894
	25	2.84	Krug and McElroy, 1892
	25	1.302 (d. = 0.7968)	Walden, 1906
	25.00	1.330	Livingston and Halverson, 1946
	25	1.1	Semenchenko and Shakparonov, 1948
	26.54	1.30	Livingston and Halverson, 1946
	37	0.795 (d. = 0.77)	Lannung, 1932
	48.75	0.89	Livingston and Halverson, 1946
	54.50	0.84	Livingston and Halverson, 1946
Acetonitrile	56	1.20	von Laszcynski, 1894
	0	2.259 (d. = 0.8198)	Walden, 1906
	18	2.05 (d. = 0.798)	Pavlopoulos and Strehlow, 1954
	24	2.003 (d. = 0.7938)	Walden, 1906
	25	5	Pleskov, 1948
	25	2	Semenchenko and Shakparonov, 1948
	25	2.07 (d. = 0.795)	Pavlopoulos and Strehlow, 1954
Anisic Aldehyde	0	1.355 (d. = 1.1223)	Walden, 1906
	25	0.644 (d. = 1.1180)	"
Benzaldehyde	25	0.328 (d. = 1.0446)	"
	25	0.31	Semenchenko and Shakparonov, 1948
Benzonitrile	25	0.0506 (d. = 1.0076)	Walden, 1906
	25	0.48	Semenchenko and Shakparonov, 1948
Ethyl Acetate	25	0.0013 gms. KI per 100 cc. sat. sol.	Walden, 1906
Ethyl Cyanacetate	25	0.930 (d. = 1.0628)	"
Ethyl Urethan	60	5.81 gms. KI per 100 cc. sat. sol.	Stuckgold, 1917
Ethylene-diamine	25	42.7	Isbin and Kobe, 1945
Ethylene Glycol	25	33.3	"
Formic Acid	18	25.9 (d. = 1.479)	Pavlopoulos and Strehlow, 1954
	25	26.1 (d. = 1.476)	"
Formic Acid, 95%	18.5	27.6	Aschen, 1913
Furfural	0	15.10 gms. per 100 cc. sat. sol.	Walden, 1906
	25	4.94 (d. = 1.2014)	"
	25	4.7	Semenchenko and Shakparonov, 1948
Glycerol	15.5	29	Ossendowski, 1907
Glycol	0	31.03 (d. = 1.3954)	Walden, 1906
	25	33.01 (d. = 1.3888)	"
	25	43	Semenchenko and Shakparonov, 1948
Methyl Cyanacetate	0	2.827 (d. = 1.1521)	Walden, 1906
	25	2.165 (d. = 1.1358)	"
Monoethanolamine	25	29.7	Isbin and Kobe, 1945
Nitrobenzene	25	0.0019 gms. per 100 cc. sat. sol.	Walden, 1906
Nitromethane	0	0.315 (d. = 1.1627)	"
	25	0.307 (d. = 1.1367)	"
	25	0.27	Semenchenko and Shakparonov, 1948
Propionitrile	0	0.0429 (d. = 0.8005)	Walden, 1906
	25	0.0404 (d. = 0.7821)	"
Pyridine	10	0.26	von Laszcynski, 1894
	119	0.11	"
Salicylic Aldehyde	0	1.093 (d. = 1.1501)	Walden, 1906
	0	0.483 (d. = 1.1373)	"

THE SYSTEM POTASSIUM IODIDE - ACETAMIDE  
(Menschutkin, 1908)

(Determinations by Synthetic Method)

t°	Gms. KI per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. KI per 100 Gms. Sat. Sol.	Solid Phase
82 m. pt.	0	CH <sub>3</sub> CONH <sub>2</sub>	70	28.75	KI
78	6.5	"	85	29.1	"
74	12.8	"	100	29.45	"
70	17.8	"	130	30.15	"
66	21.5	"	145	30.5	"
58	26.2	"	160	30.8	"
53 Eutec.	28.4	" + KI	175	31.1	"

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DISTRIBUTION OF POTASSIUM IODIDE BETWEEN ETHYLENE GLYCOL  
AND ETHYL ACETATE AT 30°  
(Dawson and Griffith, 1951)

Moles KI per liter glycol	=	0.0694	0.2770
Moles KI per liter ethyl acetate	=	0.000358	0.001590
"k"	=	194	174

Values for "k" change continuously within this range of concentrations. Data are also given for mixtures of KI + NH<sub>4</sub>I.

THE SYSTEM POTASSIUM IODIDE - SODIUM IODIDE - METHANOL  
(Sarkisov, Sakarova, and Antropov, 1949)

The solid phase was not solvated.

t°	Saturated Solution Wt. %		Wt. % KI in Solid Phase	t°	Saturated Solution Wt. %		Wt. % KI in Solid Phase
	NaI	KI			NaI	KI	
10	0.0	12.0	100.0	30	0.0	14.0	100.0
	17.7	7.2	58.05		25.0	8.6	43.2
	24.5	8.0	18.34		33.0	9.0	20.1
	28.2	5.7	0.0		34.3	9.7	2.2
	40.0	0.0	0.0		37.7	8.3	0.0
20				40	44.8	0.0	0.0
	0.0	13.1	100.0		0.0	15.3	100.0
	26.4	7.1	46.0		25.5	8.1	54.3
	33.4	7.4	20.7		32.9	9.2	26.3
	38.2	7.0	7.3		35.7	10.4	0.0
	41.9	0.0	0.0		37.8	9.1	0.0
					46.6	0.0	0.0

## K KALIUM

THE SYSTEM POTASSIUM IODIDE - SODIUM IODIDE - ETHANOL AT 25°  
(Hawkins and Partington, 1928, 1930)

The density of the absolute  $C_2H_5OH$  was  $d_{\frac{25}{4}} = 0.7851$ . The sat. solutions were prepared in an atmosphere of hydrogen.

d. of sat. sol.	Gms. per 100 gms. $C_2H_5OH$		d. of sat. sol.	Gms. per 100 gms. $C_2H_5OH$	
	NaI	KI		NaI	KI
0.7970	0.0	1.824	0.8921	15.84	0.6752
0.8215	4.248	1.268	0.9614	27.68	0.442
0.8378	7.091	0.9988	1.0500	42.8	0.19
0.8502	9.065	0.8878			

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THE SYSTEM POTASSIUM IODIDE - SODIUM IODIDE - ALLYL ALCOHOL AT 25°  
(Partington and Winterton, 1934)

The density of the Allyl Alcohol,  $CH_2CHCH_2OH$ , was  $d_{\frac{25}{4}} = 0.84572$ .

d. of sat. sol.	Gms. per 100 gms. $C_6H_5CH_2OH$		d. of sat. sol.	Gms. per 100 gms. $C_6H_5CH_2OH$	
	NaI	KI		NaI	KI
0.85080	0.0	1.133	0.90753	8.164	0.745
0.86134	1.157	1.060	0.93501	12.501	0.565
0.87286	2.138	1.000	0.96453	17.520	0.390
0.88750	5.300	0.837	0.98624	23.252	0.200
0.88890	5.321	0.820	1.02685	28.48	0.0
0.90044	7.110	0.781			

THE SYSTEM POTASSIUM IODIDE - SODIUM IODIDE - BENZYL ALCOHOL AT 25°  
(Partington and Winterton, 1934)

The density of the Benzyl alcohol,  $C_6H_5CH_2OH$ , was 1.0453.

d. of sat. sol.	Gms. per 100 gms. $C_6H_5CH_2OH$		d. of sat. sol.	Gms. per 100 gms. $C_6H_5CH_2OH$	
	NaI	KI		NaI	KI
1.04485	0.0	0.320	1.10612	5.613	0.271
1.05650	1.324	0.305	1.11923	7.267	0.263
1.06203	2.235	0.301	1.14585	11.010	0.197
1.10043	4.700	0.290	1.14633	14.400	0.000

THE SYSTEM POTASSIUM IODIDE - SODIUM IODIDE - FURFURAL  
(Sarkisov, Sakarova, and Antropov, 1947)

The solid phase is a mixture of KI + NaI in each case.

Results at 20°		Results at 30°		Results at 40°	
Gms. NaI per 100 gms. Sat. Sol.	Gms. KI per 100 gms. Sat. Sol.	Gms. NaI per 100 gms. Sat. Sol.	Gms. KI per 100 gms. Sat. Sol.	Gms. NaI per 100 gms. Sat. Sol.	Gms. KI per 100 gms. Sat. Sol.
0.0	6.0	0.0	4.5	0.0	3.1
6.5	3.4	1.9	5.3	4.8	1.8
7.4	2.9	5.0	4.6	5.0	1.8
11.2	2.8	9.1	2.9	5.3	1.7
12.2	2.7	16.2	1.6	13.0	1.6
20.5	0.0	24.0	0.0	27.2	0.0

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THE SYSTEM POTASSIUM IODIDE - MAGNESIUM IODIDE - ETHANOL AT 25°  
(Hawkins and Partington, 1928, 1930)

The saturated solutions were prepared in an atmosphere of hydrogen.

d. of sat. sol.	Gms. per 100 gms. C <sub>2</sub> H <sub>5</sub> OH		d. of sat. sol.	Gms. per 100 gms. C <sub>2</sub> H <sub>5</sub> OH	
	MgI <sub>2</sub>	KI		MgI <sub>2</sub>	KI
0.8161	2.777	1.502	0.8634	8.809	1.393
0.8202	3.20	1.513	0.9037	14.41	1.195
0.8317	5.33	1.578	0.9182	17.82	1.116
0.8420	6.017	1.560	0.9314	18.04	0.00

For data in the system KI + HgI<sub>2</sub> + ethyl ether at 20° see Dunningham, 1914a.

SOLUBILITY OF POTASSIUM IODIDE AT 20° IN SEVERAL SOLVENTS CONTAINING  
DISSOLVED IODINE  
(Olivari, 1908)

Solvent	Gm. Mols. KI per Liter in Solvent Containing:		
	0.5 Gm. Mols. I <sub>2</sub> per Liter	1.5 Gm. Mols. I <sub>2</sub> per Liter	2.5 Gm. Mols. I <sub>2</sub> per Liter
Acetic Acid	0.511	1.460	2.080
Ethyl Acetate	0.490	1.400	1.980
Ethyl Alcohol	0.520	1.220	1.1730
Nitrobenzene	0.414	0.960	1.380
Ethylbromide	0.140	0.350	--



# K KALIUM

## SOLUBILITY OF POTASSIUM IODIDE IN INORGANIC SOLVENTS

Solvent	t°	Solubility	Author
Ammonia (liq.)	0	184.2 gms. KI per 100 gms. NH <sub>3</sub>	(1)
	25	182.0 "	(2)
Sulfur dioxide (liq.)	0	41.3 gms. KI per 100 gms. SO <sub>2</sub>	(3)
	25	0.75 "	(4)
Data for equilibrium in the System KI + SO <sub>2</sub> are given by Walden and Centnerszwer, 1903. Results for the vapor pressure, temperature relations of the system are given by Foote and Fleischer, 1931.			
Phosphorus Oxychloride	20	1.71 gms KI per liter	(8)
I Hydrazine	18	0.250 moles KI per 100 moles sat. sol.	(5)
	Room	175 gms. KI per 100 cc. N <sub>2</sub> H <sub>4</sub>	(6)
Hydroxylamine	17.5	110 gms. KI per 100 gms. NH <sub>2</sub> OH	(7)
(1) Linhard and Stephen, 1933,	1934	(5) Semenchenko and Shakparonov,	1948
(2) Hunt,	1932	(6) Welsh and Broderson,	1915
(3) Jander and Ruppolt,	1937	(7) de Bruyn,	1892
(4) Shatenstein and Viktorov,	1937	(8) Gutmann,	1952

Melting points are given for:

KI + NaI	(Platonov, 1946; Nyankovskaya, 1956)
KI + K <sub>2</sub> SO <sub>4</sub>	(Ruff and Plato, 1903; Gromakov, 1951)
KI + AgI	(Sandoninni, 1912a)
KI + NaCl	(Ruff and Plato, 1903; Waxberg, 1930)
KI + PbI <sub>2</sub>	(van Klooster and Stearns, 1933)
KI + SO <sub>2</sub>	(Walden and Centnerszwer, 1903)
KI + MgI <sub>2</sub>	(Klemm, Beyersdorfer, and Oryschkewitsch, 1948)
KI + KIO <sub>3</sub>	(Bousquet and Dode, 1950)
KI + AgNO <sub>3</sub> = KNO <sub>3</sub> + AgI	(Dombrovskaya and Koloskova, 1953)
KI + NaF = KF + NaI	(Platonov, 1946; Dombrovskaya, 1950)
2KI + Na <sub>2</sub> SO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + 2NaI	(Nyankovskaya, 1956)
KI + ZnSO <sub>4</sub>	(Luzhnaya and Vereshchetina, 1954)

The reactions between the solids below their melting points were studied by Link and Wood, 1940 for the following pairs: KI + RbF, KI + CsF.

## POTASSIUM IODOMERCURATE (Thoulet Solution)

A sat. solution at 22.9°, prepared by adding KI and HgI<sub>2</sub> in excess to water, contained 8.66% K, 22.49% Hg, 52.58 (57.7)% I and 10.97 (11.15)% H<sub>2</sub>O, corresponding to 0.22 mol. alkali, 0.11 mol. Hg and 0.45 mol. I.  
(Duboin, 1905)

POTASSIUM IODATE  $\text{KIO}_3$ 

10

## SOLUBILITY OF POTASSIUM IODATE IN WATER

The results of Kremers, 1856(a); Meerburg, 1905; Flottman, 1928; Hill and Brown, 1931; Ricci, 1931; and Smith, 1947; above  $100^\circ$ , Benrath, Gjedebø, Schiffers and Wunderlich, 1937; were plotted and the following values taken from the average curve.

t°	d. of sat. sol.	Gms. $\text{KIO}_3$ per 100 gms. sat. sol.	t°	d. of sat. sol.	Gms. $\text{KIO}_3$ per 100 gms. sat. sol.	t°	d. of sat. sol.	Gms. $\text{KIO}_3$ per 100 gms. sat. sol.
0	--	4.4	30	--	9.3	125	--	27.5
5	1.043	5.15	40	--	11.2	150	--	32.2
10	--	5.9	50	1.110	13.3	175	--	37.0
15	1.0584	6.68	60	--	15.5	200	--	41.5
20	1.0643	7.48	80	--	19.9	250	--	49.8
25	1.0708	8.40	100	--	24.4	300	--	58.0

THE SYSTEM POTASSIUM IODATE - IODIC ACID - WATER  
(Meerburg, 1905 ( $30^\circ$ ); Smith, 1947 ( $0, 25, 50^\circ$ ))

The results of Smith appear to confirm the work of Meerburg, but Ricci and Amron (1951) have recalculated Smith's data and find that the compound  $\text{KIO}_3 \cdot 2\text{HIO}_3$  may actually be  $\text{KIO}_3 \cdot \text{I}_2\text{O}_5$ .

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{HIO}_3$	$\text{KIO}_3$	Solid Phase	$\text{HIO}_3$	$\text{KIO}_3$	Solid Phase
Results at $0^\circ$			Results at $30^\circ$		
0.0	4.51	$\text{KIO}_3$	0	9.51	$\text{KIO}_3$
0.35	4.47	$\text{KIO}_3 + 1:1$	0.65	9.49	" + $\text{KIO}_3 \cdot \text{HIO}_3$
1.30	1.68	1:1	0.65	8.90	$\text{KIO}_3 \cdot \text{HIO}_3$
5.76	0.13	1:1 + 1:2	0.67	6.6	"
73.69	0.39	1:2 + $\text{HIO}_3$	1.14	4.57	"
73.56	0.0	$\text{HIO}_3$	1.69	3.63	"
			2.02	3.10	"
			3.34	2.10	"
			5.00	1.32	"
0.0	8.39	$\text{KIO}_3$	7.09	1.00	"
0.61	8.46	$\text{KIO}_3 + 1:1$	8.04	0.85	" + $\text{KIO}_3 \cdot 2\text{HIO}_3$
0.77	4.90	1:1	3.47	3.59	$\text{KIO}_3 \cdot 2\text{HIO}_3$ (unstable)
7.68	0.61	1:1 + 1:2	4.80	2.90	"
75.51	0.42	1:2 + $\text{HIO}_3$	6.45	1.35	"
75.56	0.0	$\text{HIO}_3$	9.35	0.64	$\text{KIO}_3 \cdot 2\text{HIO}_3$
			12.04	0.44	"
			17.50	0.30	"
			31.20	0.52	"
0.0	13.21	$\text{KIO}_3$	53.64	0.68	"
1.34	13.58	$\text{KIO}_3 + 1:1$	62.52	0.72	"
3.74	4.64	1:1	76.40	0.80	" + $\text{HIO}_3$
11.02	1.85	1:1 + 1:2	76.7	0	$\text{HIO}_3$
78.72	1.17	1:2 + $\text{HIO}_3$			
78.78	0.0	$\text{HIO}_3$			

1:1 =  $\text{KIO}_3 \cdot \text{HIO}_3$ 1:2 =  $\text{KIO}_3 \cdot 2\text{HIO}_3$  ( $\text{I}_2\text{O}_5$ ?)

# K KALIUM

Other data on the solubility of potassium acid iodates:

Compound	Formula	t°	Gms. Compound per 100 gms. H <sub>2</sub> O	Authority
Potassium Hydrogen Iodate	$\text{KH}(\text{IO}_3)_2$	15	1.3	(Serullas)
" " "	"	17	5.4	"
" Dihydrogen "	$\text{KH}_2(\text{IO}_3)_2$	15	4.0	(Meineke, 1891)

## SOLUBILITY OF POTASSIUM IODATE IN AQUEOUS SOLUTIONS OF POTASSIUM HYDROXIDE AT 20° (Bronsted, 1920a)

Gms. mols. per liter		Gms. mols. per liter		Gms. mols. per liter		Gms. mols. per liter	
KOH	KIO <sub>3</sub>	KOH	KIO <sub>3</sub>	KOH	KIO <sub>3</sub>	KOH	KIO <sub>3</sub>
4.71	0.0390	7.95	0.0179	11.10	0.0128	14.02	0.0154
5.06	0.0362	9.41	0.0144	12.19	0.0131	14.85	0.0194
6.35	0.0256	10.95	0.0130	12.92	0.0135		

## THE SYSTEM POTASSIUM IODATE - POTASSIUM NITRATE - WATER (Hill and Brown, 1931)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	KNO <sub>3</sub>	KIO <sub>3</sub>	
Results at 5°			
1.043	0.00	5.25	KIO <sub>3</sub>
1.060	5.36	3.29	"
1.090	10.53	2.93	"
1.110	13.53	2.89	"
1.120	14.14	2.87	" + KNO <sub>3</sub>
1.100	14.26	1.08	KNO <sub>3</sub>
1.097	14.43	0.0	"
Results at 25°			
1.072	0.0	8.46	KIO <sub>3</sub>
1.084	5.48	5.92	"
1.110	8.51	5.25	"
1.156	16.77	4.57	"
1.160	18.19	4.48	"
1.232	26.84	4.24	KIO <sub>3</sub> + KNO <sub>3</sub>
1.215	27.25	2.65	KNO <sub>3</sub>
1.210	27.30	2.06	"
1.192	27.79	0.00	"
Results at 50.4°			
1.110	0.0	13.35	KNO <sub>3</sub>
1.167	17.42	7.32	"
1.259	31.43	5.79	"
1.33	39.17	5.17	"
1.35	42.42	4.91	"
1.37	44.23	4.75	" + KNO <sub>3</sub>
1.34	45.44	2.44	KNO <sub>3</sub>
1.326	46.57	0.0	"

THE SYSTEM POTASSIUM IODATE - POTASSIUM SULFATE - WATER  
(Hill and Ricci, 1931)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$K_2SO_4$	$KIO_3$			$K_2SO_4$	$KIO_3$	
Results at 5°				Results at 25°--Cont.			
1.043	0.0	5.16	$KIO_3$	1.103	10.10	2.44	$K_2SO_4$
1.060	4.07	3.14	"	1.083	10.76	0.0	"
1.081	7.08	2.57	" + $K_2SO_4$	Results at 50°			
1.077	7.25	1.80	$K_2SO_4$				
1.062	7.64	0.0	"				
Results at 25°				--	0.0	13.21	$KIO_3$
				--	7.90	8.68	"
1.071	0.0	8.45	$KIO_3$	--	11.43	7.39	"
1.085	4.75	5.66	"	--	12.0	7.06	" + $K_2SO_4$
1.103	7.74	4.72	"	--	13.0	3.78	$K_2SO_4$
1.117	9.65	4.30	" + $K_2SO_4$	--	14.18	0.0	"

THE SYSTEM POTASSIUM IODATE - SODIUM IODATE - WATER  
(Hill and Ricci, 1931)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	NaIO <sub>3</sub>	KIO <sub>3</sub>			NaIO <sub>3</sub>	KIO <sub>3</sub>	
Results at 5°				Results at 25°--Cont.			
1.043	0.00	5.16	KIO <sub>3</sub>	1.103	7.79	3.79	NaIO <sub>3</sub> ·H <sub>2</sub> O
1.051	1.41	4.71	"	1.074	8.57	0.0	"
1.060	2.17	4.72	" + NaIO <sub>3</sub> ·5H <sub>2</sub> O	Results at 50°			
1.046	2.48	3.19	NaIO <sub>3</sub> ·5H <sub>2</sub> O	--	0.0	13.21	KIO <sub>3</sub>
1.028	3.28	0.0	"	--	3.22	11.92	"
Results at 25°				--	7.70	11.14	"
				--	10.92	10.61	" + NaIO <sub>3</sub> ·H <sub>2</sub> O
1.071	0.0	8.45	KIO <sub>3</sub>	--	11.41	7.93	NaIO <sub>3</sub> ·H <sub>2</sub> O
1.098	4.26	7.09	"	--	12.55	4.24	"
1.126	7.13	6.73	" + NaIO <sub>3</sub> ·H <sub>2</sub> O	--	13.49	0.0	"

SOLUBILITY OF POTASSIUM IODATE IN DIOXANE - WATER MIXTURES AT 25°  
(Ricci and Nesse, 1942)

Wt. % Dioxane in Solvent	Gms. $KIO_3$ per 100 gms. Sat. Sol.	Moles $KIO_3$ per liter Sat. Sol.	Wt. % Dioxane in Solvent	Gms. $KIO_3$ per 100 gms. Sat. Sol.	Moles $KIO_3$ per liter Sat. Sol.
0	8.472	0.4238	60	0.1350	0.00653
10	5.300	.2598	70	.0384	.00186
20	3.172	.1531	80	.0060	.00029
30	1.815	.08770	90	.0012	.000059
40	0.8855	.04273	100	.0000	.00000
50	.4712	.02277			

Less than 0.005 gms. of  $KIO_3$  dissolve in 100 gms. of ethylenediamine at 25°. (Isbin and Kobe, 1945)

## K KALIUM

SOLUBILITY OF POTASSIUM IODATE IN LIQUID AMMONIA SOLUTIONS AT 25°  
(Anhorn and Hunt, 1941)

	Moles Added Salt per		Moles $\text{KIO}_3 \times 10^5$ per 1000 gms. $\text{NH}_3$	Moles Added Salt per		Moles $\text{KIO}_3 \times 10^5$ per 1000 gms. $\text{NH}_3$
	Liter of Sat. Sol.	1000 gms. $\text{NH}_3$		Liter of Sat. Sol.	1000 gms. $\text{NH}_3$	
	0.0	0.0	3.044		$\text{NH}_4\text{Cl}$ Added	
		KCl Added		0.0009398	0.001558	5.7782
				.002220	.003670	7.1681
	0.001907	0.003162	0.7439	.004161	.006898	8.7650
	.002658	.004407	.8428	.007543	.01251	10.662
IO	.007624 <sup>s</sup>	.01264	1.4238	.01035	.01715	11.820
				.01822	.03020	14.025
		KBr Added		.02243	.03718	14.920
				.03251	.05389	16.580
	0.002492	0.004131	0.7392	.04568	.07572	18.045
	.004468	.007407	.8180	.07695	.1275	20.688
	.005864	.009721	.8595	.1060	.1758	22.189
	.007025	.01165	.8876	.1463	.2424	23.975
	.01170	.01940	.9062	.1635	.2710	24.590
	.02591	.04295	1.0684	.2004	.3320	25.745
	.04867	.08070	1.1350	.2657	.4402	27.480
	.07078	.1173	1.1678	.3800	.6299	30.018
	.1195	.1981	1.2090	.4330	.7180	30.980
	.1549	.2568	1.2330	.5728	.9528	33.160
		KI Added			NaCl Added	
	0.001709	0.002834	0.2438	0.0003685	0.0006109	4.495
	.004258	.007058	.4893	.001655	.002744	5.489
	.005154	.008534	.5165	.003543	.005874	5.831
	.01098	.01819	.5682	.007738	.01283	6.188
	.01801	.02985	.6188	.03063	.05078	7.098
	.03735	.06191	.7211	.04352	.07214	7.377
	.03774	.06254	.7370	.09376	.1554	8.024
	.05310	.08801	.7849	.1154	.1913	8.233
	.08446	.1400	.8868	.1554	.2575	8.611
	.1031	.1709	.9362	.2101	.3482	8.913
	.1234	.2046	.9886	.2746	.4551	9.145
	.2224	.3693	1.1530			
	.3018	.5021	1.2140			

<sup>s</sup> = Saturated with KCl100 cc. anhydrous Hydrazine dissolve 1 gm.  $\text{KIO}_3$  at room temp.  
(Welsh and Broderson, 1915)

**POTASSIUM PERIODATE  $\text{KIO}_4$**   
(META)

10

SOLUBILITY OF POTASSIUM PERIODATE IN WATER  
(Hill, 1928)

t°	Gms. $\text{KIO}_4$ per 100 gms. sat. sol.	t°	Gms. $\text{KIO}_4$ per 100 gms. $\text{H}_2\text{O}$
0.2	0.169	25	0.510
5.4	0.21	50	1.44
15.00	0.334	75	3.59
18.0	0.373*	97	6.83

\*Pederson, 1941,

SOLUBILITY OF POTASSIUM PERIODATE IN  
AQUEOUS SOLUTIONS OF PERIODIC ACID AT 25°  
(Hill, 1928)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{HIO}_4$	$\text{KIO}_4$	
1.000	0.0	0.51	$\text{KIO}_4$
1.014	1.157	0.355	"
1.023	2.83	0.261	"

THE SYSTEM POTASSIUM PERIODATE - POTASSIUM HYDROXIDE - WATER AT 25°  
(Hill, 1928)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	KOH	$\text{KIO}_4$			KOH	$\text{KIO}_4$	
1.000	0.0	0.51	$\text{KIO}_4$	1.326	8.0	20.8	$\text{K}_4\text{I}_2\text{O}_9 \cdot 9\text{H}_2\text{O}$
1.044	1.01	4.12	"	1.377	9.7	24.1	"
1.087	1.99	8.03	"	1.484	11.9	28.9	"
1.116	2.55	10.32	" + $\text{K}_4\text{I}_2\text{O}_9 \cdot \text{H}_2\text{O}$	1.64	14.5	35.2	"
1.165	4.55	13.15	$\text{K}_4\text{I}_2\text{O}_9 \cdot 9\text{H}_2\text{O}$	--	16.4	39.0	"
1.221	6.03	16.12	"	--	19.1	44.6	"

SOLUBILITY OF POTASSIUM PERIODATE IN UREA AND DIOXANE SOLUTIONS  
(Pederson, 1941)

17.85°

18.00°

Moles Urea per 1000 ml. Solvent	Moles $\text{KIO}_4$ per 1000 ml. Sat. Sol.	Moles Urea per 1000 ml. Solvent	Moles $\text{KIO}_4$ per 1000 ml. Sat. Sol.
0.0	0.01605	0.0	0.01618
0.250	0.01642	0.200	0.01593
0.500	0.01679	0.400	0.01573
0.750	0.01715	0.600	0.01555
1.000	0.01751	0.800	0.01540
		1.000	0.01525

# K KALIUM

## 10 POTASSIUM DI-meso-PERIODATE $K_4I_2O_9 \cdot 9H_2O$

### SOLUBILITY OF POTASSIUM DI-MESO-PERIODATE IN WATER (Hill, 1928)

t°	d. of sat. sol.	Gms. $K_4I_2O_9$ per 100 gms. sat. sol.	Solid Phase
0.13	1.032	3.5	$K_4I_2O_9 \cdot 9H_2O$
15.0	1.073	7.7	"
25.0	1.118	12.3	"
37.5	1.216	22.0	"
50	1.395	35.0	"
65	--	50.1	"
78	--	61.7	" + $K_4I_2O_9$
98.6	--	61.7	$K_4I_2O_9$

## MnO POTASSIUM PERMANGANATE $KMnO_4$

### SOLUBILITY IN WATER

Averages of the closely agreeing results of Baxter, Boylston and Hubbard (1906), Voerman (1905, 1906), Flottmann (1928), and Noonan, 1948.

Solid Phase Ice		Solid Phase $KMnO_4$			
t°	Gms. $KMnO_4$ per 100 gms. sat. sol.	t°	Gms. $KMnO_4$ per 100 gms. sat. sol.	t°	Gms. $KMnO_4$ per 100 gms. sat. sol.
- 0.18	0.58 (V)	0	2.75	35	9.64
- 0.27	0.99 (V)	5	3.39	40	11.13
- 0.48	1.98 (V)	10	4.07	45	12.73
- 0.58*	2.91 (V)	15	5.00	50	14.40
		20	5.96	55	16.20
*Eutectic		25	7.09	60	18.15
(V) = Voerman		30	8.28	65	20.20

### SOLUBILITY OF POTASSIUM PERMANGANATE IN DEUTERIUM OXIDE SOLUTIONS (Noonan, 1948)

t°	Mole % $D_2O$	Moles $KMnO_4$ per 100 moles $H_2O + D_2O$	t°	Mole % $D_2O$	Moles $KMnO_4$ per 100 moles $H_2O + D_2O$
5	0.0	0.4002	25	0.0	0.8696
	91.59	0.302		90.86	0.700
	100.0	0.293		100.0	0.673 (0.690)*
15	0	0.600	35	0	1.1224
	90.86	0.471		90.86	1.1010
	100.0	0.458		100.0	0.989

\*Chang and Hsieh, 1949 report the molar solubility ratio  $S_{D_2O}/S_{H_2O} = 0.793$  at 25°. Assuming  $S_{H_2O} = 0.8696$  (generally accepted),  $S_{D_2O} = 0.690$ .

SOLUBILITY OF POTASSIUM PERMANGANATE IN AQUEOUS SOLUTIONS OF  
POTASSIUM HYDROXIDE  
(Sackur and Taegener, 1912)

t°	Mols. $\text{KMnO}_4$ per Liter in:						
	$\text{H}_2\text{O}$	1 n KOH	2 n KOH	4 n KOH	6 n KOH	8 n KOH	10 n KOH
0	0.176	0.050	0.031	0.027	0.023	0.017	0.012
10	0.278	0.112	0.068	0.048	0.042	0.028	0.016
20	0.411	0.179	0.119	0.079	0.074 <sup>1</sup>	0.032	0.029
30	0.573	0.316 <sup>2</sup>	0.213 <sup>2</sup>	0.149 <sup>2</sup>	0.114	0.062 <sup>2</sup>	0.040
40	0.792	0.439	0.306	0.211	0.161	0.084	0.052
50	1.154 <sup>3</sup>	0.638	0.462	0.304	0.219	0.111	--
70	1.812	1.172	0.869	0.572	0.390	0.188	0.082
80	--	1.513	1.190	--	0.500	0.231	--
90	--	--	--	--	0.649	0.297	--

MnO

<sup>1</sup>(19°)<sup>2</sup>(32°)<sup>3</sup>(53°)

SOLUBILITY OF POTASSIUM PERMANGANATE IN AQUEOUS SOLUTIONS OF  
POTASSIUM CARBONATE  
(Sackur and Taegener, 1912)

t°	Mols. $\text{KMnO}_4$ per Liter in:				
	0.1 n $\frac{1}{2}\text{K}_2\text{CO}_3$	1 n $\frac{1}{2}\text{K}_2\text{CO}_3$	2 n $\frac{1}{2}\text{K}_2\text{CO}_3$	4 n $\frac{1}{2}\text{K}_2\text{CO}_3$	6 n $\frac{1}{2}\text{K}_2\text{CO}_3$
0	0.1462	0.0629	0.0446	0.027	0.0156
25	0.4375	0.2589	--	0.093	--
40	0.7380	0.5007	0.3519	--	--

SOLUBILITY OF POTASSIUM PERMANGANATE IN AQUEOUS SOLUTIONS OF  
POTASSIUM CHLORIDE  
(Sackur and Taegener, 1912; Herz and Hiebenthal, 1929)

At 0°		At 25°				At 40°	
(S. and T.)		(S. and T.)		(H. and H.)		(S. and T.)	
Moles per liter		Moles per liter		Moles per liter		Moles per liter	
KCl	$\text{KMnO}_4$	KCl	$\text{KMnO}_4$	KCl	$\text{KMnO}_4$	KCl	$\text{KMnO}_4$
0.1	0.1395	0.1	0.4315	0.36	0.312	0.1	0.738
0.5	0.076	0.5	0.306	0.61	0.260	0.5	0.584
1.0	0.0532	1.0	0.220	1.65	0.148	1.0	0.444
2.0	0.0379	2.0	0.1432	2.32	0.116	2.0	0.288
				2.89	0.102		
				4.06	0.080		



# K KALIUM

THE SYSTEM POTASSIUM PERMANGANATE - POTASSIUM SULFATE - WATER AT 25°  
(Trimble, 1922; see also Benrath and Schackman, 1934)

The author also gives data for the densities of aqueous solutions of  $\text{KMnO}_4$ ,  $\text{K}_2\text{SO}_4$  and of  $\text{Na}_2\text{SO}_4$ . He also gives a few determinations of the solubility of  $\text{KMnO}_4$  in aqueous solutions of mixtures of  $\text{K}_2\text{SO}_4$  and  $\text{Na}_2\text{SO}_4$ .

$d_{25}^4$ of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{K}_2\text{SO}_4$	$\text{KMnO}_4$	
MnO 1.0454	0.0	7.10	$\text{KMnO}_4$
1.0483	0.80	6.59	"
1.0537	1.98	5.92	"
1.0730	5.47	4.52	"
1.0876	7.79	3.87	"
1.0979	9.26	3.55	" + $\text{K}_2\text{SO}_4$
1.0864	10.75	0.00	$\text{K}_2\text{SO}_4$

THE SYSTEM POTASSIUM PERMANGANATE - RUBIDIUM PERMANGANATE - WATER AT 7°  
(Muthmann and Kuntze, calc. by Fock)

Milligram Mols. per Liter		Gms. per Liter		Mol. percent $\text{KMnO}_4$ in Crystals of Solid Phase
$\text{KMnO}_4$	$\text{RbMnO}_4$	$\text{KMnO}_4$	$\text{RbMnO}_4$	
27.04	22.69	4.28	4.64	3.50
75.00	22.22	11.84	4.54	13.75
120.26	31.29	19.03	6.40	34.29
188.30	38.98	29.80	7.97	71.45
198.36	41.29	31.39	8.44	92.50
205.76	42.50	32.56	8.69	99.47
225.12	26.00	35.61	5.32	99.32
264.27	0	41.81	0	100

SOLUBILITY OF POTASSIUM PERMANGANATE IN AQUEOUS SOLUTIONS  
OF VARIOUS SALTS AT 25°  
(Herz and Hiebenthal, 1929)

Results for Aqueous Solutions of:

Lithium Chloride		Sodium Chloride		Ammonium Chloride	
Gm. Mols. per liter		Gm. Mols. per liter		Gm. Mols. per liter	
$\text{LiCl}$	$1/5\text{-KMnO}_4$	$\text{NaCl}$	$1/5\text{-KMnO}_4$	$\text{NH}_4\text{Cl}$	$1/5\text{-KMnO}_4$
0.0	2.25	0.59	2.32	0.59	1.94
0.51	2.18	0.96	2.29	0.95	1.75
0.87	2.09	2.26	2.13	2.69	1.05
2.56	1.51	3.35	1.86	3.78	0.86
3.81	1.16	4.22	1.73	4.57	0.78
4.56	0.95	4.515	1.53	4.545	0.72

SOLUBILITY OF POTASSIUM PERMANGANATE IN AQUEOUS SOLUTIONS  
OF VARIOUS SALTS AT 25°--Cont.

Lithium Chloride		Calcium Chloride		Strontium Chloride	
Gm. Mols. per liter		Gm. Mols. per liter		Gm. Mols. per liter	
1/2-MgCl <sub>2</sub>	1/5-KMnO <sub>4</sub>	1/2-CaCl <sub>2</sub>	1/5-KMnO <sub>4</sub>	1/2-SrCl <sub>2</sub>	1/5-KMnO <sub>4</sub>
0.96	2.01	0.0	2.25	0.0	2.25
1.92	1.78	1.70	2.00	0.64	2.27
4.62	0.96	4.90	1.20	2.45	1.94
6.42	0.64	6.80	0.91	3.92	1.64
7.64	0.48	8.10	0.80	4.52	1.50
8.10	0.40			+5.90	1.36
+9.52	0.16				

MnO

THE SYSTEM POTASSIUM PERMANGANATE - SODIUM SULFATE - WATER AT 25°  
(Trimble, 1922)

d <sub>25</sub> <sup>4</sup> of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d <sub>25</sub> <sup>4</sup> of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	Na <sub>2</sub> SO <sub>4</sub>	KMnO <sub>4</sub>			Na <sub>2</sub> SO <sub>4</sub>	KMnO <sub>4</sub>	
1.0554	0.88	7.33	KMnO <sub>4</sub>	--	12.85	7.27	KMnO <sub>4</sub>
--	4.62	7.83	"	--	17.05	6.68	"
1.1180	7.05	7.75	"	1.2363	19.43	6.25	"
--	9.34	7.67	"	--	21.04	5.91	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
				1.2071	21.80	0.0	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O

SOLUBILITY OF POTASSIUM PERMANGANATE IN AQUEOUS SOLUTIONS  
OF ACETONE AT 13°  
(Herz and Knock, 1904)

cc. CH <sub>3</sub> COCH <sub>3</sub> per 100 cc. solvent	Gms. KMnO <sub>4</sub> per 100 cc. sat. sol.	cc. CH <sub>3</sub> COCH <sub>3</sub> per 100 cc. solvent	Gms. KMnO <sub>4</sub> per 100 cc. sat. sol.
0	4.70	60	10.02
10	5.13	70	10.38
20	5.61	80	9.89
30	6.59	90	7.18
40	8.14	100	2.14
50	9.16		

100 cc. anhy. hydrazine dissolve 2 gms. KMnO<sub>4</sub>, with evolution of gas and formation of a brown precipitate, at room temp.

(Welsh and Broderson, 1915)

# K KALIUM

## MnO POTASSIUM MANGANATE $K_2MnO_4$

### SOLUBILITY OF POTASSIUM MANGANATE IN AQUEOUS SOLUTIONS OF POTASSIUM HYDROXIDE (Sackur and Taegener, 1912)

(The  $K_2MnO_4$  was prepared by boiling  $KMnO_4$  with very conc. KOH, draining by suction and washing with ice cold  $K_2CO_3$  solution. The impurities were of no consequence since the determinations were made in alkaline solutions.)

t°	Mols. $K_2MnO_4$ per Liter in:				
	2 n KOH'	4 n KOH	6 n KOH	8 n KOH	10 n KOH
0	0.907	0.554	0.155	0.063	0.0145
10	1.013	--	--	0.070	0.0152
15	--	0.681 (17°)	0.224	--	--
20	1.140	0.733 (25°)	0.261 (23°)	0.078	0.0160
30	1.252	0.772	0.303	0.096	0.0215
40	--	0.852	0.362	0.119	0.0305
45	1.424	0.889	0.388	--	--
50	--	0.938 (51°)	--	0.142	0.0462
60	--	1.003	0.469	0.167	0.062 (63°)
70	--	1.074	0.528	0.196	0.070
80	--	1.143	0.587	0.222	0.083

## MoO POTASSIUM MOLYBDATE $K_2MoO_4$

### SOLUBILITY IN WATER (Ricci and Loprest, 1953)

The Solid Phase is anhydrous  $K_2MoO_4$  throughout.

Solid Phase ICE		Solid Phase $K_2MoO_4$			
t°	Gms. $K_2MoO_4$ per 100 gms. sat. sol.	t°	Gms. $K_2MoO_4$ per 100 gms. sat. sol.	t°	Gms. $K_2MoO_4$ per 100 gms. sat. sol.
- 2.1	11.00	-18.1	63.15	52.88	65.30
- 4.7	19.81	+ 9.00	64.22	56.89	65.41
- 7.1	26.83	17.94	64.46	59.15	65.61
-15.6	40.24	25.00	64.57(64.86) <sup>a</sup>	64.46	65.72
-16.7	41.72	27.59	64.59	70.01	65.98
-22.5	46.88	31.40	64.80	76.65	66.19
-38*	62.7	34.91	64.78	81.93	66.39
		40.41	65.03	89.96	66.54
		46.23	65.07	119†	67.6

\*Eutectic

<sup>a</sup>Amadori, 1912a

† Normal boiling pt.

SOLUBILITY OF POTASSIUM MOLYBDATE IN POTASSIUM HYDROXIDE  
SOLUTIONS AT 25°  
(Ricci and Loprest, 1953)

Gms. per 100 gms. sat. sol.		Solid Phase
KOH	K <sub>2</sub> MoO <sub>4</sub>	
0.0	64.57	K <sub>2</sub> MoO <sub>4</sub>
2.29	60.94	"
5.27	56.91	"
13.93	43.04	"
22.28	31.17	"
23.88	28.47	"
33.51	16.00	"

MoO

THE SYSTEM POTASSIUM MOLYBDATE - POTASSIUM IODATE - WATER AT 25°  
(Ricci and Loprest, 1953)

Sat. Soln. wt. %		Density	Solid Phase	Sat. Soln. wt. %		Density	Solid Phase
K <sub>2</sub> MoO <sub>4</sub>	KIO <sub>3</sub>			K <sub>2</sub> MoO <sub>4</sub>	KIO <sub>3</sub>		
64.57	0.0	1.800	K <sub>2</sub> MoO <sub>4</sub>	38.10	1.92	1.406	KIO <sub>3</sub>
63.95	1.17	1.821	" + KIO <sub>3</sub>	30.97	2.33	1.331	"
60.52	1.13	--	KIO <sub>3</sub>	21.75	2.92	1.225	"
56.57	1.13	1.683	"	13.93	3.69	1.151	"
51.08	1.30	1.600	"	10.00	4.37	1.115	"
43.86	1.63	1.484	"	0.0	8.45	1.071	"

THE SYSTEM POTASSIUM MOLYBDATE - POTASSIUM NITRATE - WATER AT 25°  
(Ricci and Loprest, 1953)

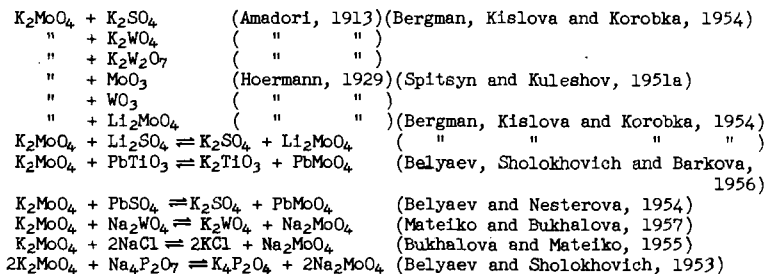
Sat. Soln. wt. %		Density	Solid Phase	Sat. Soln. wt. %		Density	Solid Phase
K <sub>2</sub> MoO <sub>4</sub>	KNO <sub>3</sub>			K <sub>2</sub> MoO <sub>4</sub>	KNO <sub>3</sub>		
64.57	0.0	1.800	K <sub>2</sub> MoO <sub>4</sub>	61.28	5.19	1.827	KNO <sub>3</sub>
63.08	3.14	1.821	"	57.91	5.08	1.753	"
62.67	3.80	1.827	"	46.08	6.23	1.565	"
62.49	4.30	1.831	"	35.43	9.35	1.433	"
61.98	5.17	--	"	25.32	13.25	1.353	"
62.06	5.26	1.843	" + KNO <sub>3</sub>	14.39	18.65	1.270	"
				0.0	27.71	1.193	"

THE SYSTEM POTASSIUM MOLYBDATE - POTASSIUM SULFATE - WATER AT 25°  
(Amadori, 1912a)

Continuous solid solutions are formed.	
Gms. per 100 gms. H <sub>2</sub> O	Gms. per 100 gms. H <sub>2</sub> O
K <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> MoO <sub>4</sub>
0	184.6
0.46	180.7
0.72	177
0.98	127.2
1.27	107.5
K <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> MoO <sub>4</sub>
1.50	99.49
2.13	45.89
3.95	17.48
8.55	4.73
12.10	0

## K KALIUM

Melting point data are given for:



### POTASSIUM CHROMIUM MOLYBDATE $3\text{K}_2\text{O} \cdot \text{Cr}_2\text{O}_3 \cdot 12\text{MoO}_3 \cdot 20\text{H}_2\text{O}$

At 17°, 2.5 gms. of the salt dissolve in 100 gms. H<sub>2</sub>O.  
(Jorgensen, 1879, 1884, 1890; Struve, 1899)

### MoO POTASSIUM PHOSPHOMOLYBDATE $\text{K}_3\text{PO}_4 \cdot 11\text{MoO}_3 \cdot 1\frac{1}{2}\text{H}_2\text{O}$

100 gms. H<sub>2</sub>O dissolve 0.0007 gm. at 30°.  
100 gms. aqueous 10% HNO<sub>3</sub> dissolve 0.204 gm. at 30°.  
(Donk, M. G., 1905)

#### SOLUBILITY OF POTASSIUM PHOSPHOMOLYBDATE IN AQUEOUS SOLUTIONS OF POTASSIUM NITRATE (Heidenhain, 1918)

In order to avoid errors due to impurities in the phosphomolybdate, small quantities of the washed precipitate were digested for a time long enough to insure saturation, and the dissolved part determined either by evaporation and weighing or by titration. The temperature is not stated.

Gms. per 100 cc. Aq. solvent		Gms. P <sub>2</sub> O <sub>5</sub> per 100 cc. sat. sol.	Gms. per 100 cc. Aq. solvent		Gms. P <sub>2</sub> O <sub>5</sub> per 100 cc. sat. sol.
KNO <sub>3</sub>	HNO <sub>3</sub>		KNO <sub>3</sub>	HNO <sub>3</sub>	
10	0.0	1.30	10	0.0504	0.12
15	0.0	1.30	10	0.0252	0.18
20	0.0	1.30	10	0.0126	0.49
10	0.063	0.06			

POTASSIUM AZIDE  $\text{KN}_3$ 

N

SOLUBILITY OF POTASSIUM AZIDE IN WATER  
(Wohlgemuth, 1934)

The results are given in the form of a diagram but numerical values only for the following points.

t°	Gms. $\text{KN}_3$ per 100 gms. $\text{KN}_3 + \text{H}_2\text{O}$	Solid Phase
- 12.9 (Eutec.)	26.2	$\text{KN}_3 + \text{H}_2\text{O}$
0	29.3	$\text{KN}_3$
10.5	31.7*	"
15.5	32.8*	"
17.0	33.2*	"
100	51.4	"
354 (m. pt.)	100.0	"

\*The results at 10.5, 15.5 and 17.0 are by Curtius and Rissom, 1898.

SOLUBILITY OF POTASSIUM AZIDE IN ORGANIC SOLVENTS  
(Cranston and Livingstone, 1926)

100 gms. Alcohol ( $d_{17} = 0.799$ ) dissolve 0.16 gm.  $\text{KN}_3$  at 0° and 0.54 gm. at b. pt.

100 gms. Alcohol (80 per cent) dissolve 1.8 gm.  $\text{KN}_3$  at 0° and 5.9 gm. at b. pt.

100 gms. Benzene dissolve 0.15 gm.  $\text{KN}_3$  at b. pt.

POTASSIUM AMIDE  $\text{KNH}_2$ 

NH

100 gms. liquid ammonia dissolve 3.6 gms.  $\text{KNH}_2$  at 25°.  
(Hunt and Boncyk, 1933)

Data for the freezing-points of mixtures of potassium amide and sodium amide are given by Kraus, 1923.

Tetra POTASSIUM HYDRAZINE Tetra SULFONATE  
 $\text{K}_4[(\text{SO}_3)_2\text{N}-\text{N}(\text{SO}_3)_2]$ 

At 27° ( $\pm 1^\circ$ ), the solubility is 2.7 gms. per liter in water.  
(Grinstead, 1957)

# K KALIUM

## NO POTASSIUM NITRITE $\text{KNO}_2$

### SOLUBILITY IN WATER

(Ostwald, 1912, 1914; Rakowski and Slawina, 1931; also Nardelli, Cavalca and Braibanti, 1952; Voskresenskaya and Berul, 1954; Divers, 1899.)

The data of Bureau, 1935a, 1937 are too high. The data for the ice curve are those of Ostwald; those of Rakowski and Slawina agree. Bureau reports a pentahydrate,  $\text{KNO}_2 \cdot 5\text{H}_2\text{O}$  to be stable below  $-8.9^\circ$ . The values from  $-5$  to  $120^\circ$  were read from a plot of the various data.

Solid Phase ICE		Solid Phase $\text{KNO}_2$			
$t^\circ$	Gms. $\text{KNO}_2$ per 100 gms. sat. sol.	$t^\circ$	Gms. $\text{KNO}_2$ per 100 gms. sat. sol.	$t^\circ$	Gms. $\text{KNO}_2$ per 100 gms. sat. sol.
- 4.1	16.1	- 5	73.3	60	77.9
- 7.6	24.1	0	73.7	70	78.5
-13.8	40.2	+10	74.5	80	79.0
-18.6	50.1	20	75.4	90	79.6
-24.6	61.7	30	76.1	100	80.2
-30.0	69.8	40	76.8	110	80.8
-31.6 Eutec.	71.8	50	77.3	120	81.4

### THE SYSTEM POTASSIUM NITRITE - POTASSIUM NITRATE - WATER (Bureau, 1937)

Results in the form of a diagram are presented for the temperatures,  $0^\circ$ ,  $25^\circ$ ,  $56.6^\circ$  and  $98.5^\circ$  but numerical values are given only for the temperatures  $25^\circ$  and  $98.5^\circ$ .

Data for this system at  $0^\circ$ ,  $20^\circ$ ,  $40^\circ$ ,  $60^\circ$ ,  $80^\circ$  and  $98^\circ$  are also given by Rakowsky and Slavina, 1931, but the results are not in good accord with those below.

Results at $25^\circ$			Results at $98.5^\circ$		
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{KNO}_2$	$\text{KNO}_3$		$\text{KNO}_2$	$\text{KNO}_3$	
68.7	8.53	MC, $\text{KNO}_2 + \text{KNO}_3$	64.80	14.80	MC, $\text{KNO}_2 + \text{KNO}_3$
66.45	11.20	"	57.0	13.80	"
64.15	13.05	"	51.10	35.15	"
61.5	15.10	$\beta \text{KNO}_3$	46.70	39.15	"
55.8	14.95	"	39.70	43.80	$\text{KNO}_3$
35.85	15.05	$\alpha$ "	20.45	55.40	"
19.90	18.75	"			

MC,  $\text{KNO}_2 + \text{KNO}_3$  = Mixed Crystals.





## K KALIUM

Melting point data are given for the following systems:

$\text{KNO}_2 + \text{KNO}_3$	(Meneghini, 1912; Berul and Bergman, 1952)
$\text{KNO}_2 + \text{NaNO}_2$	(Ettinger, 1932; Berul and Bergman, 1952)
$\text{KNO}_2 + \text{NaNO}_3 \rightleftharpoons \text{KNO}_3 + \text{NaNO}_2$	(Berul and Bergman, 1954)
$\text{KNO}_2 + \text{KOH}$	(Bergman and Reshetnikov, 1954)
$\text{KNO}_2 + \text{NaOH}$	(Bergman and Reshetnikov, 1954)
$\text{KNO}_2 + \text{Na acetate} \rightleftharpoons \text{K acetate} + \text{NaNO}_2$	(Bergman and Evdokimova, 1956)

## NO POTASSIUM NITRATE $\text{KNO}_3$

### SOLUBILITY IN WATER

Averages of the results of Mulder; Andrac, 1884; Gerardin, 1865; Etard, 1894; Ost., 1878; at 31.25°, Kohler, 1897; Euler, 1904; Tilden and Shenstone, 1884; Berkeley, 1904; Massink, 1917-18; Gladstone and Saunders, 1923; Wright, 1927; Malquori, 1928; Nikolajew, 1929; Benrath and Wazelle, 1929; Ehret, 1932; Muller, 1933; Ricci, 1934; and Saslowsky and Ettinger, 1935; Cornec and Krombach, 1929; Bergman and Nagory, 1938; Bergman and Botchkareff, 1938; Alexandrov, 1941; Thompson and Verner, 1948; and for temperatures above 100° by Berkeley, 1904; Bronsted, 1913; Aronowa and Lumskaia, 1931 and Benrath, Gjedebo, Schiffers and Wunderlich, 1937.

t°	Gms. $\text{KNO}_3$ per 100 gms. sat. sol.	t°	Gms. $\text{KNO}_3$ per 100 gms. sat. sol.	t°	Gms. $\text{KNO}_3$ per 100 gms. sat. sol.
- 2.84 <sup>e</sup>	10.9	60	52.2	160	85.0
0	11.7	70	57.8	180	87.0
10	24.0	80	62.8	200	89.0
20	24.0	90	67.0	225	91.7
25	27.5	100	71.0	250	93.5
30	31.3	110	74.8	275	96.0
40	39.0	120	77.5	300	98.0
50	46.0	140	81.5	336 m.pt.	100.0

<sup>e</sup>Eutectic

### SOLUBILITY OF $\text{KNO}_3$ IN DEUTERIUM OXIDE (Chang and Hsieh, 1949)

At 25° the molal solubility (moles per 55.51 moles of solvent) in  $\text{D}_2\text{O}$  is 0.912 x the solubility in  $\text{H}_2\text{O}$ .

SOLUBILITY OF POTASSIUM NITRATE IN WATER - HYDROGEN  
PEROXIDE MIXTURES  
(Floyd and Gross, 1955)

The data show a discontinuity at about 0.7 mole fraction  $H_2O_2$  in the solvent. The agreement with Akerlof and Turck, 1935 at 25° is good. The data were read from curves drawn by the authors through their experimental points.

Mole fraction $H_2O_2$ in solvent	Moles $KNO_3$ per 1000 gms. solvent			Mole fraction $H_2O_2$ in solvent	Moles $KNO_3$ per 1000 gms. solvent			
	0°	15°	25°		0°	15°	25°	
0	1.2	2.4	3.6	0.7	--	9.6	--	NO
0.1	2.1	3.6	4.9	--	--	10.8*	11.9*	
0.2	3.2	4.8	6.0	0.8	8.2	10.1	11.3	
0.3	4.5	6.1	7.3	--	--	12.0*	12.9*	
0.4	5.8	7.3	8.4	0.9	9.0	10.5	11.9	
0.5	7.2	8.5	9.6	1.0	9.7	11.0	12.3	
0.6	8.5	9.7	10.8					

\*Metastable (?)

THE SYSTEM POTASSIUM NITRATE - NITRIC ACID - WATER

(Engel, 1887 (0°); Kazantzov, 1923, 1925 (0°, 15°, 30°, 75°); Nikolajew, 1928 (25°); Nikolaev, Chirkov and Kogan, 1935 (-21°, 0°, 50°, 75°, 83°); Nichols, Howes et al., 1919 (20°))

Additional data are given by Groschuff, 1904. The data of Nichols, Howes, et al. are in error above 42%  $HNO_3$ . The results of Malquori, 1928c at 25° are much too high.

The data at 0° and 75° are those of Kazantzov, except as noted by superscripts. See the tables following for further data and invariant points.

Solid Phase  $KNO_3$

Sat. Sol. wt. %		Sat. sol. wt. %		Sat. sol. wt. %		Sat. sol. wt. %	
$HNO_3$	$KNO_3$	$HNO_3$	$KNO_3$	$HNO_3$	$KNO_3$	$HNO_3$	$KNO_3$
Results at -21° (N.S.A.)		Results at 0°--Cont.		Results at 0°--Cont.		Results at 0°--Cont.	
20.63	2.64 <sup>y</sup>	1.3	11.0	17.0	6.55 <sup>d</sup>	48.0	16.5
45.31	9.26	3.42	9.24 <sup>a</sup>	25.0	6.38 <sup>e</sup>	50.7	19.1 <sup>g</sup>
51.80	15.12	4.7	8.5	25.5	6.4	50.7	23.1
54.90	34.87 <sup>x</sup>	7.66	7.66 <sup>b</sup>	27.45	6.96 <sup>n</sup>	52.2	30.2
		7.90	7.94 <sup>n</sup>	30.1	7.0	52.2	38.2
		8.7	7.2	33.3	8.09 <sup>f</sup>	52.2	39.4
Results at 0° (K.)		12.13	6.70 <sup>c</sup>	33.5	7.5	51.52	41.34 <sup>n</sup>
		12.78	7.03 <sup>n</sup>	37.34	9.81 <sup>n</sup>	50.7	48.4
0.0	11.9	13.2	6.4	39.9	9.7	51.82	41.58 <sup>n,x</sup>
0	11.80 <sup>n</sup>	16.5	6.1	47.60	17.03 <sup>n</sup>	57.5	34.4 <sup>x</sup>
						73.0	25.5 <sup>x</sup>

(Cont.)

<sup>n</sup> = Nikolaev, Chirkov and Kogan, 1935.

<sup>a-g</sup> = Engel, 1887; densities: <sup>a</sup>1.086, <sup>b</sup>1.093, <sup>c</sup>1.117, <sup>d</sup>1.144, <sup>e</sup>1.202, <sup>f</sup>1.289, <sup>g</sup>1.498

<sup>x</sup>Solid phase  $KNO_3 \cdot 2HNO_3$

<sup>y</sup>Solid phase  $KNO_3$  + Ice

## K KALIUM

## THE SYSTEM POTASSIUM NITRATE - NITRIC ACID - WATER--Cont.

Solid Phase  $\text{KNO}_3$ 

	Sat. Sol. wt. %		Sat. Sol. wt. %		Sat. Sol. wt. %		Sat. Sol. wt. %	
	$\text{HNO}_3$	$\text{KNO}_3$	$\text{HNO}_3$	$\text{KNO}_3$	$\text{HNO}_3$	$\text{KNO}_3$	$\text{HNO}_3$	$\text{KNO}_3$
	Results at 15° (K.)		Results at 25° (N.)		Results at 50° (N.S.A.)		Results at 75°-- Cont.	
	0.0	20.7	0.0	27.87	0.0	46.20	32.2	36.7
	7.5	14.2	9.89	19.00	0.56	45.48	38.5	37.6
	18.0	10.7	16.68	15.27	3.08	42.06	42.5	39.9
	23.3	10.1	32.29	14.02	20.40	26.90	45.5	43.9
NO	24.0	10.2	42.57	17.15	27.63	24.91	45.93	46.98 <sup>n</sup>
	29.2	10.5	49.53	25.37	38.11	26.65	46.7	50.0
	40.0	13.6			41.77	29.13	46.2	52.6
	45.1	17.7	Results at 30° (K.)		48.40	43.52	46.24	53.68 <sup>n</sup>
	49.3	25.1			47.71	51.85		
	51.0	32.7			Results at 75° (K.)		Results at 83° (N.S.A.)	
	51.6	38.1	0.0	31.5				
	51.3	44.1	5.4	25.6	0.0	60.0	3.83	59.47
	50.0	49.2	11.0	20.9	0	60.20 <sup>n</sup>	6.29	56.96
			18.2	17.2	5.1	53.6	19.99	45.28
	Results at 20° (N., H. et al.)		27.2	15.7	5.46	53.69 <sup>n</sup>	25.85	42.76
			40.1	18.9	13.52	46.10 <sup>n</sup>	29.74	41.50
			47.7	27.7	17.7	41.3	31.26	41.22
	0.0	23.9	49.0	33.2	19.36	41.70 <sup>n</sup>	44.69	49.10
	8.4	16.0	50.1	39.5	21.8	38.9	44.90	49.95
	17.5	12.7	50.6	42.5	29.3	37.4		
	26.9	10.2	49.7	49.9				
	34.7	13.2						
	42.2	15.7						

n = Nikolaev, Chirkov and Kogan, 1935.

a-g Engel, 1887; densities: <sup>a</sup>1.086, <sup>b</sup>1.093, <sup>c</sup>1.117, <sup>d</sup>1.144, <sup>e</sup>1.202, <sup>f</sup>1.289, <sup>g</sup>1.498.X Solid phase  $\text{KNO}_3 \cdot 2\text{HNO}_3$ Y Solid phase  $\text{KNO}_3 + \text{Ice}$ 

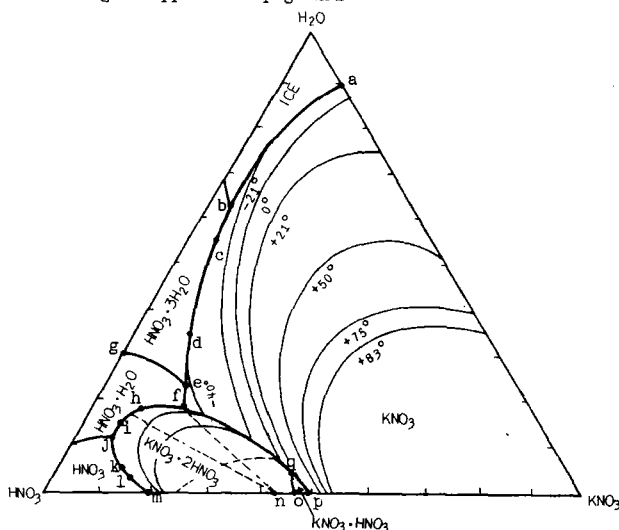
## Additional Data of Nikolaev, Chirkov and Kogan, 1935

Point in Figure	t°	Sat. Soln. wt. %		Solid Phase
		$\text{HNO}_3$	$\text{KNO}_3$	
a	-3	0.0	10.72	$\text{KNO}_3 + \text{Ice}$
b	-44	34.45	2.10	$\text{KNO}_3 + \text{HNO}_3 \cdot 3\text{H}_2\text{O} + \text{Ice}$
c	-36	40.19	4.00	$\text{KNO}_3 + \text{HNO}_3 \cdot 3\text{H}_2\text{O}$
d	-27	55.33	11.00	"
e	-46.5	62.98	15.57	" " + $\text{HNO}_3 \cdot \text{H}_2\text{O}$
f	-49.	65.04	16.07	" + $\text{KNO}_3 \cdot 2\text{HNO}_3 + \text{HNO}_3 \cdot \text{H}_2\text{O}$
g	-45	67.36	4.85	$\text{HNO}_3 \cdot 3\text{H}_2\text{O} + \text{HNO}_3 \cdot \text{H}_2\text{O}$
h	-53	74.11	8.20	$\text{HNO}_3 \cdot \text{H}_2\text{O} + \text{KNO}_3 \cdot 2\text{HNO}_3$
i	-68.5	78.77	6.69	" "
j	-94	81.62	6.90	$\text{HNO}_3 + \text{HNO}_3 \cdot \text{H}_2\text{O} + \text{KNO}_3 \cdot 2\text{HNO}_3$
k	-76	83.00	11.00	$\text{HNO}_3 + \text{KNO}_3 \cdot 2\text{HNO}_3$
l	-70	82.00	13.06	" "
m	-50	80.0	20.0	" "
n	+22	55.5	44.5	$\text{KNO}_3 \cdot 2\text{HNO}_3$
o	+29	49.9	50.1	$\text{KNO}_3 + \text{KNO}_3 \cdot \text{HNO}_3$
p	+21.5	53.1	46.9	$\text{KNO}_3 \cdot \text{HNO}_3 + \text{KNO}_3 \cdot 2\text{HNO}_3$
q*	(21)	(52.5)	(51.0)	$\text{KNO}_3 + \text{KNO}_3 \cdot \text{HNO}_3 + \text{KNO}_3 \cdot 2\text{HNO}_3$

\*estimated

THE SYSTEM  $\text{KNO}_3 + \text{HNO}_3 + \text{H}_2\text{O}$ --Cont.

Legend to diagram appears on page 252.



NO

THE SYSTEM POTASSIUM NITRATE - BORIC ACID - WATER  
(Ugai and Simkina, 1950)

Results at 0°		Results at 5°		Results at 10°		Solid Phase each temperature
Sat. Sol. wt. % $\text{KNO}_3$	$\text{H}_3\text{BO}_3$	Sat. sol. wt. % $\text{KNO}_3$	$\text{H}_3\text{BO}_3$	Sat. sol. wt. % $\text{KNO}_3$	$\text{H}_3\text{BO}_3$	
0.0	2.4	0.0	2.9	0.0	3.50	$\text{H}_3\text{BO}_3$
3.89	2.7	3.88	3.1	3.85	3.65	"
7.77	2.9	7.44	3.2	7.70	3.75	"
10.67	3.0	10.63	3.35	10.58	3.80	"
—	—	13.51	3.5	13.45	3.9	"
11.90	3.1	14.6	3.5	17.50	3.90	" + $\text{KNO}_3$
11.9	1.76	14.4	1.71	17.40	1.65	$\text{KNO}_3$
11.7	0.88	14.4	0.86	17.50	0.83	"
11.5	0.0	14.5	0.0	17.7	0.0	"
Results at 15°		Results at 20°		Results at 25°		
Sat. Sol. wt. % $\text{KNO}_3$	$\text{H}_3\text{BO}_3$	Sat. sol. wt. % $\text{KNO}_3$	$\text{H}_3\text{BO}_3$	Sat. sol. wt. % $\text{KNO}_3$	$\text{H}_3\text{BO}_3$	
0.0	4.1	0.0	4.75	0.0	5.45	$\text{H}_3\text{BO}_3$
3.83	4.20	3.81	4.85	3.77	5.70	"
7.70	4.35	7.60	4.95	7.60	5.75	"
10.50	4.40	10.40	5.00	10.35	5.75	"
13.38	4.40	13.30	5.00	13.20	5.70	"
20.08	4.40	19.95	5.00	19.80	5.70	"
—	—	—	—	28.32	5.60	"
20.6	4.35	24.55	4.95	28.60	5.60	" + $\text{KNO}_3$
20.6	1.59	24.3	1.52	27.9	1.44	$\text{KNO}_3$
20.6	0.79	24.2	0.76	27.8	0.72	"
20.7	0.0	24.2	0.0	27.7	0.0	"

# K KALIUM

## SOLUBILITY OF POTASSIUM NITRATE IN AQUEOUS SOLUTIONS OF POTASSIUM HYDROXIDE AT 20° (Bronsted, 1920a)

Gm. mols. per liter		Gm. mols. per liter		Gm. mols. per liter	
KOH	KNO <sub>3</sub>	KOH	KNO <sub>3</sub>	KOH	KNO <sub>3</sub>
4.71	0.847	9.41	0.364	14.02	0.241
7.90	0.455	10.95	0.298	14.85	0.232
7.95	0.450	12.19	0.271	15.02	0.233

## SOLUBILITY OF POTASSIUM NITRATE IN AMMONIA SOLUTIONS (Alexandrov, 1941)

NO

The values in parentheses at 0° are from Guyer, Bieler and Schmid, 1934 (given in detail in the table following).

Gms. NH <sub>3</sub> per 100 gms. H <sub>2</sub> O in Sat. Sol.	Gms. KNO <sub>3</sub> per 100 gms. H <sub>2</sub> O in Sat. Sol.					
	-10°	0°	10°	20°	30°	40°
0	--	13.3 (13.6)	22.1	31.7	45.2	64.0
10	5.4	8.9 (10.3)	13.6	20.0	29.7	42.7
20	4.1	7.2 ( 7.9)	11.0	15.5	23.2	33.7
25	3.8	6.6 ( 6.9)	10.1	14.4	21.1	30.6
30	3.6	6.4 ( 6.3)	9.6	13.8	19.5	28.0
40	3.3	6.1 ( 5.4)	9.1	13.1	18.0	25.0

## Results of Guyer, Bieler and Schmid, 1934 at 0°

The authors present their results in the form of diagrams but do not give their experimental determinations. The following approximate values have been estimated from the published diagram.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
NH <sub>3</sub>	KNO <sub>3</sub>		NH <sub>3</sub>	KNO <sub>3</sub>	
0.0	12.0	KNO <sub>3</sub>	60	8.5	KNO <sub>3</sub>
10.0	8.0	"	70	10.5	"
20.0	5.0	"	80	13.0	"
30.0	3.5	"	86	13.5	"
40.0	5.0	"	90	13.0	"
50.0	7.0	"	100	9.5	"

SOLUBILITY OF POTASSIUM NITRATE IN POTASSIUM CARBONATE AND  
BICARBONATE SOLUTIONS  
(Touren, 1900)

Potassium Carbonate

Results at 14.5°

Mols. per Liter		Gms. per Liter	
K <sub>2</sub> CO <sub>3</sub>	KNO <sub>3</sub>	K <sub>2</sub> CO <sub>3</sub>	KNO <sub>3</sub>
0.0	2.228	0.0	225
0.48	1.85	66.4	188
1.25	1.39	172.9	141
2.58	0.86	356.9	87
3.94	0.64	544.9	65

Results at 25°

0.0	3.217	0.0	326
0.59	2.62	81.6	265
1.35	1.97	186.7	199
2.10	1.46	290.5	148
2.70	1.14	373.6	115
3.58	0.79	495.1	80

Potassium Bicarbonate

Results at 14.5°

Mols. per Liter		Gms. per Liter	
KHCO <sub>3</sub>	KNO <sub>3</sub>	KHCO <sub>3</sub>	KNO <sub>3</sub>
0.0	2.33	0.0	236
0.39	2.17	39.0	220
0.76	2.03	76.0	205
1.16	1.92	116	194
1.55	1.81	155	183

NO

Results at 25°

0.0	3.28	0.0	332
0.89	2.84	89	287
1.33	2.65	133	268
1.91	2.45	191	249

Results of Kremann and Zitek, 1909  
At 24.2°

Gms. per 1000 Gms. H <sub>2</sub> O		Solid Phase
KNO <sub>3</sub>	K <sub>2</sub> CO <sub>3</sub>	
376.8	0.0	KNO <sub>3</sub>
285.0	130.3	"
161.7	348.4	"
141.8	371.9	"
73.0	688.1	"
38.8	878.3	"
31.1	1112.2	" + K <sub>2</sub> CO <sub>3</sub>

HIGH TEMPERATURE EQUILIBRIA IN THE SYSTEM POTASSIUM NITRATE -  
POTASSIUM CHLORIDE - WATER  
(Benrath, 1943)

See also p. 127, this Volume..

t°	Gms. KNO <sub>3</sub> per 100 gms. sat. sol.	Gms. KCl <sub>3</sub> per 100 gms. sat. sol.	Solid Phase
125	68.2	8.8	KCl + α-KNO <sub>3</sub> + β-KNO <sub>3</sub>
150	73.5	8.5	KCl + β-KNO <sub>3</sub>
175	77.3	8.2	"
200	81.3	8.2	"
225	83.7	8.3	"
250	85.8	8.2	"
331.5*	94.4	5.6	"

\*Perman and Saunders, 1923.

## K KALIUM

THE SYSTEM POTASSIUM NITRATE - POTASSIUM DIHYDROGEN PHOSPHATE - WATER  
(Bergman and Botchkareff, 1938)

The results are also given per 100 moles of dissolved salts.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
KNO <sub>3</sub>	KH <sub>2</sub> PO <sub>4</sub>	Solid Phase	KNO <sub>3</sub>	KH <sub>2</sub> PO <sub>4</sub>	Solid Phase
Results at 0°			Results at 10°		
11	0.0	KNO <sub>3</sub>	16.6	0.0	KNO <sub>3</sub>
9.9	3.6	"	15.3	3.4	"
9.3	6.0	"	13.2	8.6	"
8.5	9.0	"	12.8	10.2	KNO <sub>3</sub> + KH <sub>2</sub> PO <sub>4</sub>
8.4	9.8	KNO <sub>3</sub> + KH <sub>2</sub> PO <sub>4</sub>	8.9	11.2	KH <sub>2</sub> PO <sub>4</sub>
4.2	10.5	KH <sub>2</sub> PO <sub>4</sub>	5.0	12.6	"
NO 0.0	11.8	"	0.0	15.	"
Results at 20°			Results at 30°		
23.0	0.0	KNO <sub>3</sub>	31.0	0.0	KNO <sub>3</sub>
21.6	3.0	"	28.8	2.8	"
19.0	8.0	"	25.6	7.4	"
17.9	10.4	KNO <sub>3</sub> + KH <sub>2</sub> PO <sub>4</sub>	23.2	10.9	KNO <sub>3</sub> + KH <sub>2</sub> PO <sub>4</sub>
16.1	10.8	KH <sub>2</sub> PO <sub>4</sub>	15.8	12.2	KH <sub>2</sub> PO <sub>4</sub>
8.7	13.2	"	8.4	15.8	"
5.8	14.6	"	6.8	17.	"
0.0	18.2	"	0.0	21.4	"

The eutectic occurs at -3.8°; 7% KNO<sub>3</sub>, 9.3% KH<sub>2</sub>PO<sub>4</sub>.THE SYSTEM KNO<sub>3</sub> + NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub> = NH<sub>4</sub>NO<sub>3</sub> + KH<sub>2</sub>PO<sub>4</sub>  
(Bochkarev and Bergman, 1940; Bergman and Bochkarev, 1938)

The system was studied from -10° to the melting points of the salts, and the data are presented in weight and molar bases, and in many diagrams. Continuous solid solutions of KH<sub>2</sub>PO<sub>4</sub> + NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub> occupy the largest area of the diagram, and they become discontinuous as the KNO<sub>3</sub> field is approached. At higher temperatures the solid solutions become continuous at all concentrations. Some isothermal invariant points are given below:

Moles per 100 moles of Dissolved Salts						Solid Phase
t°	KH <sub>2</sub> PO <sub>4</sub>	NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>	NH <sub>4</sub> NO <sub>3</sub>	KNO <sub>3</sub>	H <sub>2</sub> O	
-10	--	16.0	63.0	21.0	1240	KNO <sub>3</sub> + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub> + Ice
-10	--	12.5	69.5	18.0	1000	KNO <sub>3</sub> + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub> + xKNO <sub>3</sub> ·yNH <sub>4</sub> NO <sub>3</sub>
-10	--	2.5	88.5	9.0	510	NH <sub>4</sub> NO <sub>3</sub> + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub> + xKNO <sub>3</sub> ·yNH <sub>4</sub> NO <sub>3</sub>
-5	55.0	--	40.0	5.0	2500	Ice + KNO <sub>3</sub> + KH <sub>2</sub> PO <sub>4</sub>
-5	--	54.5	4.5	41.0	1800	KNO <sub>3</sub> + KH <sub>2</sub> PO <sub>4</sub> + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>
-5	--	17.0	62.5	20.5	1200	KNO <sub>3</sub> + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub> + xKNO <sub>3</sub> ·yNH <sub>4</sub> NO <sub>3</sub>
-5	--	2.5	88.0	9.5	440	NH <sub>4</sub> NO <sub>3</sub> + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub> + xKNO <sub>3</sub> ·yNH <sub>4</sub> NO <sub>3</sub>
0	--	2.0	89.0	9.0	480	NH <sub>4</sub> NO <sub>3</sub> + xKNO <sub>3</sub> ·yNH <sub>4</sub> NO <sub>3</sub> + NH <sub>4</sub> (K)H <sub>2</sub> PO <sub>4</sub>
0	55.0	--	45.0	--	1860	K(NH <sub>4</sub> )H <sub>2</sub> PO <sub>4</sub> + NH <sub>4</sub> (K)H <sub>2</sub> PO <sub>4</sub> + KNO <sub>3</sub>
0	--	16.5	59.5	24.0	1000	KNO <sub>3</sub> + xKNO <sub>3</sub> ·yNH <sub>4</sub> NO <sub>3</sub> + NH <sub>4</sub> (K)H <sub>2</sub> PO <sub>4</sub>
+10	45.0	--	36.5	18.5	1500	KNO <sub>3</sub> + K(NH <sub>4</sub> )H <sub>2</sub> PO <sub>4</sub> + NH <sub>4</sub> (K)H <sub>2</sub> PO <sub>4</sub>
10	--	1.8	91.2	7.0	300	NH <sub>4</sub> NO <sub>3</sub> + xKNO <sub>3</sub> ·yNH <sub>4</sub> NO <sub>3</sub> + NH <sub>4</sub> (K)H <sub>2</sub> PO <sub>4</sub>
10	--	16.0	56.5	27.5	1850	KNO <sub>3</sub> + xKNO <sub>3</sub> ·yNH <sub>4</sub> NO <sub>3</sub> + NH <sub>4</sub> (K)H <sub>2</sub> PO <sub>4</sub>
20	--	32.0	--	68.0	1150	KNO <sub>3</sub> + K(NH <sub>4</sub> )H <sub>2</sub> PO <sub>4</sub>
20	--	16.0	49.0	35.0	760	KNO <sub>3</sub> + xKNO <sub>3</sub> ·yNH <sub>4</sub> NO <sub>3</sub> + NH <sub>4</sub> (K)H <sub>2</sub> PO <sub>4</sub>
20	--	1.5	93.0	5.0	270	NH <sub>4</sub> NO <sub>3</sub> + xKNO <sub>3</sub> ·yNH <sub>4</sub> NO <sub>3</sub> + NH <sub>4</sub> (K)H <sub>2</sub> PO <sub>4</sub>
30	--	16.0	44.0	40.0	680	KNO <sub>3</sub> + xKNO <sub>3</sub> ·6NH <sub>4</sub> NO <sub>3</sub> + NH <sub>4</sub> (K)H <sub>2</sub> PO <sub>4</sub>
30	--	1.4	94.6	4.0	220	NH <sub>4</sub> NO <sub>3</sub> + xKNO <sub>3</sub> ·yNH <sub>4</sub> NO <sub>3</sub> + NH <sub>4</sub> (K)H <sub>2</sub> PO <sub>4</sub>

THE SYSTEM POTASSIUM NITRATE - POTASSIUM SULFATE - WATER  
(Hering, 1926, 1927)

Additional data at 35° are given by Massink (1916, 1917), and by Janecke (1929) at 0°, 25° and 50°.

The results at 310° are those of Benrath, 1943. At about 310°, the solubility curve of potassium sulfate in water exhibits a sharp change in slope, and the salt becomes less soluble upon increasing the temperature. Although the nature of the change has not been determined crystallographically, the break is sharp enough to be followed in the ternary system with added potassium nitrate. This maximum of the solubility of potassium sulfate was found to remain at 310° as the potassium nitrate is added.

d. of sat. sol.	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	d. of sat. sol.	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	NO
	KNO <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>			KNO <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>		
Results at -3.32° (Dutec)				Result at 40°				
--	10.3	4.7	Ice + KNO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>	1.287	61.0	5.00	KNO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>	
Results at 0°				Results at 50°				
--	13.3	0.0	KNO <sub>3</sub>	1.339	83.3	3.20	KNO <sub>3</sub>	
--	12.4	3.56	"	1.341	82.5	4.53	" + K <sub>2</sub> SO <sub>4</sub>	
--	12.2	4.95	" + K <sub>2</sub> SO <sub>4</sub>	1.301	68.7	4.54	K <sub>2</sub> SO <sub>4</sub>	
--	11.0	5.05	K <sub>2</sub> SO <sub>4</sub>	1.203	34.9	7.9	"	
--	6.4	5.74	"	1.171	24.9	9.2	"	
--	0.0	7.33	"	1.152	18.0	10.6	"	
Result at 8.5°				1.104	0.0	16.5	"	
--	18.1	5.45	KNO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>	Results at 75°				
Result at 17.5°				1.467	150.5	3.33	KNO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>	
1.176	22.7	5.77	KNO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>	1.433	131.2	3.71	K <sub>2</sub> SO <sub>4</sub>	
Result at 20°				1.380	105.5	4.53	"	
1.187	30.0	5.73	KNO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>	1.335	86.2	5.18	"	
Results at 25°				1.268	60.5	7.01	"	
--	37.3	0.0	KNO <sub>3</sub>	1.197	39.1	9.75	"	
--	38.2	0.0 (I)	"	1.148	17.8	13.8	"	
--	38.5	2.31(I)	"	1.116	0.0	20.6	"	
--	36.1	2.75(H)	"	Result at 90°				
--	36.5	4.22(I)	"	--	197	1.88(H)	KNO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>	
1.205	36.4	4.67	"	Results at 100°				
--	35.9	5.59(I)	" + K <sub>2</sub> SO <sub>4</sub>	1.572	242.	2.85	KNO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>	
1.210	35.7	5.86	"	1.566	237.3	2.75	K <sub>2</sub> SO <sub>4</sub>	
--	33.6	6.22(H)	"	1.567	237.4	2.80	"	
1.199	32.4	6.06	K <sub>2</sub> SO <sub>4</sub>	1.497	182.0	3.49	"	
1.170	25.0	6.78	"	1.467	162.3	3.31	"	
--	18.3	7.40(I)	"	1.394	120.6	4.85	"	
1.144	18.0	7.78	"	1.352	101.0	5.60	"	
--	13.5	8.40(H)	"	1.229	50.4	9.46	"	
1.115	10.3	9.09	"	1.163	25.3	14.0	"	
--	6.79	9.45(I)	"	1.119	0.0	24.1	"	
--	5.58	10.25(H)	"	Results at 310°				
1.234	43.4	5.53	KNO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>	--	3120.	164	K <sub>2</sub> SO <sub>4</sub>	
Results at 35°				--	210.	23.3	"	
--	53.3	0.0 (M)	KNO <sub>3</sub>	--	80.0	20.0	"	
--	49.2	1.77(M)	"	--	25.8	25.8	"	
--	46.7	5.20(M)	" + K <sub>2</sub> SO <sub>4</sub>	--	8.8	35.1	"	
--	21.1	8.37(M)	K <sub>2</sub> SO <sub>4</sub>	--	4.1	36.0	"	
--	0.0	13.8 (M)	"					

I = Inouye, 1925

M = Massink, 1918

H = Hamid, 1926



# K KALIUM

## THE SYSTEM POTASSIUM NITRATE - POTASSIUM VANADATE - WATER AT 25° (Trujillo and Tejera, 1951)

N = KNO<sub>3</sub>

V = KVO<sub>3</sub>

NO	Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
	KVO <sub>3</sub>	KNO <sub>3</sub>		KVO <sub>3</sub>	KNO <sub>3</sub>		KVO <sub>3</sub>	KNO <sub>3</sub>	
	9.74	--	V	1.64	18.95	V	0.85	31.30	V
	7.15	3.12	V	1.50	21.67	V	0.87	32.30	V
	4.47	6.33	V	1.20	24.07	V	0.81	33.20	V + N
	3.55	8.30	V	1.15	24.66	V	0.80	33.20	V + N
	2.81	10.60	V	1.17	24.90	V	0.34	33.45	N
	2.53	11.94	V	1.17	26.20	V	0.19	33.50	N
	2.24	14.10	V	1.00	27.30	V	--	33.60	N
	1.82	16.50	V	0.89	29.10	V			

## THE SYSTEM POTASSIUM NITRATE - ALUMINUM NITRATE - WATER (Tanaka, 1930)

[See also Vol. I, page 190.]

At 0°

At 10°

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
Al(NO <sub>3</sub> ) <sub>3</sub>	KNO <sub>3</sub>		Al(NO <sub>3</sub> ) <sub>3</sub>	KNO <sub>3</sub>	
43.23	0.0	Al(NO <sub>3</sub> ) <sub>3</sub> ·9H <sub>2</sub> O	35.75	0.0	Al(NO <sub>3</sub> ) <sub>3</sub> ·9H <sub>2</sub> O
43.32	6.83	" + KNO <sub>3</sub>	36.32	10.83	" + KNO <sub>3</sub>
20.39	7.05	KNO <sub>3</sub>	20.53	7.57	KNO <sub>3</sub>
0.0	11.75	"	14.79	9.00	"
			8.47	11.60	"
			0.0	17.3	"

## THE SYSTEM POTASSIUM NITRATE - MAGNESIUM NITRATE - WATER (Benrath and Benrath, 1929(a), 1930; Benrath and Sichelschmidt, 1931)

Mg = Mg(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O

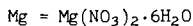
K = KNO<sub>3</sub>

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	Mg(NO <sub>3</sub> ) <sub>2</sub>	KNO <sub>3</sub>			Mg(NO <sub>3</sub> ) <sub>2</sub>	KNO <sub>3</sub>	
1.079	0.0	11.7	K	1.296	27.29	4.35	K
1.091	2.26	11.5	K	1.350	33.42	4.40	K
1.106	5.45	8.35	K	1.389	37.6	3.26	K + Mg
1.146	11.06	6.48	K	1.382	38.45	1.09	Mg
1.174	17.55	4.29	K	1.369	38.58	0.0	Mg

Results at 0°

(Cont.)

## THE SYSTEM POTASSIUM NITRATE - MAGNESIUM NITRATE - WATER--Cont:



d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	Mg(NO <sub>3</sub> ) <sub>2</sub>	KNO <sub>3</sub>			Mg(NO <sub>3</sub> ) <sub>2</sub>	KNO <sub>3</sub>	
Results at 25°				Results at 75°			
1.194	0.0	27.49	K	1.470	0.0	60.53	K
1.202	5.98	21.40	K	1.445	3.78	54.17	K
1.221	10.06	17.84	K	1.432	13.52	40.68	K
1.265	18.73	12.41	K	1.426	23.30	30.76	K
1.320	26.09	10.18	K	1.510	34.07	24.04	K
1.438	37.2	8.63	Mg	1.510	40.41	22.30	K
1.462	39.3	7.67	Mg	1.645	44.58	22.00	K + Mg
1.431	40.49	3.98	Mg	1.599	45.69	16.96	Mg
1.394	42.0	0.0	Mg	1.537	48.01	10.15	Mg
Results at 50°				1.461	51.00	0.0	Mg
1.315	0.0	46.10	K	Results at 99.5°			
1.318	4.44	39.37	K				
1.316	14.12	28.36	K	1.529	0.0	70.8	K
1.361	26.18	19.36	K	1.532	12.14	54.52	K
1.455	35.86	15.45	K	1.555	23.19	42.90	K
1.459	37.03	15.40	K	1.672	37.93	32.05	K
1.505	40.47	15.02	K + Mg	1.690	38.46	30.93	K
1.462	42.50	8.32	Mg				
1.416	45.44	0.0	Mg				

These authors also give results for the reciprocal salt pair  
 $(\text{KNO}_3)_2 + \text{MgSO}_4 = \text{Mg}(\text{NO}_3)_2 + \text{K}_2\text{SO}_4 \cdot (+\text{H}_2\text{O})$

THE SYSTEM  $2\text{KNO}_3 + \text{MgCl}_2 = 2\text{KCl} + \text{Mg}(\text{NO}_3)_2$  IN  $\text{H}_2\text{O}$   
(Bergman and Nagorny, 1938)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
MgCl <sub>2</sub>	KNO <sub>3</sub>		MgCl <sub>2</sub>	KNO <sub>3</sub>	
Results at 30°			Results at 20°		
0.0	31.3	KNO <sub>3</sub>	0.0	24.2	KNO <sub>3</sub>
7.8	20.6	"	8.2	15.8	"
17.0	14.0	"	17.6	10.4	"
21.4	11.7	"	21.9	8.39	"
23.2	10.8	"	24.0	8.3	"
24.0	10.4	KNO <sub>3</sub> + KCl	24.5	8.2	KNO <sub>3</sub> + KCl
27.6	5.2	KCl	24.8	7.6	KCl
28.4	3.8	"	27.6	3.8	"
33.5	0.4	KCl + MgCl <sub>2</sub> ·6H <sub>2</sub> O	28.3	3.0	"
			33.8	0.3	KCl + MgCl <sub>2</sub> ·6H <sub>2</sub> O

(Cont.)

# K KALIUM

## THE SYSTEM $2\text{KNO}_3 + \text{MgCl}_2 \rightleftharpoons 2\text{KCl} + \text{Mg}(\text{NO}_3)_2$ IN $\text{H}_2\text{O}$ --Cont.

	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	MgCl <sub>2</sub>	KNO <sub>3</sub>		MgCl <sub>2</sub>	KNO <sub>3</sub>	
NO	Results at 10°			Results at 0°		
	0.0	17.7	KNO <sub>3</sub>	0.0	11.5	KNO <sub>3</sub>
	8.8	12.0	"	9	8.8	"
	18.0	8.0	"	18.4	6.0	"
	19.2	7.8	"	22.9	5.2	"
	21.4	6.8	"	24.8	4.6	"
	22.4	6.3	"	25.4	4.4	KNO <sub>3</sub> + KCl
	25	6.2	KNO <sub>3</sub> + KCl	26.0	3.6	KCl
	26.6	3.6	KCl	28.7	1.0	"
	28.6	1.6	"	34.0	1.05	"
33.9	0.2	KCl + MgCl <sub>2</sub> ·6H <sub>2</sub> O				
Results at -10°			Results at -20°			
11.6	0.0	Ice	16.8	0.0	Ice	
11.2	1.6	"	16.2	2.2	"	
10.6	3.3	"	15.6	3.4	Ice + KNO <sub>3</sub>	
9.6	5.8	Ice + KNO <sub>3</sub>	19.9	3	KNO <sub>3</sub>	
15.4	4.8	KNO <sub>3</sub>	21.4	2.9	"	
18.8	4.3	"	23.5	2.7	"	
23.2	3.8	"	25.8	2.4	KNO <sub>3</sub> + KCl	
25.0	3.5	"	26.0	2.35	KCl	
25.4	3.3	KNO <sub>3</sub> + KCl	28.2	0.6	KCl + MgCl <sub>2</sub> ·12H <sub>2</sub> O	
29.0	0.6	KCl + MgCl <sub>2</sub> ·8H <sub>2</sub> O	26.8	0.0	MgCl <sub>2</sub> ·12H <sub>2</sub> O	
32.6	0.0	MgCl <sub>2</sub> ·8H <sub>2</sub> O				
Results at -30°			The Invariant points are:			
19.4	0.0	Ice	(-33.5°):			
19.8	2	Ice KNO <sub>3</sub>	20.2 2.1 Ice + KNO <sub>3</sub> + MgCl <sub>2</sub> ·12H <sub>2</sub> O			
22.4	2	KNO <sub>3</sub> + MgCl <sub>2</sub> ·12H <sub>2</sub> O	(-23.2°):			
22	1.4	MgCl <sub>2</sub> ·12H <sub>2</sub> O	25.8 2 KNO <sub>3</sub> + KCl + MgCl <sub>2</sub> ·12H <sub>2</sub> O			
22.0	0.0	"				

## THE SYSTEM POTASSIUM NITRATE - AMMONIUM NITRATE - WATER

Very complete data for the complex system  $\text{KNO}_3 + \text{NH}_4\text{NO}_3 + \text{H}_2\text{O}$ , in which several modifications of the mix crystals (solid solutions) of the two salts are formed, are given by Janecke, 1928, and very much more complete results by Janecke, Hamacher and Rahlfs, 1932. These authors made more than 300 solubility determinations, including analyses of both the saturated solutions and solid phases. The results are presented in the form of tables of experimental determinations and diagrams which show the limits of composition and fields of existence of each of the several modifications of the mix crystals as well as the corresponding compositions of the saturated solutions at temperatures between -15° and +150°. Other data are given by Ando, 1925 and Caillart, 1918. The results reported by Bahl and Singh, 1940, and by Chand and Jain, 1945 do not represent equilibrium conditions.

The nature of the solid phases has been reexamined at 0° by Mukimov and Bergman, and by Karnaukhov 1956, 1957 at 25°. Karnaukhov reports a region of stability for the compound  $3\text{KNO}_3 \cdot \text{NH}_4\text{NO}_3$ .

## DATA OF KARNAUKHOV AT 25°:

Sat. sol. wt. %		Wet residue wt. %		Solid Phase
KNO <sub>3</sub>	NH <sub>4</sub> NO <sub>3</sub>	KNO <sub>3</sub>	NH <sub>4</sub> NO <sub>3</sub>	
27.64	0.0	89.13	0.0	Solid solution NH <sub>4</sub> NO <sub>3</sub> in KNO <sub>3</sub>
25.67	3.30	85.82	2.68	"
25.50	9.00	90.04	3.40	"
25.20	13.61	79.83	5.86	"
25.05	18.64	80.03	7.50	"
24.05	22.25	79.00	10.23	"
23.22	29.01	76.00	12.61	"
22.00	35.00	83.00	12.00	"
22.73	43.18	66.11	26.25	"
21.27	44.10	56.00	30.50	3KNO <sub>3</sub> ·NH <sub>4</sub> NO <sub>3</sub>
19.28	46.21	60.03	29.30	"
19.94	47.31	64.36	27.86	"
20.00	47.00	56.86	32.42	"
18.83	48.53	36.10	57.25	Solid solution KNO <sub>3</sub> in NH <sub>4</sub> NO <sub>3</sub>
17.04	49.80	31.16	57.44	"
15.31	52.33	22.59	69.23	"
12.14	56.80	14.32	76.60	"
6.61	61.80	7.50	84.36	"
0.0	67.08	--	--	"

NO

THE SYSTEM  $2\text{KNO}_3 + (\text{NH}_4)_2\text{SO}_4 \rightleftharpoons \text{K}_2\text{SO}_4 + 2\text{NH}_4\text{NO}_3 (+\text{H}_2\text{O})$  AT 25°  
(Osaka and Inouye, 1925)

Mixtures of the salts in roughly calculated proportions were rotated in a thermostat for several days, and both the saturated solutions and the solid phases were analyzed. There are five series of solid solutions present as solid phases. These are:

1.  $(\text{NH}_4, \text{K})_2\text{SO}_4$ ;
2.  $(\text{NH}_4, \text{K})_2(\text{NO}_3)_2 \alpha$ ;
3.  $(\text{NH}_4, \text{K})_2(\text{NO}_3)_2 \beta$ ;
4.  $(\text{NH}_4, \text{K})_2 0.5\text{SO}_4 0.5(\text{NO}_3)_2$ ;
5.  $(\text{NH}_4, \text{K})_2 0.4\text{SO}_4 0.6(\text{NO}_3)_2$ .

Complete tables showing the composition of the liquid and solid phases for each of the five series of solid solutions are given. The results are presented in gram percentages, and in molal proportion according to the formula

$$100m \text{ H}_2\text{O} \cdot x\text{K}_2 \cdot (100-x)(\text{NH}_4)_2y\text{SO}_4 \cdot (100-y)(\text{NO}_3)_2.$$

Additional data at various temperatures are given by Janecke, 1929.

Data for the mix crystals, solutions and melts in the System  $\text{KNO}_3 + \text{NH}_4\text{Cl}$   $\text{KCl} + \text{NH}_4\text{NO}_3$  are given by Janecke, 1928.

## THE SYSTEM POTASSIUM NITRATE - SODIUM NITRATE - WATER

Leather and Mukerji, 1913 (30°, 40°, 91°); Cornec and Krombach, 1929 (0°, 25°, 50°, 62.5°, 75°, 87.5°, 100°); Saslawsky and Ettinger, 1935, 1937 (0°, 20°, 40°, 60°). Additional data are given by Carnelly and Thomson (1888), Nicol (1891), Kremann and Zitek (1909).

Data above 100° are those of Benrath, 1943. However, the system was reinvestigated from the eutectic to the melting points of Ravich and

## K KALIUM

Ginsberg, 1947 with different high-temperature results. Above 150°  
I -  $\text{KNO}_3$  +  $\text{NaNO}_3$  were found to form continuous solid solutions. Below  
105° II -  $\text{KNO}_3$  and  $\text{NaNO}_3$  are stable as pure phases.

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{NaNO}_3$	$\text{KNO}_3$	
	Results at -19.0° (Eutectic) (Ravich)		
--	36.88	5.58	Ice + $\text{KNO}_3$ + $\text{NaNO}_3$
	Results at 0° (CK)		
--	0.0	11.7	$\text{KNO}_3$
1.422	39.0	10.4	" + $\text{NaNO}_3$
(1.424)*	(39.22)	(10.53)	" + "
1.352	42.3	0.0	$\text{NaNO}_3$
	Results at 20° (SE)		
1.162	0.0	24.13	$\text{KNO}_3$
1.494	42.03	17.13	" + $\text{NaNO}_3$
--	40.38	16.41	" "
1.406	46.27	0.0	$\text{NaNO}_3$
	Results at 25° (CK)		
1.189	0.0	27.7	$\text{KNO}_3$
1.512	40.3	19.1	" + $\text{NaNO}_3$
1.391	47.9	0.0	$\text{NaNO}_3$
	Results at 30° (LM)		
1.317	15.10	26.65	$\text{KNO}_3$
1.403	26.30	23.65	"
1.472	34.2	21.95	"
1.544	40.1	21.10	" + $\text{NaNO}_3$
1.520	41.1	19.01	$\text{NaNO}_3$
1.481	43.8	13.05	"
1.451	46.5	6.70	"
1.406	48.9	0.0	"
	Results at 40° (LM)		
1.358	12.75	33.78	$\text{KNO}_3$
1.428	23.34	29.9	"
1.505	32.3	27.0	"
1.570	40.0	25.5	" + $\text{NaNO}_3$
--	(39.70)*	(24.60)	" + "
1.573	40.8	24.1	$\text{NaNO}_3$
1.526	43.8	17.13	"
1.476	47.7	8.83	"
1.421	51.3	0.0	"
	Results at 50° (CK)		
1.332	0.0	46.2	$\text{KNO}_3$
1.434	19.1	35.9	"
1.529	31.7	31.3	"
1.602	39.8	28.9	" + $\text{NaNO}_3$
1.557	43.3	21.6	$\text{NaNO}_3$
1.502	47.6	12.3	"
1.427	53.2	0.0	"

\*Saslawsky and Ettinger

(Cont.)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	NaNO <sub>3</sub>	KNO <sub>3</sub>	
Results at 60° (SE)			
1.343	0.0	52.0	KNO <sub>3</sub>
--	38.13	33.05	" + NaNO <sub>3</sub>
1.467	55.50	0.0	NaNO <sub>3</sub>
Results at 62.5° (CK)			
--	0.0	53.8	KNO <sub>3</sub>
1.648	38.7	34.3	" + NaNO <sub>3</sub>
--	56.4	0.0	NaNO <sub>3</sub>
Results at 75° (CK)			
1.462	0.0	60.4	KNO <sub>3</sub>
1.545	18.7	47.7	"
1.635	31.3	41.5	"
1.700	38.3	39.1	" + NaNO <sub>3</sub>
1.644	42.4	30.9	NaNO <sub>3</sub>
1.568	49.0	18.0	"
1.469	58.7	0.0	"
Results at 87.5° (CK)			
--	0.0	66.2	KNO <sub>3</sub>
1.746	37.3	43.9	" + NaNO <sub>3</sub>
--	61.2	0.0	NaNO <sub>3</sub>
Results at 91° (LM)			
1.615	12.6	58.4	KNO <sub>3</sub>
1.674	23.2	51.8	"
1.751	33.2	47.3	"
1.790	36.9	45.1	" + NaNO <sub>3</sub>
--	(37.57)	(45.26)†	" + "
1.774	39.1	41.4	NaNO <sub>3</sub>
1.695	44.9	31.0	"
1.610	52.6	16.91	"
1.521	61.6	0.0	"
Results at 100° (CK)			
1.569	0.0	70.9	KNO <sub>3</sub>
1.658	18.7	57.7	"
1.744	29.7	51.4	"
1.793	36.7	48.1	" + NaNO <sub>3</sub>
1.744	41.1	40.0	NaNO <sub>3</sub>
1.647	49.5	25.3	"
1.507	63.7	0.0	"
Results above 100° (Benrath, 1943; See note page 261)			
t°			
125	30.5	56.5	NaNO <sub>3</sub> + βKNO <sub>3</sub> + αKNO <sub>3</sub>
150	34.5	55.5	NaNO <sub>3</sub> + βKNO <sub>3</sub>
175	39.75	54	" "
200	43.5	54	" "
225†	45.4	54.6	" "

\*Saslawsky and Ettinger.

†Hamid, 1926.

‡Madgin and Briscoe, 1923.

# K KALIUM

Data for the quaternary system  $2\text{KNO}_3 + \text{Na}_2\text{SO}_4 \rightleftharpoons \text{K}_2\text{SO}_4 + 2\text{NaNO}_3 + \text{H}_2\text{O}$  at  $25^\circ$  and at  $90^\circ$  are given by Hamid, 1926.

## EQUILIBRIUM IN SYSTEMS COMPOSED OF POTASSIUM AND SODIUM CHLORIDES, NITRATES AND SULFATES

Complete experimental data, including densities, in the form of tabular results and diagrams for these complex systems at temperatures between  $0^\circ$  and  $90^\circ$  are given by Cornec and Krombach, 1929, and Cornec, Krombach and Spack, 1930. These authors have made use whenever necessary of the results for the ternary systems and quaternary systems previously reported from their own laboratory or by others, including Chretien, 1929; Cornec and Hering, 1925-7; Cornec and Krombach, 1929; Meyerhoffer and Saunders, 1899; D'Ans, 1915 and Blasdale, 1918.

NO

## SOLUBILITY OF MIXTURES OF POTASSIUM AND SODIUM NITRATES IN AQUEOUS SOLUTIONS OF NITRIC ACID AT $25^\circ$ (Nikolajew, 1929)

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
$\text{HNO}_3$	$\text{KNO}_3$	$\text{NaNO}_3$		$\text{HNO}_3$	$\text{KNO}_3$	$\text{NaNO}_3$	
0	19.7	40.25	$\text{KNO}_3 + \text{NaNO}_3$	38.98	16.74	7.15	$\text{KNO}_3 \cdot 2\text{HNO}_3 + \text{NaNO}_3$
5.20	17.68	35.26	"	42.61	11.68	5.75	"
10.66	16.04	30.01	"	54.04	6.52	4.10	"
16.17	15.74	23.64	"	58.62	3.48	3.82	"
21.18	16.06	19.24	"	62.59	1.02	3.32	"
32.65	16.70	11.20	"				

## SOLUBILITY OF MIXTURES OF POTASSIUM AND SODIUM NITRATES IN AQUEOUS SOLUTIONS OF POTASSIUM HYDROXIDE AND OF SODIUM HYDROXIDE AT $25^\circ$ (Nikolajew, 1929)

Results for Aq. KOH				Results for Aq. NaOH			
Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
KOH	$\text{KNO}_3$	$\text{NaNO}_3$		NaOH	$\text{KNO}_3$	$\text{NaNO}_3$	
0.0	19.17	40.25	$\text{KNO}_3 + \text{NaNO}_3$	1.17	16.60	38.70	$\text{KNO}_3 + \text{NaNO}_3$
1.19	15.65	41.57	"	4.33	13.84	35.75	"
2.84	10.48	43.00	"	7.04	11.46	32.68	"
4.58	6.86	43.22	"	8.20	10.56	31.63	"
7.35	3.12	42.48	"	14.75	6.47	23.67	"
10.54	0.0	40.40	"	28.53	3.34	10.29	"
				31.87	3.29	7.64	"
				40.43	5.20	2.14	"

Results for the quaternary mixtures in the system composed of  $\text{KNO}_3 + \text{NaNO}_3 + \text{Al}(\text{NO}_3)_3 + \text{H}_2\text{O}$  at temperatures between  $0^\circ$  and  $60^\circ$  are given by Saslawsky and Ettinger, 1935, 1937.

SOLUBILITY OF MIXTURES OF POTASSIUM NITRATE, SODIUM CHLORIDE  
AND SODIUM NITRATE IN WATER  
(Cornec and Krombach, 1929)

Additional data showing the effect of varying amounts of NaCl are also given.

t°	d. of sat. sol.	Gms. per 100 gms. H <sub>2</sub> O			Solid Phase
		KNO <sub>3</sub>	NaCl	NaNO <sub>3</sub>	
0	1.384	16.4	28.4	39.6	KNO <sub>3</sub> + NaCl + NaNO <sub>3</sub>
5	--	19.7	27.4	44.4	"
20	--	34.0	24.3	58.6	"
25	1.475	40.3	23.5	64.3	"
40	--	66.7	20.8	82.7	"
50	1.585	90.3	19.3	96.9	"
60	--	119.7	18.3	114.1	"
75	1.695	176.0	17.5	145.0	"
80	--	200.5	17.6	158.1	"
87.5	1.750	241.5	18.0	179.5	"
100	1.799	337.6	19.6	222.6	"

THE PSEUDO-TERNARY SYSTEM KNO<sub>3</sub> + NaCl + H<sub>2</sub>O  
(Leather and Mikerji, 1913)

Some additional data at higher temperatures are also given.

## Results at 20°

## Results at 30°

Sp. Gr. Sat. Sol.	Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase	Sp. Gr. Sat. Sol.	Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase
	KNO <sub>3</sub>	NaCl			KNO <sub>3</sub>	NaCl	
1.167	31.49	0	KNO <sub>3</sub>	1.261	46.48	9.82	KNO <sub>3</sub>
1.220	33.41	9.94	"	1.302	47.08	20.18	"
1.267	34.93	19.44	"	1.343	47.24	29.86	"
1.311	36.41	29.46	"	1.372	49.24	38.72	" + NaCl
1.344	37.30	37.73	" + NaCl	1.342	38.36	38.55	NaCl
1.330	31.41	37.57	NaCl	1.298	25.32	38.23	"
1.283	19.56	37.51	"	1.258	12.15	37.38	"
1.243	9.76	36.73	"	1.202	--	36.30	"

## Results at 40°

## Results at 91°

1.288	64.74	0	KNO <sub>3</sub>	1.552	202.8	0	KNO <sub>3</sub>
1.320	64.66	11.32	"	1.573	204.2	12.81	"
--	64.05	23.41	"	1.601	208.1	28.45	"
1.396	64.13	35.08	"	1.645	213.3	37.92	"
1.411	64.77	38.79	" + NaCl	1.660	218.8	39.08	" + NaCl
1.376	52.81	39.51	NaCl	1.607	175.8	40.87	NaCl
1.323	34.98	38.98	"	1.517	126.9	44.33	"
1.267	17.33	37.74	"	1.378	57.53	42.90	"

(Cont.)



# K KALIUM

## SOLUBILITY OF MIXTURES OF POTASSIUM NITRATE AND SODIUM CHLORIDE IN WATER (Etard, 1894)

(Other data by Rudorff, Karsten, Mulder, Soch, 1898, etc. agree)

t°	Gms. per 100 gms. solution		t°	Gms. per 100 gms. solution		t°	Gms. per 100 gms. solution	
	KNO <sub>3</sub>	NaCl		KNO <sub>3</sub>	NaCl		KNO <sub>3</sub>	NaCl
0	13	24	40	30.5	19	120	73	8.0
10	16	23	50	36	17	140	77	7.0
20	20	22	60	42.5	15	160	79.5	6.0
25	23	21.5	80	55	12	170	80.5	5.5
NO 30	25	20.5	100	67	9.5			

## THE SYSTEM POTASSIUM NITRATE - LEAD NITRATE - WATER

Recent physical chemical studies on solutions containing KNO<sub>3</sub> + Pb(NO<sub>3</sub>)<sub>2</sub> (Nayar and Pande, 1948; Vartak and Kabadi, 1955) seem to show molecular association compounds in solution. Vartak and Kabadi, 1957 claim to have isolated solids of corresponding compositions, but these were not found in the equilibrium phase studies, below.

P = Pb(NO<sub>3</sub>)<sub>2</sub>

K = KNO<sub>3</sub>

(Ehret, 1932)		(Gladstone and Saunders, 1923)						Solid Phase at each temp.
Results at 0°		Results at 25°		Results at 50°		Results at 100°		
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
KNO <sub>3</sub>	Pb(NO <sub>3</sub> ) <sub>2</sub>	KNO <sub>3</sub>	Pb(NO <sub>3</sub> ) <sub>2</sub>	KNO <sub>3</sub>	Pb(NO <sub>3</sub> ) <sub>2</sub>	KNO <sub>3</sub>	Pb(NO <sub>3</sub> ) <sub>2</sub>	
0.0	26.66	0.0	37.17	0.0	44.79	0.0	55.65	P
4.15	29.63	2.75	37.37	5.90	44.44	3.79	53.44	P
8.95	32.94	4.90	37.95	11.26	44.75	15.98	49.93	P
14.20	37.37	8.42	39.27	16.16	44.61	36.90	44.5	P
--	--	14.73	40.86	19.38	44.38	--	--	P
--	--	--	--	27.47	43.45	--	--	P
--	--	--	--	30.98	43.05	--	--	P
14.86	37.14	24.67	41.93	33.14	42.14	--	--	P+K
14.89	36.27	24.92	40.99	36.33	32.32	51.24	27.04	K
14.33	26.05	25.93	28.05	37.69	26.47	--	--	K
13.67	22.95	26.93	9.24	41.72	12.03	--	--	K
--	--	27.03	15.14	--	--	--	--	K
12.24	0.0	27.39	0.0	45.51	0.0	71.00	0.0	K

THE SYSTEM POTASSIUM NITRATE - STRONTIUM NITRATE - WATER  
(Findlay, Morgan and Morris, 1914)

## Results at 20°

Gms. per 100 gms. sat. sol.		Solid Phase
KNO <sub>3</sub>	Sr(NO <sub>3</sub> ) <sub>2</sub>	
22.90	5.49	KNO <sub>3</sub>
21.70	9.17	"
21.01	17.10	"
19.60	31.24	"
19.49	34.91	"
19.69	39.56	" + Sr(NO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
17.56	40.37	Sr(NO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
12.65	41.12	"
10.00	40.70	"

## Results at 40°

Gms. per 100 gms. sat. sol.		Solid Phase
KNO <sub>3</sub>	Sr(NO <sub>3</sub> ) <sub>2</sub>	
30.26	23.70	KNO <sub>3</sub>
26.90	38.52	" + Sr(NO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
22.50	40.22	Sr(NO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
11.19	44.19	"
0	47.7	"

NO

## Result at 25°

1000 gms. H<sub>2</sub>O, simultaneously saturated with both salts, contain  
552 gms. KNO<sub>3</sub> + 1074 gms. Sr(NO<sub>3</sub>)<sub>2</sub> at 25°. (LeBlanc and Noyes, 1890)

THE SYSTEM POTASSIUM NITRATE - THALLIUM NITRATE - WATER AT 25°  
(Fock, 1897)

[Solid Solutions are formed]

Grams per Liter		Mg. Mols. per liter		Mol. percent TlNO <sub>3</sub> in Solution	Sp. Gr. of Solutions	Mol. percent TlNO <sub>3</sub> in Solid Phase
TlNO <sub>3</sub>	KNO <sub>3</sub>	TlNO <sub>3</sub>	KNO <sub>3</sub>			
0.00	351.0	0.0	3468.2	0.00	1.2632	0.00
2.37	329.0	8.9	3251.5	0.43	1.1903	0.08
6.15	332.4	23.1	3285.1	0.70	1.1956	0.20
17.64	333.7	66.3	3298.1	1.97	1.2050	0.57
49.74	333.3	186.9	3294.4	5.37	1.2196	1.78
63.60	321.0	239.0	3172.4	7.01	1.2436	2.19
86.18	330.5	323.8	3265.8	9.02	1.2617	2.77
123.8	428.3	465.2	4232.6	9.90	1.2950	6.00
101.3	245.1	380.6	2423.3	13.58	1.2050	27.04
116.1	0.0	463.1	0.0	100.00	1.0964	93.33
						100.00

THE SYSTEM POTASSIUM NITRATE - URANYL NITRATE - WATER  
(Perova, 1956)

K = KNO <sub>3</sub> At 0°		U = UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> At 5°		U <sub>3</sub> = UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·3H <sub>2</sub> O At 10°		U <sub>6</sub> = UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O At 15°		Solid Phase each temp.
Sat. sol. wt. %		Sat. sol. wt. %		Sat. sol. wt. %		Sat. sol. wt. %		
U	K	U	K	U	K	U	K	
0.0	12.24	0.0	14.4	0.0	17.70	0.0	20.0	K
1.00	11.3	0.9	14.3	0.8	16.7	0.75	19.8	K
7.4	9.0	7.1	11.4	7.0	14.0	6.8	17.0	K
24.0	6.0	23.6	7.6	23.0	9.6	22.4	11.7	K
38.7	4.1	38.0	5.1	37.3	6.4	37.0	7.9	K
--	--	48.0	4.5	47.6	5.8	47.3	7.2	K
48.3	2.69	49.8	4.8	51.5	6.0	53.0	7.3	K + U <sub>6</sub>
49.8	0.0	51.3	0.0	52.0	0.0	52.8	0.0	U <sub>6</sub>

(Cont.)

# K KALIUM

## THE SYSTEM POTASSIUM NITRATE - URANYL NITRATE - WATER--Cont.

K = KNO<sub>3</sub> U = UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub> U<sub>3</sub> = UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub>·3H<sub>2</sub>O U<sub>6</sub> = UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O

Results at 25°

(Perova)			(Colani, 1928)					
Sat. sol. wt. %		Solid Phase	Sat. sol. wt. %		Solid Phase	Sat. sol. wt. %		Solid Phase
U	K		U	K		U	K	
0.0	27.64	K	0.0	27.44	K	48.65	10.36	K
0.65	26.7	K	3.16	23.15	K	53.88	10.40	U <sub>6</sub>
6.2	23.5	K	6.46	21.23	K	53.90	9.51	U <sub>6</sub>
21.5	15.4	K	9.71	19.94	K	54.21	5.30	U <sub>6</sub>
35.6	11.0	K	25.80	12.74	K	54.68	3.36	U <sub>6</sub>
45.8	10.6	K	40.60	11.11	K	56.08	0.0	U <sub>6</sub>
54.1	10.9	K + U <sub>6</sub>						
55.9	0.0	U <sub>6</sub>						

At 20°		At 50°		At 70°		At 90°		Solid Phase each temp.
U	K	U	K	U	K	U	K	
0.0	23.95	0.0	46.09	0.0	57.9	0.0	66.8	K
0.7	23.6	0.88	43.50	0.98	55.8	0.75	63.5	K
6.4	20.15	4.82	40.12	4.20	52.2	4.25	61.0	K
22.0	13.6	17.20	32.00	14.35	43.8	11.60	54.0	K
36.3	9.4	30.53	23.66	26.00	35.9	21.72	46.3	K
46.3	8.8	40.00	20.00	35.22	30.72	29.70	41.25	K
--	--	52.6	19.70	48.34	25.81	43.32	33.41	K
--	--	--	--	56.80	22.90	52.21	28.80	K
--	--	--	--	61.30	21.80	58.30	25.75	K
53.6	8.9	58.73	19.60	63.00*	21.00	66.60*	21.60	K + U <sub>6</sub>
--	--	65.5	2.0	76.20*	2.00	80.20*	1.55	U <sub>6</sub>
54.4	0.0	67.5	0.0	78.00*	0.0	81.0*	0.0	U <sub>6</sub>

\*Solid phase = U<sub>3</sub>

## SOLUBILITY OF POTASSIUM NITRATE IN AQUEOUS METHANOL SOLUTIONS

Results at 25°  
(Akerlof and Turck, 1935)

Results at 30°  
(Schreinemakers, 1908-09)

Wt. % CH <sub>3</sub> OH in Aq. Solvent	Gm. Mols. KNO <sub>3</sub> per 1000 gms. Solvent	In Aq. CH <sub>3</sub> OH Gms. per 100 Gms. Sat. Sol.		In Aq. (CH <sub>3</sub> OH+C <sub>2</sub> H <sub>5</sub> OH)* Gms. per 100 Gms. Sat. Sol.	
		CH <sub>3</sub> OH	KNO <sub>3</sub>	(CH <sub>3</sub> OH+C <sub>2</sub> H <sub>5</sub> OH)	KNO <sub>3</sub>
0.00	3.774	0	31.3	0	31.3
4.98	3.046	7.8	23.3	12.7	18.9
9.45	2.503	17.3	16.3	29.2	12.8
21.04	1.522	27.8	11.2	41.0	6.7
40.30	0.7130	38.4	7.7	47.8	5.1
59.94	0.3125	57.0	3.8	56.4	3.5
70.05	0.1898	98.58	0.43	74.8	1.2
78.46	0.1123				
89.45	0.0607				

\*The mixture contained 51.7% CH<sub>3</sub>OH and 48.3% C<sub>2</sub>H<sub>5</sub>OH.

SOLUBILITY OF POTASSIUM NITRATE IN ETHANOL - WATER MIXTURES  
(Thompson and Vener, 1948)

The results agree with those of Gerardin, 1865; Bathrick, 1896; Schreinemakers, 1908-09. (For results at lower temperatures and at different compositions see the tables following.) Results are in gms.  $\text{KNO}_3$  per 100 gms. Sat. Sol. Densities (in parentheses) are gms./ml. in vacuo.

Solvent: Wt. % Alcohol, (Density at 35°)	Temperature						
	25°	30°	35°	40°	45°	50°	
0.0	27.24 (1.1864)	31.49 (1.2167)	35.40 (1.2458)	39.02 (1.2740)	42.64 (1.3059)	46.11 (1.3358)	NO
9.82 (0.97714)	19.16 (1.1049)	22.40 (1.1285)	25.73 (1.1524)	29.25 (1.1771)	33.03 (1.2026)	37.18 (1.2302)	
19.90 (0.96150)	13.18 (1.0469)	15.80 (1.0607)	18.54 (1.0763)	21.54 (1.0938)	24.80 (1.1136)	28.43 (1.1367)	
29.89 (0.94424)	9.02 (1.0018)	10.85 (1.0097)	12.86 (1.0195)	15.18 (1.0324)	17.87 (1.0473)	21.00 (1.0636)	
49.90 (0.90191)	4.20 (0.9326)	5.11 (0.9334)	6.07 (0.9347)	7.11 (0.9367)	8.34 (0.9398)	9.80 (0.9443)	
69.83 (0.85510)	1.353 (0.8708)	1.633 (0.8670)	1.925 (0.8639)	2.236 (0.8613)	2.953 (0.8594)	3.001 (0.8570)	
92.63 (0.79769)	0.096 (0.8058)	0.111 (0.8017)	0.128 (0.7977)	0.146 (0.7933)	0.168 (0.7890)	0.195 (0.7851)	
	55°	60°	65°	70°	75°		
0.0	49.28 (1.3640)	52.33 (1.3905)	55.20 (1.4137)	57.87 (1.4390)	60.50 (1.4629)		
9.82 (0.97714)	41.05 (1.2596)	44.55 (1.2892)	47.88 (1.3180)	51.14 (1.3461)	54.38 (1.3738)		
19.90 (0.96150)	32.10 (1.1628)	35.80 (1.1910)	39.52 (1.2190)	43.16 (1.2456)	46.78 (1.2735)		
29.89 (0.94424)	24.09 (1.0802)	27.39 (1.0987)	30.77 (1.1199)	34.45 (1.1433)	38.38 (1.1685)		
49.90 (0.90191)	11.58 (0.9508)	13.50 (0.9592)	15.60 (0.9692)	17.94 (0.9805)	20.60 (0.9930)		
69.83 (0.85510)	3.457 (0.8554)	3.993 (0.8542)	4.575 (0.8531)	5.207 (0.8524)	5.945 (0.8520)		
92.63 (0.79769)	0.236 (0.7814)	0.284 (0.7779)	0.349 (0.7742)	0.422 (0.7705)	0.501 (0.7668)		

# K KALIUM

## SOLUBILITY OF POTASSIUM NITRATE IN AQUEOUS ALCOHOL SOLUTIONS (Gerardin, 1865)

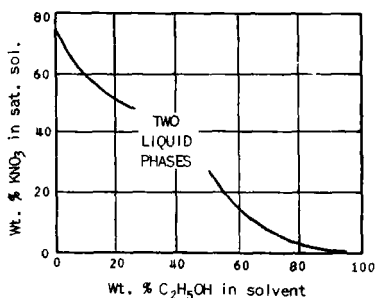
Grams $\text{KNO}_3$ per 100 Grams Aqueous Alcohol of Sp. Gr.:								
t°	0.9904 = 5.5	0.9843 = 9.35	0.9793 = 13.6	0.9726 = 19.1	0.9571 = 30	0.939 = 40	0.8967 = 60	0.8429 = 90
	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %
10	17	13	10	7	4.5	3	1	0.2
18	22.5	18.5	14.5	10	6.2	4.5	1.6	0.3
20	24	20	16	11	7.0	5	2	0.3
25	29	24.5	20	13.5	9.0	6.5	2.5	0.4
30	36	30	25	17	11.5	8	3.0	0.5
40	52	43	36	27	16.5	11	4	0.6
50	72	61	50	38	23.0	16	6	0.7
60	93	79	69	52	31.0	21	8	1.1

## SOLUBILITY OF POTASSIUM NITRATE IN AQUEOUS ALCOHOL AT 18° (Bodlander, 1891)

Sp. Gr. of Solution	Gms. per 100 cc. Solution			Sp. Gr. of Solution	Gms. per 100 cc. Solution		
	$\text{C}_2\text{H}_5\text{OH}$	$\text{H}_2\text{O}$	$\text{KNO}_3$		$\text{C}_2\text{H}_5\text{OH}$	$\text{H}_2\text{O}$	$\text{KNO}_3$
1.1480	--	89.80	25.0	1.0120	23.33	69.81	8.06
1.1085	3.30	87.44	20.11	0.9935	28.11	64.74	6.50
1.1010	5.24	86.26	18.60	0.9585	37.53	54.21	4.11
1.0805	8.69	83.18	16.18	0.9450	42.98	48.15	3.37
1.0755	9.06	83.10	15.39	0.9050	51.23	27.32	1.95
1.0655	14.08	77.93	14.54	0.8722	61.65	24.74	0.83
1.0490	16.27	76.36	12.27	0.8375	69.60	13.95	0.20
1.0375	19.97	72.93	10.8				

## SOLUBILITY OF $\text{KNO}_3$ IN ETHANOL - WATER MIXTURES AT THE BOILING POINT (Rieder and Thompson, 1950)

Viscosities were also determined.



100 gms. aq. 40 weight %  $\text{C}_2\text{H}_5\text{OH}$ , simultaneously saturated with the two salts, dissolve 13.74 gms.  $\text{KNO}_3$  + 15.78 gms.  $\text{NaCl}$  at 25°.  
(Soch, 1898)

SOLUBILITY OF POTASSIUM NITRATE IN ISOPROPYL ALCOHOL - WATER MIXTURES  
(Thompson and Molstad, 1945)

Results are in gms.  $\text{KNO}_3$  per 100 gms. Sat. Sol. Densities (in parentheses) are gms./ml. in vacuo.

Solvent Wt. % Isopropyl Alcohol (Density at 35°)	Temperature					
	25°	30°	35°	40°	45°	50°
0.0	27.24 (1.1864)	31.49 (1.2167)	35.40 (1.2458)	39.02 (1.2740)	42.64 (1.3059)	46.11 (1.3358)
5.07 (0.98510)	22.86 (1.1416)	26.62 (1.1681)	30.38 (1.1951)	34.13 (1.2219)	37.85 (1.2503)	41.50 (1.2792)
7.01 (0.98186)	21.16 (1.1255)	24.91 (1.1506)	28.64 (1.1764)	32.34 (1.2034)	36.03 (1.2304)	39.72 (1.2751)
9.96 (0.97726)	18.96 (1.1046)	22.44 (1.1256)	25.98 (1.1478)	29.53 (1.1720)	33.32 (1.1998)	37.13 (1.2294)
19.89 (0.96112)	13.14 (1.0448)	16.06 (1.0610)	19.11 (1.0790)	22.42 (1.0988)	26.15 (1.1218)	
29.88 (0.94087)	9.53 (1.0021)	11.85 (1.0131)	14.27 (1.0242)	17.00 (1.0380)	20.25 (1.0550)	
49.94 (0.89417)	4.44 (0.9277)	5.78 (0.9296)	7.09 (0.9318)	8.33 (0.9348)	9.50 (0.9380)	
69.84 (0.84647)	1.495 (0.8626)	1.785 (0.8597)	2.099 (0.8570)	2.456 (0.8545)	2.876 (0.8524)	3.346 (0.8505)
79.86 (0.82248)	0.488 (0.8341)	0.603 (0.8297)	0.720 (0.8256)	0.837 (0.8216)	0.956 (0.8177)	1.075 (0.8140)
87.60 (0.80358)	0.126 (0.8136)	0.151 (0.8088)	0.178 (0.8041)	0.206 (0.8000)	0.237 (0.7948)	0.271 (0.7896)
	55°	60°	65°	70°	75°	
0.0	49.28 (1.3640)	52.33 (1.3905)	55.20 (1.4137)	57.87 (1.4390)	60.50 (1.4629)	
5.07 0.98510	45.03 (1.3090)	48.39 (1.3381)	51.56 (1.3665)	54.56 (1.3930)	57.52 (1.4186)	
7.01 (0.98186)	43.36 (1.2850)	46.84 (1.3166)	50.38 (1.3502)			
9.96 (0.97726)	41.14 (1.2610)					
69.84 (0.84647)	3.847 (0.8486)					
79.86 (0.82248)	1.213 (0.8103)	1.425 (0.8068)	1.675 (0.8032)	1.841 (0.7966)		
87.60 (0.80358)	0.312 (0.7851)	0.365 (0.7806)	0.411 (0.7766)	0.443 (0.7727)	0.477 (0.7689)	

(Cont.)

# K KALIUM

## [TWO-PHASE DATA $\text{KNO}_3$ - ISOPROPANOL - WATER]

t°	Upper Layer			Lower Layer		
	Wt. % $\text{KNO}_3$ in	Density Sat. Sol.	Wt. % Alcohol in Solvent	Wt. % $\text{KNO}_3$ in	Density Sat. Sol.	Wt. % Alcohol in Solvent
	Sat. Sol.	Sol.		Sat. Sol.	Sol.	
50	7.52	0.8892	5.92	31.55	1.1852	17.5
55	4.197	.8531	68.7	40.22	1.2510	11.2
60	3.185	.8293	73.1	45.82	1.3043	8.4
65	2.491	.8150	76.4	50.25	1.3486	6.9
70	2.000	.8036	78.9	54.11	1.3862	5.8
75	1.75	.7932	80.8	57.43	1.4125	5.1

# NO

## SOLUBILITY OF POTASSIUM NITRATE IN AQUEOUS ACETONE AT 40° (Bathrick, 1896)

Solvent	Gms. $\text{KNO}_3$ per 100 Gms. Solvent	Solvent	Gms. $\text{KNO}_3$ per 100 Gms. Solvent
Wt. % Acetone		Wt. % Acetone	
0	64.5	44.1	17.0
8.5	51.3	53.9	11.9
16.8	38.9	64.8	7.2
25.2	22.8	76.0	3.0
34.3	24.7	87.6	0.7

Rothchild, Templeton, and Hall (1948) studied the distribution of  $\text{KNO}_3$  between methyl n-hexyl ketone and water at room temperature. 14.5 gms.  $\text{KNO}_3$  were dissolved in 100 gms. of saturated aqueous phase and  $(0.0085) \times (14.5)$  in the ketone phase.

## SOLUBILITY OF POTASSIUM NITRATE IN AQUEOUS SOLUTIONS OF URETHAN AT 25° (Palitsch, 1928, 1929)

Gm. Mols. per 1000 gms. $\text{H}_2\text{O}$		Solid Phase	Gm. Mols. per 1000 gms. $\text{H}_2\text{O}$		Solid Phase
$\text{KNO}_3$	$\text{NH}_2\text{COOC}_2\text{H}_5$		$\text{KNO}_3$	$\text{NH}_2\text{COOC}_2\text{H}_5$	
3.772	0.0	$\text{KNO}_3$	1.911	13.35	$\text{KNO}_3$
3.372	1.1225	"	1.592	27.76	"

The system Potassium Nitrate - Urea - Water was studied by Polosin and Vasil'eva, 1956. The eutectic lies at  $-13.4^\circ$ , with the solution containing 31.60%  $\text{CO}(\text{NH}_2)_2$  and 5.50%  $\text{KNO}_3$ . Data up to  $+40^\circ$  are given.

100 gms.  $\text{H}_2\text{O}$  saturated with sugar and  $\text{KNO}_3$  dissolve 224.7 gms. sugar + 41.9 gms.  $\text{KNO}_3$ , or 100 gms. of the saturated solution contain 61.36 gms. sugar + 11.45 gms.  $\text{KNO}_3$  at  $31.25^\circ$ . (Kohler, 1897)

0.37 gms.  $\text{KNO}_3$  dissolve in 100 gms. of ethylenediamine at  $25^\circ$ .  
(Isbin and Kobe, 1945)

100 gms. trichlorethylene dissolve 0.01 gm.  $\text{KNO}_3$  at  $15^\circ$ .  
(Wester and Bruins, 1914)

THE SYSTEM  $\text{KNO}_3$  - UREA  
(Howells, 1931)

$t^\circ$	Gms. $\text{KNO}_3$ per 100 gms. Mixture	Solid Phase	$t^\circ$	Gms. $\text{KNO}_3$ per 100 gms. Mixture	Solid Phase
151.6	36.90	$\text{KNO}_3$	110.1	24.6	$\text{KNO}_3$
136.1	32.64	"	109.5	24.59	" + $\text{NH}_2\text{CONH}_2$
129.8	31.09	"	110.9	21.79	$\text{NH}_2\text{CONH}_2$
129.0*	--	"	115.6	14.75	"
124.9	29.61	"	121.2	8.93	"
120.1	27.79	"	128.9	2.52	"
			132.2 m. pt.	0.0	"

NO

\*Point of transition of rhombohedral  $\text{KNO}_3$  into rhombic  $\text{KNO}_3$ .

SOLUBILITY OF POTASSIUM NITRATE IN GLACIAL ACETIC ACID SOLUTIONS  
OF AMMONIUM CHLORIDE AND OF AMMONIUM NITRATE AT  $25^\circ$   
(Seward and Humblet, 1932)

Results for  $\text{CH}_3\text{COOH} + \text{NH}_4\text{Cl}$

Gms. per liter		Solid Phase
$\text{NH}_4\text{Cl}$	$\text{KNO}_3$	
0.097	2.122	$\text{KNO}_3$
0.195	2.218	"
0.405	2.464	"
0.653	2.829	"

Results for  $\text{CH}_3\text{COOH} + \text{NH}_4\text{NO}_3$

Gms. per liter		Solid Phase
$\text{NH}_4\text{NO}_3$	$\text{KNO}_3$	
0.00	1.848	$\text{KNO}_3$
0.592	1.919	"
2.035	1.982	"

THE SYSTEM  $\text{KNO}_3$  -  $\text{HNO}_3$

(Potier and Potier, 1957; also Dunning and Nutt, 1951, Derby, 1918)

$t^\circ$	Mole % $\text{KNO}_3$	Solid Phase	$t^\circ$	Mole % $\text{KNO}_3$	Solid Phase
-41.6	0	$\text{HNO}_3$	-15.7	15.0	$\text{KNO}_3 \cdot 2\text{HNO}_3$
-42.5	2.0	"	-15.4	15.1	"
-44.0	4.0	"	-5.2	17.6	"
-46.1	6.0	"	0.0	19.0	"
-48.7	8.0	"	+ 8.6	21.2	"
-51.3	9.7	" + $\text{KNO}_3 \cdot 2\text{HNO}_3$	14.7	23.7	"
-39.0	11.5	$\text{KNO}_3 \cdot 2\text{HNO}_3$	20.3	28.5	"
-34.8	11.7	"	22.2	31.5	"
-27.5	12.5	"	22.0	35.3	" + $\text{KNO}_3 \cdot \text{HNO}_3$
-23.0	13.8	"	31.3	38.8	$\text{KNO}_3 \cdot \text{HNO}_3$ + $\text{KNO}_3$
-21.9	13.6	"	*20.7	38.6	$\text{KNO}_3 \cdot 2\text{HNO}_3$ + $\text{KNO}_3$

\*Metastable



## K KALIUM

## SOLUBILITY OF POTASSIUM NITRATE IN LIQUID AMMONIA

t°	d. of sat. sol.	Gms. KNO <sub>3</sub> per 100 gms.		Author
		sat. sol.	NH <sub>3</sub>	
0.0	--	9.52	10.52	(Linhard and Stephan, 1933, 1934)
0.1	0.695	9.7	10.74	(Schattenstein and Monossohn, 1932)
0.12	0.695	9.58	--	(Schattenstein and Viktorov, 1936)
25	0.672	10.56	--	(Schattenstein and Viktorov, 1936)
25	0.672	10.55	--	(Schattenstein and Monossohn, 1932)
25.0	--	9.42	10.4	(Hunt, 1932)

100 cc. anhydrous hydrazine dissolve 14 gms. KNO<sub>3</sub> at room temperature.  
(Welsh and Broderson, 1915)

NO

Melting point data have been determined for the following:

KNO <sub>3</sub> + LiNO <sub>3</sub>	(Corveth, 1898; Harkins and Clark, 1915; Protsenko and Shelomov, 1953; Protsenko, 1952a)
KNO <sub>3</sub> + KOH	(Retortille and Moles, 1933; Bergman and Reshetnikov, 1954; Reshetnikov and Vilutis, 1958)
KNO <sub>3</sub> + NH <sub>4</sub> NO <sub>3</sub>	(Perman and Saunders, 1923; Janecke, 1928, 1949)
KNO <sub>3</sub> + NH <sub>4</sub> NO <sub>3</sub> + Pb(NO <sub>3</sub> ) <sub>2</sub>	(Glass, Laybourn and Madgin, 1932, 1933)
KNO <sub>3</sub> + NaNO <sub>3</sub>	(Kagan and Kamyschan, 1932; Janecke, 1942, 1949; Carvetti, 1898; Hissink, 1900; Quartaralli, 1920; Briscoe and Madgin, 1923; Glass, Labourn and Madgin, 1932, 1933; Palkin, 1949b; Kofler, 1955; Protsenko and Bergman, 1950)
KNO <sub>3</sub> + NaNO <sub>3</sub> + PbNO <sub>3</sub>	(Laybourn and Madgin, 1932)
KNO <sub>3</sub> + NaNO <sub>3</sub> + Sr(NO <sub>3</sub> ) <sub>2</sub>	(Harkins and Clark, 1915)
KNO <sub>3</sub> + Pb(NO <sub>3</sub> ) <sub>2</sub> + Pb <sub>3</sub> O <sub>4</sub>	(Freeman, Laybourn and Madgin, 1933)
KNO <sub>3</sub> + RbNO <sub>3</sub>	(Puschin and Rudoiic, 1937)
KNO <sub>3</sub> + Sr(NO <sub>3</sub> ) <sub>2</sub>	(Hawkins and Clark, 1915; Protsenko and Bergman, 1951; Gromakov and Gromakova, 1953)
KNO <sub>3</sub> + TlBr	(Rostkowski, 1929)
KNO <sub>3</sub> + TlNO <sub>3</sub>	(Van Eyk, 1899, 1905; Palkin, 1949b; Protsenko and Shelomov, 1953)
KNO <sub>3</sub> + NH <sub>4</sub> NO <sub>3</sub> + NaNO <sub>3</sub>	(Campbell and Campbell, 1947; Janecke, 1949)
KNO <sub>3</sub> + Mg(NO <sub>3</sub> ) <sub>2</sub>	(Janecke, 1942)
KNO <sub>3</sub> + Mg(NO <sub>3</sub> ) <sub>2</sub> + NaNO <sub>3</sub>	( " " )
KNO <sub>3</sub> + NaNO <sub>3</sub> + TlNO <sub>3</sub>	(Leman, 1940)
2KNO <sub>3</sub> + Tl <sub>2</sub> SO <sub>4</sub> = 2TlNO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>	(Leman, 1940)
KNO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub> + Tl <sub>2</sub> Cl <sub>2</sub>	(Rostovskii, 1940)
2KNO <sub>3</sub> + Na <sub>2</sub> SO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + 2NaNO <sub>3</sub>	(Bergman and Wachsberg, 1947)
KNO <sub>3</sub> + Ca(NO <sub>3</sub> ) <sub>2</sub>	(Kitrov, 1947; Protsenko and Belova, 1957)
KNO <sub>3</sub> + NaNO <sub>2</sub> = KNO <sub>2</sub> + NaNO <sub>3</sub>	(Alexander and Hindin, 1947)
KNO <sub>3</sub> + N <sub>2</sub> H <sub>2</sub> ·HNO <sub>3</sub>	(Barlot and Marsaule, 1948)
KNO <sub>3</sub> + NaNO <sub>3</sub> + Sr(NO <sub>3</sub> ) <sub>2</sub>	(Protsenko and Bergman, 1951)
KNO <sub>3</sub> + NaClO <sub>3</sub>	(Platonov, 1946b)
KNO <sub>3</sub> + LiNO <sub>3</sub> + TlNO <sub>3</sub>	(Protsenko and Shelomov, 1953)
KNO <sub>3</sub> + LiOH = KOH + LiNO <sub>3</sub>	(Diogenov, 1951)
KNO <sub>3</sub> + Na acetate = K acetate + NaNO <sub>3</sub>	(Bergman and Evdokimova, 1956)
2KNO <sub>3</sub> + Ca(NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>2</sub> + Ca(NO <sub>3</sub> ) <sub>2</sub>	(Protsenko and Belova, 1957)
2KNO <sub>3</sub> + Ba(NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>2</sub> + Ba(NO <sub>3</sub> ) <sub>2</sub>	(Protsenko and Malakhova, 1957)
KNO <sub>3</sub> + K <sub>2</sub> WO <sub>4</sub>	(Kislova, Posypaiko and Bergman, 1955)
KNO <sub>3</sub> + NaOH	(Bergman and Reshetnikov, 1954; Reshetnikov and Vilutis, 1958)
KNO <sub>3</sub> + Na <sub>2</sub> SO <sub>4</sub> + Na <sub>2</sub> CrO <sub>4</sub>	(Rassonskaya and Bergman, 1953)

The temperatures at which  $\text{KNO}_3 + \text{TiBr}$  are completely immiscible, alone and with added salts, were determined by Semenchenko and Shaahkina, 1945.

Studies of the cryoscopy of various salts (up to 0.1 M) in molten  $\text{KNO}_3$  were made by Kordes, Bergman and Vogel, 1951.

# POTASSIUM NIOBATE $\text{KNbO}_3$

NbO

## SOLUBILITY IN WATER

(Lapitakii, Shishkina, Pchelkina, and Stepanov, 1955)

t°	Mg. per 100 ml. sat. sol.	Moles per liter
0	13.36	$7.4 \times 10^{-4}$
25	15.54	$8.7 \times 10^{-4}$
50	78.29	$4.4 \times 10^{-3}$
75	171.1	$9.5 \times 10^{-3}$
100	234.4	$1.3 \times 10^{-2}$

Melting points are given for:

$\text{KNbO}_3 + \text{NaNbO}_3$  (Reisman and Banks, 1958; Shirane, Newnham, and Pepinsky, 1954)  
 $\text{KNbO}_3 + \text{KTaO}_3$  ( " " " ; Reisman, Triebwasser, and Holtzberg, 1955)

# POTASSIUM TARTRATONIOBATE $\text{K}_2\text{O} \cdot \text{Nb}_2\text{O}_5 \cdot (\text{C}_2\text{H}_4\text{O}_5)_2 \cdot 10\text{H}_2\text{O}$

## SOLUBILITY IN WATER

(Srinivasan, 1950)

The salt dissolves slowly and forms supersaturated solutions readily. After 96 hours, the solubility became constant at 2.60 gms./100 gms.  $\text{H}_2\text{O}$  at 25°. Data at 5°, 35° and in alcohol and tartaric acid solutions are also given but do not represent equilibrium conditions.

## K KALIUM

## OH POTASSIUM HYDROXIDE KOH

THE SYSTEM KOH - H<sub>2</sub>O

The results of Pickering, 1893 and Holzi, 1937 are in reasonable agreement. Single determinations by Ferchland 1902 (15°), Akerlof and Short, 1937 (25°), de Waal, 1910 (30°) and Cohen-Adad, 1957 (0°, 30°) also agree. The isolated results of de Forcrand, 1909, Greenish and Smith, 1901, and Shibata, Oda, and Furukawa, 1932 are in error. Thermal analysis by Nizhnik and Lastochkina in the range 60-97° KOH revealed only the monohydrate as a stable phase. Cohen-Adad and Michaud, 1956 found a pentahydrate stable below the eutectic.

Gms. KOH per 100 gms. sat. sol.			Solid Phase	t°	Gms. KOH per 100 gms. sat. sol.			Solid Phase
- 2.2	3.6	(P)	Ice	25	54.3	(AS)	KOH·2H <sub>2</sub> O	
-20.7	18.4	(P)	"		54.23	(H)	"	
-65.2	30.8	(P)	"	30	55.76	(P)	"	
-62.8	30.9	(CAM)	" + KOH·4H <sub>2</sub> O					
-36.2	26.6	(P)	KOH·4H <sub>2</sub> O		56.3	(CA)	"	
-32.7	43.8	(P)	"		55.75	(W)	"	
-33.7	43.7*	(CAM)	"					
-33	44.4	(P)	" + KOH·2H <sub>2</sub> O	32.5	57.44	(P)	" + KOH·H <sub>2</sub> O	
-34.0	45.2	(CAM)	" + "					
-23.2	45.9	(P)	KOH·2H <sub>2</sub> O	33	57.53	(H)	" + "	
0	49.2	(P)	"	40	58.03	(H)	KOH·H <sub>2</sub> O	
	49.	(CA)	"	50	58.33	(P)	"	
	48.85	(H)	"	65.3	60.36	(H)	"	
10	50.7	(P)	"	80	61.73	(H)	"	
11.5	51.07	(H)	"	100	65.15	(H)	"	
15	51.7	(F)	"		64.03	(P)	"	
20	52.8	(P)	"	125	68.06	(P)	"	
				143*	75.73	(P)	"	
				99	87	(CAM)	" + KOH	
				401	100	(CAM)	KOH	

\*Melting point.

Data for the system KOH + NH<sub>3</sub> + H<sub>2</sub>O are given by Janecke, 1933(a). Weighed amounts of the three components were placed in small glass ampules which were then sealed. By warming or cooling these ampules, the upper and lower temperatures were determined at which a solid phase, two liquid layers or a combination of solid and liquid layers appeared or disappeared. The temperatures at which certain of the ampules exploded are also given.

Vuillard, 1957 studied this system by thermal analysis. An ice - dihydrate transition occurs at -98°, 32.9% NH<sub>3</sub>. A stable dihydrate - monohydrate eutectic occurs at -103.3°, 33.9% NH<sub>3</sub>.

THE SYSTEM POTASSIUM TARTRATE (*meso*) - POTASSIUM HYDROXIDE - WATER AT 17°  
(Peyronel, 1951)

T = tartrate A =  $K_2T \cdot 2H_2O$  B =  $K_2T \cdot KOH \cdot 3H_2O$  C =  $K_2T \cdot 2.5KOH \cdot 3H_2O$  D =  $KOH \cdot 2H_2O$

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
K <sub>2</sub> T	KOH	Solid Phase	K <sub>2</sub> T	KOH	Solid Phase	K <sub>2</sub> T	KOH	Solid Phase
40.75	0.0	A	61.40	19.40	B	37.70	38.50	C
27.11	10.47	A	45.12	29.71	B	37.38	38.40	C
20.70	18.32	A	64.45	18.90	B	24.32	42.43	C + D
18.80	23.08	A	45.85	29.78	B	27.80	43.90	C + D
18.35	26.57	A	55.95	23.98	B	24.18	42.25	C + D
19.62	29.53	A	47.90	30.10	B + C	21.21	47.25	C + D
24.93	30.42	A	43.50	32.05	C	20.78	47.10	C + D
32.45	29.61	A	44.75	32.25	C	12.82	47.80	D
42.00	26.67	A	37.85	34.55	C	5.23	56.35	D
43.10	27.03	A	42.75	33.98	C	25.20	42.27	D
56.40	23.00	A*	36.95	36.08	C	11.12	52.95	D
41.73	29.15	B	41.38	35.12	C	39.95	37.60	D*
50.65	24.30	B	30.35	38.23	C	23.05	46.93	D*
41.06	29.90	B	40.40	35.80	C	20.57	48.60	D*
61.80	19.15	B	27.33	40.40	C	37.42	38.30	D*
43.40	30.09	B	34.72	38.50	C	30.40	46.50	D*
62.40	19.07	B	26.68	41.38	C	32.00	44.25	D*

\* = metastable.

THE SYSTEM POTASSIUM HYDROXIDE - ETHYL ALCOHOL - WATER  
(Peyronel, 1949a; See also de Waal, below)

t°	Upper Layer		Lower Layer	
	Wt. % C <sub>2</sub> H <sub>5</sub> OH	Wt. % KOH	Wt. % C <sub>2</sub> H <sub>5</sub> OH	Wt. % KOH
17	56.40	30.10	0.64	52.80
	55.15	27.55	0.93	48.60
	54.52	26.35	1.34	45.45
	48.95	23.93	2.77	39.82
	29.50	27.08	10.13	32.68
30	58.70	31.73	0.48	56.66
	56.52	26.93	1.20	47.40
	48.17	22.13	3.87	47.83
	46.10	22.08	5.13	35.63
	36.04	23.63	9.84	33.62
	25.60	26.73	(One layer only)	
60	60.50	32.72	--	61.00
	59.24	24.90	1.36	48.70
	54.10	19.18	4.47	36.63
	43.45	19.83	8.88	31.80
	38.50	21.00	11.50	31.60
90	59.70	35.08	--	63.55
	60.40	24.95	0.90	47.60
	53.95	19.33	6.57	34.04
	47.70	18.50	9.78	31.20

## K KALIUM

SOLUBILITY OF POTASSIUM HYDROXIDE IN AQUEOUS SOLUTIONS OF ETHYL  
ALCOHOL AT 30°  
(de Waal, 1910)

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
KOH	C <sub>2</sub> H <sub>5</sub> OH	H <sub>2</sub> O		KOH	C <sub>2</sub> H <sub>5</sub> OH	H <sub>2</sub> O	
55.75	0	44.25	KOH·2H <sub>2</sub> O	27.67	69.92	2.41	KOH·2H <sub>2</sub> O
54.81	0.43	44.76	"	27.20	73.01	negative*	"
Two liquid layers are formed here.				26.25	81.95	"	"
31.00	57.50	11.50	KOH·2H <sub>2</sub> O				
28.99	65.07	5.94	"				

OH \*Negative on account of reaction  $\text{KOH} + \text{C}_2\text{H}_5\text{OH} \rightarrow \text{C}_2\text{H}_5\text{OK} + \text{H}_2\text{O}$ .

SOLUBILITY OF POTASSIUM HYDROXIDE IN AQUEOUS SOLUTIONS OF ACETONE AT 0°  
(Gibby, 1934)

The binodal curve was determined by titrating acetone into aqueous KOH solutions until a permanent separation into two layers occurred. Tie lines, \*, were located by means of mixtures which yielded sufficient amounts of the two layers to be used for titrating the KOH in each.

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
KOH	C <sub>3</sub> H <sub>6</sub> O	KOH	C <sub>3</sub> H <sub>6</sub> O	KOH	C <sub>3</sub> H <sub>6</sub> O	KOH	C <sub>3</sub> H <sub>6</sub> O
0.4	80.1	2.2	55.1	15.1	11.1	25.0	--
0.6	70.1	3.0	50.4	16.2	9.8	27.2	2.0
0.7	70.5	4.4	41.7	17.9	7.8	28.4	1.3
1.7	58.6	4.8	41.1	20.7	5.5	28.8	--*
2.0	52.7	8.2	26.6	21.3	5.2	37.9	--*
				24.1	--*	43.8	0.4

THE SYSTEM POTASSIUM HYDROXIDE - DIOXANE - WATER AT 25°  
(Duhamel and Laurent, 1952, 1954; Laurent and Duhamel, 1953)

Dioxane was added to KOH solutions until a second liquid phase formed. The data are points on the binodal curve.

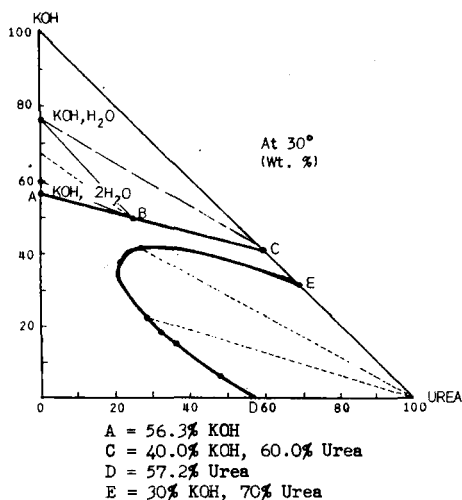
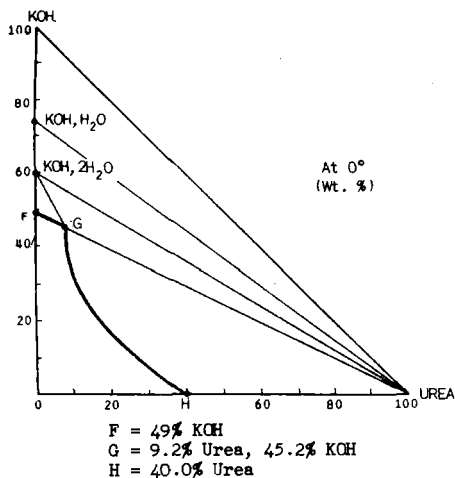
Wt. %			Wt. %			Wt. %		
KOH	Dioxane	Density	KOH	Dioxane	Density	KOH	Dioxane	Density
53.89	0.00	1.544	17.90	8.63	1.167	2.89	53.26	1.055
42.90	0.45	1.47	15.50	11.90	"	2.45	55.45	"
38.75	0.55	"	13.60	15.00	1.133	2.00	59.00	1.050
34.25	0.76	1.43	10.59	22.20	"	1.69	60.71	"
33.10	1.58	"	8.51	27.60	1.103	1.39	62.56	"
30.85	1.80	1.285	7.02	33.20	1.084	1.15	64.05	"
28.50	2.29	"	5.78	38.70	1.076	0.94	66.51	"
23.90	3.88	1.221	4.85	43.40	"	0.80	68.25	"
20.72	5.20	"	3.60	50.00	1.055	0.00	100.0	1.030

Data for the Systems KOH - acetone - water and KOH - pyridine - water at 25° are given in graphical form by Laurent and Duhamel, 1953.

Data for equilibrium in the system potassium hydroxide - phenol - water at 25° are given by van Meurs (1916).

Data for the system potassium tartrate - potassium hydroxide - ethanol - water at 18° are given by Peyronel and Venosta, 1952. The system forms two liquid phases and the compositions of several conjugate liquids are given.

THE SYSTEM POTASSIUM HYDROXIDE - UREA - WATER  
(Cohen-Adad, 1957)



# K KALIUM

## SOLUBILITY OF POTASSIUM HYDROXIDE IN METHYL ALCOHOL AND IN ETHYL ALCOHOL (Murray, 1929)

The mixtures were shaken occasionally during about three weeks.

t°	Solvent	Formula	d. of sat. sol.	Gms. KOH per 100		Normality of sat. sol.
				cc. sat. sol.	gms. sat. sol.	
28	Methyl Alcohol	CH <sub>3</sub> OH	1.14	40.3	35.5	7.19
28	Ethyl Alcohol	C <sub>2</sub> H <sub>5</sub> OH	1.04	29.0	27.9	5.17

## THE SYSTEM POTASSIUM HYDROXIDE - HYDRAZINE - WATER AT 50° (Penneman and Andrieth, 1949)

Gms. per 100 gms. Sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
N <sub>2</sub> H <sub>4</sub>	KOH		N <sub>2</sub> H <sub>4</sub>	KOH	
91.9	1.8	KOH·H <sub>2</sub> O	38.2	32.2	KOH·H <sub>2</sub> O
68.8	12.8	"	19.1	45.6	"
59.1	19.1	"	13.0	50.2	"
42.7	29.3	"	4.8	56.0	"

Melting point data are given for the following:

KOH + LiOH	(Unzhakov, 1952; Reshetnikov and Diogenov, 1952) (Reshetnikov and Unzhakov, 1953)
KOH + NaOH	(von Hevesy, 1900)
KOH + RbOH	( " " " )
KOH + KI	(Scarpa, 1915)
2KOH + Na <sub>2</sub> SO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + 2NaOH	(Bergman and Khitrov, 1952)
K <sub>2</sub> O + V <sub>2</sub> O <sub>5</sub>	(Illarionov, Ozerov and Kildisheva, 1956, 1957) (Canneri, 1928)
K <sub>2</sub> O + Ta <sub>2</sub> O <sub>5</sub>	(Reisman, Holtzberg, Berkenblit and Berry, 1956)
K <sub>2</sub> O + Nb <sub>2</sub> O <sub>5</sub>	( " " " " " " )

# F POTASSIUM FLUOPHOSPHATE KPF<sub>6</sub>

## SOLUBILITY IN WATER (Sarmousakis and Low, 1955)

t°	Gms. KPF <sub>6</sub> per 100 gms. sat. sol.	t°	Gms. KPF <sub>6</sub> per 100 gms. sat. sol.	t°	Gms. KPF <sub>6</sub> per 100 gms. sat. sol.
0	3.560	35	11.15	70	24.61
4.5	4.242	40	12.85	75	27.29
10.5	5.270	45	14.82	80	29.38
16.2	6.400	50	16.48	85	31.96
20.2	7.30	55	18.22	90	34.03
25	8.35*	60	20.29	95	35.88
30	9.69	65	22.49	100	38.30

\*Lange and Muller, 1930 report 0.432 moles/l at 22.5°, in agreement with the data above.

## POTASSIUM PHOSPHATES

PO

THE SYSTEM  $K_2O - P_2O_5 - H_2O$   
(Ravich, 1938a; Berg, 1938, 1938a)

The results of these authors are in good agreement. Earlier data are given by Janecke, 1927; D'Ans and Schreiner, 1910a; Parker, 1914. A review of the system is given by Wendrow and Kobe, 1954; Crystallographic data are given by Berg and Bokii, 1940. The results of Flatt, Brunisholz and Bourgeois, 1956 at 25° are similar to those listed.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
K <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>		K <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>	
Results at 0°					
0.0	57.17	2H <sub>3</sub> PO <sub>4</sub> ·H <sub>2</sub> O	27.05	23.01	K <sub>2</sub> HPO <sub>4</sub> ·6H <sub>2</sub> O
1.64	58.01	"	25.94	20.80	"
3.78	58.84	"	24.91	18.82	"
4.89	59.57	"	26.92	18.60	"
5.06	59.50	2H <sub>3</sub> PO <sub>4</sub> ·H <sub>2</sub> O + KH <sub>5</sub> (PO <sub>4</sub> ) <sub>2</sub>	29.35	18.72	"
*5.75	62.01	KH <sub>5</sub> (PO <sub>4</sub> ) <sub>2</sub>	31.29	19.75	"
*5.51	61.60	"	32.62	19.80	K <sub>2</sub> HPO <sub>4</sub> ·6H <sub>2</sub> O + K <sub>3</sub> PO <sub>4</sub> ·7H <sub>2</sub> O
*5.27	61.11	"	32.83	19.80	K <sub>3</sub> PO <sub>4</sub> ·7H <sub>2</sub> O
4.93	58.92	"	32.28	19.53	"
4.38	56.12	"	31.26	17.55	"
4.33	55.87	"	30.20	15.81	"
5.30	50.19	"	29.46	14.80	"
6.05	47.93	"	29.60	13.59	"
8.15	45.02	"	29.28	13.41	"
10.37	43.62	"	29.18	11.98	"
10.54	43.49	KH <sub>5</sub> (PO <sub>4</sub> ) <sub>2</sub> + KH <sub>2</sub> PO <sub>4</sub>	29.20	7.25	"
*10.92	45.04	KH <sub>2</sub> PO <sub>4</sub>	29.16	6.76	"
10.22	41.76	"	33.19	2.12	"
8.93	35.92	"	38.16	1.74	"
8.17	32.30	"	40.16	2.11	"
6.85	22.48	"	41.82	2.70	K <sub>2</sub> PO <sub>4</sub> ·7H <sub>2</sub> O + KOH·2H <sub>2</sub> O
5.75	15.75	"	*36.23	21.04	K <sub>3</sub> PO <sub>4</sub> ·9H <sub>2</sub> O
4.89	9.75	"	*33.65	18.74	"
4.41	6.66	"	*32.65	17.45	"
6.35	8.05	"	*31.70	15.92	"
8.50	9.80	"	*31.18	14.40	"
15.18	15.10	"	*31.40	12.26	"
16.20	15.98	"	*31.52	12.00	"
21.18	19.86	"	*32.24	11.16	"
22.49	20.45	"	*36.82	11.00	"
27.10	24.00	"	*41.75	16.67	K <sub>3</sub> PO <sub>4</sub> ·3H <sub>2</sub> O
27.63	23.97	KH <sub>2</sub> PO <sub>4</sub> + K <sub>2</sub> HPO <sub>4</sub> ·6H <sub>2</sub> O	*40.93	12.52	"
*29.24	25.23	?	*41.14	5.92	"
*30.54	25.69	?	*41.86	3.66	"
*31.50	25.58	K <sub>2</sub> HPO <sub>4</sub> ·3H <sub>2</sub> O	*42.30	2.99	KOH·2H <sub>2</sub> O
*31.03	24.05	"	*41.95	2.62	"
*30.86	23.26	"	*41.80	2.17	"
*32.70	22.23	"	*41.68	1.50	"
34.38	21.90	K <sub>2</sub> HPO <sub>4</sub> ·3H <sub>2</sub> O + K <sub>3</sub> PO <sub>4</sub> ·7H <sub>2</sub> O	*41.01	0.0	"
34.49	22.06				

\*Metastable

(Cont.)



## K KALIUM

THE SYSTEM  $K_2O - P_2O_5 - H_2O$ —Cont.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$K_2O$	$P_2O_5$	Solid Phase	$K_2O$	$P_2O_5$	Solid Phase
Results at 25°					
*47.25	0.0	KOH·H <sub>2</sub> O	35.53	29.09	$K_2HPO_4 \cdot KH_2PO_4 \cdot 3H_2O + K_2HPO_4 \cdot 3H_2O$
45.51	0.0	KOH·2H <sub>2</sub> O	35.51	28.96	
*47.49	1.37	KOH·H <sub>2</sub> O + $K_3PO_4 \cdot 3H_2O$	35.16	29.01	
*46.18	1.73	$K_3PO_4 \cdot 3H_2O$	35.01	29.19	$K_2HPO_4 \cdot KH_2PO_4 \cdot 3H_2O$
*45.92	1.78	"	34.48	29.39	"
45.90	1.86	KOH·2H <sub>2</sub> O + $K_3PO_4 \cdot 3H_2O$	33.32	28.30	$KH_2PO_4$
45.75	1.85	"	32.65	27.75	"
43.20	3.75	$K_3PO_4 \cdot 3H_2O$	31.30	27.12	"
41.69	9.04	"	26.33	24.23	"
41.53	9.52	$K_3PO_4 \cdot 3H_2O + K_3PO_4 \cdot 7H_2O$	20.12	19.67	"
41.50	9.57	"	17.68	18.13	"
*41.67	9.61	$K_3PO_4 \cdot 3H_2O$	14.20	15.89	"
*41.63	11.78	"	11.66	13.37	"
*41.55	13.51	"	7.77	10.73	"
*41.50	14.56	"	7.14	10.45	"
*41.70	15.19	"	6.87	10.17	"
*41.58	15.23	"	6.90	11.00	"
*41.56	15.45	"	7.06	11.44	"
*41.87	16.54	"	7.08	12.12	"
*42.01	17.44	"	8.49	20.35	"
*42.12	17.69	"	9.52	26.89	"
*42.44	20.78	"	10.19	32.90	"
*43.34	26.75	$K_3PO_4 \cdot 3H_2O + K_2HPO_4$	11.69	42.42	"
37.18	8.15	$K_3PO_4 \cdot 7H_2O$	12.50	46.38	"
34.39	10.99	"	*12.68	47.40	"
34.06	16.70	"	*12.91	49.90	"
39.42	24.17	$K_3PO_4 \cdot 7H_2O + K_2HPO_4 \cdot 3H_2O$	*13.67	50.76	"
*41.48	25.62	$K_3PO_4 \cdot 7H_2O$	*14.27	52.78	"
*41.64	27.21	$K_2HPO_4$	*14.29	53.94	"
*41.07	27.46	"	12.77	47.16	$KH_2PO_4 + KH_5(PO_4)_2$
*40.40	28.12	"	11.83	47.73	$KH_5(PO_4)_2$
*40.22	27.79	"	10.27	48.66	"
*37.59	30.03	"	9.69	49.40	"
*37.20	30.72	"	8.36	51.58	"
*36.96	30.65	"	8.10	51.91	"
*41.90	24.89	$K_2HPO_4 \cdot 3H_2O$	6.99	55.23	"
*40.33	24.62	"	6.85	56.80	"
36.69	24.37	"	8.36	65.08	"
34.15	25.48	"	8.76	65.94	"
34.05	25.52	"	0.0	64.41	$2H_3PO_4 \cdot H_2O$
34.22	26.02	"	0.46	64.40	"
34.13	26.39	"	1.13	64.83	"
34.22	26.90	"	1.27	64.86	"
34.55	27.57	"	1.93	65.03	"
34.92	28.90	"	2.35	65.16	"
*37.46	29.47	$K_2HPO_4 \cdot KH_2PO_4 \cdot 3H_2O$	0.89	67.55	"
*35.84	28.95	"			

\*Metastable

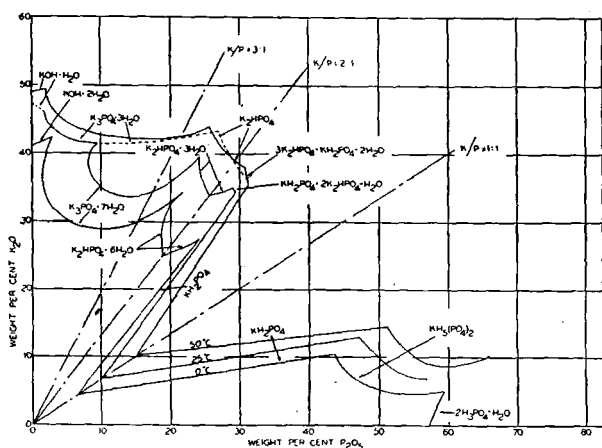
(Cont.)

THE SYSTEM  $K_2O - P_2O_5 - H_2O$ —Cont.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
K <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>		K <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>	
Results at 50°					
48.83	0.0	KOH·H <sub>2</sub> O	35.69	31.91	K <sub>2</sub> HPO <sub>4</sub> ·KH <sub>2</sub> PO <sub>4</sub> ·2H <sub>2</sub> O
49.44	2.13	KOH·H <sub>2</sub> O+K <sub>3</sub> PO <sub>4</sub> ·3H <sub>2</sub> O	35.77	31.10	KH <sub>2</sub> PO <sub>4</sub>
*50.19	2.60	K <sub>3</sub> PO <sub>4</sub> ·3H <sub>2</sub> O      *?	35.58	31.16	"
46.60	2.64	"      *?	35.54	31.30	"
46.50	2.95	"	35.35	31.44	"
44.88	4.70	"	34.00	30.30	"
43.12	7.80	"	33.79	29.93	"
42.35	12.36	"	33.70	30.25	"
42.30	15.64	"	32.80	29.69	"
42.25	21.07	"	31.80	29.08	"
42.89	23.55	"	27.91	26.78	"
43.80	25.64	K <sub>3</sub> PO <sub>4</sub> ·3H <sub>2</sub> O + K <sub>2</sub> HPO <sub>4</sub>	25.60	25.20	"
42.39	26.14	K <sub>2</sub> HPO <sub>4</sub>	25.25	24.80	"
41.72	26.92	"	21.78	22.71	"
41.39	26.87	"	12.56	17.01	"
40.98	27.49	"	10.63	15.31	"
40.84	27.59	"	10.06	15.15	"
40.01	27.90	"	10.15	15.30	"
39.68	28.48	"	10.32	15.56	"
39.73	28.59	"	10.48	17.87	"
39.52	28.59	"	10.71	19.42	"
39.18	28.86	"	11.11	25.51	"
38.98	29.29	"	12.03	30.40	"
38.72	29.64	"	12.24	31.94	"
*38.70	30.00	?	12.96	39.74	"
38.12	31.13	K <sub>2</sub> HPO <sub>4</sub> + K <sub>2</sub> HPO <sub>4</sub> ·	13.22	40.85	"
37.96	31.24	KH <sub>2</sub> PO <sub>4</sub> ·2H <sub>2</sub> O (?)	14.21	49.71	"
*37.97	31.79	K <sub>2</sub> HPO <sub>4</sub>	14.30	49.87	"
38.50	29.60	3K <sub>2</sub> HPO <sub>4</sub> ·KH <sub>2</sub> PO <sub>4</sub> ·2H <sub>2</sub> O(?)	14.34	51.15	KH <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>
36.71	31.42	"	5.65	55.84	"
38.93	30.57	K <sub>2</sub> HPO <sub>4</sub> ·KH <sub>2</sub> PO <sub>4</sub> ·2H <sub>2</sub> O(?)	9.53	55.72	"
38.83	30.74	"	8.84	57.92	"
38.06	30.78	K <sub>2</sub> HPO <sub>4</sub> + K <sub>2</sub> HPO <sub>4</sub> ·	8.71	58.17	"
		KH <sub>2</sub> PO <sub>4</sub> ·2H <sub>2</sub> O(?)	8.68	60.24	"
36.65	31.02	K <sub>2</sub> HPO <sub>4</sub> ·KH <sub>2</sub> PO <sub>4</sub> ·2H <sub>2</sub> O	9.10	62.48	"
36.61	31.38	"	10.05	65.93	"

\*Metastable

# K KALIUM



The System  $K_2O - P_2O_5 - H_2O$  from  $0^\circ C$  to  $75^\circ C$  (Wendrow and Kobe, 1954)

## P0 POTASSIUM PHOSPHATE $K_3PO_4$ (ortho)

SOLUBILITY OF  $K_3PO_4$  IN WATER  
(Ravich, 1938)

t°	Saturated Solution		Solid Phase	t°	Saturated Solution		Solid Phase
	Wt. % $K_3PO_4$	Mole% $K_3PO_4$			Wt. % $K_3PO_4$	Mole% $K_3PO_4$	
-1.18	4.54	0.40	Ice	44.5	60.84	11.64	$K_3PO_4 \cdot 7H_2O$
-2.60	9.75	0.91	"	45.4	61.94	12.13	"
-4.6	15.43	1.52	"	45.6	62.51	12.39	"
-7.7	21.74	2.30	"	45.6	63.12	12.68	"
-12.0	27.34	3.09	"	45.4	--	--	$K_3PO_4 \cdot 7H_2O + K_3PO_4 \cdot 3H_2O$
-15.8	31.53	3.76	"				
-20.0	35.12	4.39	"	*25.0	63.17	12.70	$K_3PO_4 \cdot 3H_2O$
-24.0	38.33	5.00	Ice+ $K_3PO_4 \cdot 9H_2O$	*30.0	63.19	12.71	"
*-28.2	40.25	5.40	Ice+ $K_3PO_4 \cdot 7H_2O$	*35.0	63.33	12.77	"
-8.8	42.92	6.00	$K_3PO_4 \cdot 7H_2O$	*40.0	63.41	12.81	"
0	44.26	6.31	"	*45.0	63.56	12.89	"
10.0	46.83	6.95	"	50.0	63.80	13.00	"
20.0	49.62	7.71	"	60.0	64.08	13.14	"
25.0	51.42	8.23	"	*-7.7	43.85	6.21	$K_3PO_4 \cdot 9H_2O$
30.0	53.08	8.75	"	* 0	47.62	7.16	"
35.0	55.43	9.54	"	* 5.0	49.80	7.76	"
40.0	57.51	10.30	"	* 8.8	52.23	8.49	"
42.6	59.46	11.06	"	*12.3	57.72	10.00	"

\*Metastable

POTASSIUM MONOHYDROGEN PHOSPHATE  $K_2HPO_4$ 

PO

SOLUBILITY OF  $K_2HPO_4$  IN WATER  
(Ravich, 1938; Selva, 1947)

The data are in fairly good agreement.

Data of Ravich, 1938			Data of Selva, 1947		Solid Phase in each case
t°	Saturated Solution		t°	Sat. Sol.	
	Wt. % K <sub>2</sub> HPO <sub>4</sub>	Mole % K <sub>2</sub> HPO <sub>4</sub>		Wt. % K <sub>2</sub> HPO <sub>4</sub>	
- 4.2	16.78	2.04	- 4.2	16.44	Ice
- 6.4	23.60	3.09	- 7.4	25.92	
- 9.0	29.61	4.17	--	--	"
-11.7	34.10	5.07	-11.6	34.05	Ice + K <sub>2</sub> HPO <sub>4</sub> ·6H <sub>2</sub> O
-13.5	36.78	5.67	-13.9	36.67	
--	--	--	-10.0	38.80	K <sub>2</sub> HPO <sub>4</sub> ·6H <sub>2</sub> O
0.0	46.11	8.12	0.0	45.58	"
4.95	50.12	9.40	--	--	"
9.7	54.43	10.99	10.2	53.94	"
13.15	57.89	12.44	13.4	57.63	"
*14.6	60.82	13.82	--	--	" *
*14.85	61.73	14.29	--	--	" *
*14.7	62.96	14.94	--	--	" *
*12.8	65.95	16.68	--	--	" *
* 8.2	69.09	18.75	--	--	" *
14.3	--	--	14.7	60.2	" + K <sub>2</sub> HPO <sub>4</sub> ·3H <sub>2</sub> O
* 0.0	57.05	12.01	*0.0	57.28	K <sub>2</sub> HPO <sub>4</sub> ·3H <sub>2</sub> O*
*10.0	59.08	12.96	*10.2	58.86	" *
--	--	--	*13.4	59.76	" *
15.0	60.16	13.49	17.2	60.30	"
20.0	61.52	14.16	--	--	"
25.0	62.74	14.83	25.0	62.03	"
30.0	64.13	15.60	--	--	"
35.0	65.68	16.51	34.0	64.56	"
39.5	67.54	17.68	--	--	"
44.0	69.83	19.29	44.2	68.95	"
46.0	71.26	20.42	46.2	70.76	"
48.3	--	--	48.3	71.90	" + KHPO <sub>4</sub>
--	--	--	*28.7	71.63	KHPO <sub>4</sub> *
--	--	--	*44.2	71.50	" *
51.0	72.64	21.55	51.0	72.04	" *
56.0	72.50	21.38	--	--	"
63.0	72.79	21.66	64.8	72.53	"
--	--	--	84.5	72.83	"
--	--	--	99.4	73.80	"

\*Metastable

## K KALIUM

THE SYSTEM  $K_2HPO_4 + Na_2HPO_4 + H_2O$   
(Ravich and Popova, 1942)

Results at 0°		Results at 25°		Solid Phase at each temperature
Sat. Sol. wt. %		Sat. Sol. wt. %		
K <sub>2</sub> HPO <sub>4</sub>	Na <sub>2</sub> HPO <sub>4</sub>	K <sub>2</sub> HPO <sub>4</sub>	Na <sub>2</sub> HPO <sub>4</sub>	
--	--	60.66	2.36	K <sub>2</sub> HPO <sub>4</sub> · 3H <sub>2</sub> O
--	--	59.68	4.60	"
*55.60	2.89	57.85	7.14	K <sub>2</sub> HPO <sub>4</sub> · 3H <sub>2</sub> O + KNaHPO <sub>4</sub> · 5H <sub>2</sub> O
*53.41	2.98	54.94	7.66	KNaHPO <sub>4</sub> · 5H <sub>2</sub> O
40.83	5.42	45.31	9.91	"
--	--	30.98	17.80	"
--	--	29.57	19.05	"
44.59	4.38	--	--	KNaHPO <sub>4</sub> · 5H <sub>2</sub> O + K <sub>2</sub> HPO <sub>4</sub> · 6H <sub>2</sub> O
--	--	26.64	21.82	KNaHPO <sub>4</sub> · 5H <sub>2</sub> O + Na <sub>2</sub> HPO <sub>4</sub> · 7H <sub>2</sub> O
--	--	26.61	22.04	"
--	--	26.31	21.76	"
--	--	26.72	21.84	"
--	--	26.63	21.48	"
--	--	25.84	22.02	"
39.41	5.82	23.13	21.40	Na <sub>2</sub> HPO <sub>4</sub> · 7H <sub>2</sub> O + Na <sub>2</sub> HPO <sub>4</sub> · 12H <sub>2</sub> O
--	--	23.54	20.78	"
35.17	3.94	23.12	21.72	Na <sub>2</sub> HPO <sub>4</sub> · 12H <sub>2</sub> O
31.84	3.66	18.80	16.94	"
25.57	3.24	10.87	14.46	"
--	--	6.42	13.20	"
0.0	1.80	0.0	10.80	"

\*Metastable

0.02 gms. of  $K_2HPO_4$  are dissolved in 100 gms. of a saturated solution in furfural at 25° - Trimble, 1941.

PO POTASSIUM DIHYDROGEN PHOSPHATE  $KH_2PO_4$ SOLUBILITY OF  $KH_2PO_4$  IN WATER

The various results are in only fair agreement. The averages were read from a curve drawn through a plot of original data. Additional values are given by Janecke, 1927; Askenasy and Nessler, 1930 and Muthman and Kunze, 1894. Data by Polosin and Ozolin, 1940; Kuznetsov, Kozhukhovskii and Borovaya, 1948; and Zvorkin and Kuzetsov, 1938 are included in the average. Additional data are given by Bel'chev, 1953 and Sulaimankulov, Sharandina, Turdubaev and Fel'dsher, 1954.

Gms.  $KH_2PO_4$  per 100 gms. sat. sol.

t°	Average	Kazancev 1938	Apfel 1911	Bergman & Botchkareff 1938	Polosin & Sachparonov 1947	Menzel & Gabler 1929
	Curve					
- 0.7	4.	--	--	4	--	--
- 1.5	8.	--	--	8	--	--
- 2.1	10.	--	--	10	--	--
- 2.6	11.8	--	--	11.7	--	--

(Cont.)

SOLUBILITY OF  $\text{KH}_2\text{PO}_4$  IN WATER--CONT.Gms.  $\text{KH}_2\text{PO}_4$  per 100 gms. sat. sol.

t°	Average Curve	Kazancev 1938	Apfel 1911	Bergman & Botchkareff 1938	Polosin & Sachparonov 1947	Menzel & Gabler 1929	
0	12.4	12.88	10.48?	12 <sup>b</sup>	12.15	12.48	
5	13.7	14.00	--	--	--	--	
10	15.1	15.50	--	--	14.95	--	
15	16.7	16.87	--	16 <sup>c</sup>	--	16.78	
20	18.3	18.45	--	18 <sup>d</sup>	18.20	--	
25	20.0	20.04	20.15	20 <sup>e</sup>	19.80	20.07	
30	21.7	21.90	--	22 <sup>f</sup>	--	--	
35	23.4	23.65	--	--	22.90	--	P0
40	25.1	25.10	--	--	--	--	
45	27.0	26.90	--	--	--	--	
50	29.0	29.00	29.27	--	--	--	
60	33.0	33.40	--	--	--	--	
70	37.2	37.05	36.67	--	--	--	
80	41.3	41.30	41.94 <sup>a</sup>	--	--	--	
90	45.5	45.50	--	--	--	--	
ag3°	b0.8°	c13.6°	d19.8°	e2.6°	f31.8°		

SOLUBILITY OF POTASSIUM DIHYDROGEN PHOSPHATE IN AQUEOUS  
SOLUTIONS OF HYDROGEN PEROXIDE AT 0°  
(Menzel and Gabler, 1929)

Gms. per 100 gms. sat. sol.

H <sub>2</sub> O <sub>2</sub>	KH <sub>2</sub> PO <sub>4</sub>
0.0	12.48
6.590	16.07
8.242	18.67

Results for the system  $\text{KH}_2\text{PO}_4 - \text{K}_2\text{SO}_4 - \text{H}_2\text{O}$  from  $-3.1^\circ$  to  $+30^\circ$  are given by Bel'chev, 1953. The ternary eutectic is at  $-3.1^\circ$ , with the solution containing 10.3%  $\text{KH}_2\text{PO}_4$ , 4.2%  $\text{K}_2\text{SO}_4$ .

For solubilities in the System  $\text{KH}_2\text{PO}_4 - \text{Ca}(\text{H}_2\text{PO}_4)_2 - \text{H}_3\text{PO}_4 - \text{H}_2\text{O}$  at  $25^\circ$  see Flatt, Brunisholz and Bourgeois, 1956.

THE SYSTEM  $\text{KH}_2\text{PO}_4 - \text{NH}_4\text{H}_2\text{PO}_4 - \text{H}_2\text{O}$ 

Results at 0°  
(Askensay and Nessler, 1930)

This pair of salts form a continuous series of mix-crystals. The results are expressed in accordance with the terms adopted by Janecke. Additional results for the quarternary system  $(\text{K}, \text{NH}_4)(\text{Cl}, \text{H}_2\text{PO}_4) + \text{H}_2\text{O}$  are also given.

(Cont.)

## K KALIUM

THE SYSTEM  $\text{KH}_2\text{PO}_4 - \text{NH}_4\text{H}_2\text{PO}_4 - \text{H}_2\text{O}$ —Cont.

## Results at 0°

d. of sat. sol.	Mols. $\text{KH}_2\text{PO}_4$ per 100 mols. of dissolved $\text{KH}_2\text{PO}_4 + \text{NH}_4\text{H}_2\text{PO}_4$	Mols. $\text{H}_2\text{O}$ to dissolve 100 mols. of $\text{KH}_2\text{PO}_4 + \text{NH}_4\text{H}_2\text{PO}_4$	Mol. Percent $\text{KH}_2\text{PO}_4$ in the Mix-Crystals forming the Solid Phase
1.1043	0.0	2815	0.0
1.1312	12.4	2450	6.5
1.1350	15.3	2350	9.0
1.1447	18.2	2280	13.2
1.1568	26.4	2200	23.2
1.1574	31.2	2130	30.7
1.1611	35.2	2105	35.9
1.1604	36.4	2120	42.4
1.1603	38.1	2130	48.8
1.1571	44.2	2240	71.1
1.1577	49.3	2325	81.9
1.1472	54.7	2540	87.8
1.1393	67.4	2950	94.5
1.1169	80.6	3400	96.7
1.1151	100.0	4125	100.0

Additional data for the solubility of mixtures of various Potassium and Ammonium Phosphates in Water at 0° and 25° are given by Janecke, 1927. Attention was directed particularly to the system  $\text{K}_3\text{PO}_4 + \text{NH}_4\text{H}_2\text{PO}_4 + \text{H}_2\text{O}$  in which the following solid phases occur at either 0° or 25°;  $\text{K}_3\text{PO}_4 \cdot 8\text{H}_2\text{O}$ ,  $\text{K}_2\text{HPO}_4$ ,  $(\text{NH}_4)_3\text{PO}_4 \cdot 3\text{H}_2\text{O}$ ,  $(\text{NH}_4)_2\text{HPO}_4$ ,  $\text{KH}_2\text{PO}_4$  and  $\text{NH}_4\text{H}_2\text{PO}_4$ . The determinations were made by the synthetic method. The solid phases were identified by the polarization microscope. Nine binary mixtures composed of the three potassium and three ammonium salts were studied. The results however are given in an abridged form chosen to show the most important features of the system.

## Results at 25°

(Kuznetsov, Kozhukhovskii, and Borovaya, 1948)

Saturated Solution Wt. %		Solid Phase Wt. %		
$\text{KH}_2\text{PO}_4$	$\text{NH}_4\text{H}_2\text{PO}_4$	$\text{KH}_2\text{PO}_4$	$\text{NH}_4\text{H}_2\text{PO}_4$	$\text{H}_2\text{O}$
20.21	0.0			
17.53	7.85	53.90	7.49	29.61
16.19	13.05			
15.48	15.84			
14.27	17.53	56.70	29.66	13.64
13.08	20.12			
7.97	24.48	11.22	40.53	48.25
0.0	28.85			

Specific heats of solutions in the system  $\text{KH}_2\text{PO}_4 - \text{NH}_4\text{H}_2\text{PO}_4 - \text{H}_2\text{O}$  at 25°, 50°, and 75° were determined by Voskresenskaja and Ruzkow, 1940.

(Cont.)

THE SYSTEM  $\text{KH}_2\text{PO}_4 - \text{NH}_4\text{H}_2\text{PO}_4 - \text{H}_2\text{O}$ —Cont.

## Results at 50°

(Zvorikin and Kuzetzov, 1938)

Liquid					
Sat. Sol. wt. %		Sat. Sol. mole %		Solid mole %	
$\text{KH}_2\text{PO}_4$	$\text{NH}_4\text{H}_2\text{PO}_4$	$\text{KH}_2\text{PO}_4$	$\text{NH}_4\text{H}_2\text{PO}_4$	$\text{KH}_2\text{PO}_4$	$\text{NH}_4\text{H}_2\text{PO}_4$
28.09	0.0	4.91	0.0	100.	0.0
25.23	9.49	4.76	2.12	87.33	12.67
18.97	25.91	4.07	6.58	51.60	48.40
15.92	29.12	3.41	7.40	56.82	43.18
14.38	30.96	3.10	7.89	--	--
11.79	33.22	2.52	8.42	26.37	73.63
7.69	35.19	1.60	8.66	11.28	88.72
3.45	38.42	0.71	9.31	6.64	93.36
0.0	39.88	0.0	9.41	0.0	100.00

PO

THE SYSTEM  $\text{KH}_2\text{PO}_4 + \text{NH}_4\text{NO}_3 \rightleftharpoons \text{KNO}_3 + \text{NH}_4\text{H}_2\text{PO}_4 (+ \text{H}_2\text{O})$   
(Bergman and Botchkareff, 1938)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
NH <sub>4</sub> NO <sub>3</sub>	KH <sub>2</sub> PO <sub>4</sub>	Solid Phase	NH <sub>4</sub> NO <sub>3</sub>	KH <sub>2</sub> PO <sub>4</sub>	Solid Phase
Results at -10°			Results at 0°		
27.2	0.0	Ice	0.0	12.2	KH <sub>2</sub> PO <sub>4</sub>
21.8	6.4	Ice + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>	3.4	14.0	"
28.6	4.8	NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>	8.0	16.6	KNO <sub>3</sub>
38.6	3.5	"	6.6	15.9	"
45.0	2.5	NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub> + NH <sub>4</sub> NO <sub>3</sub>	8.3	16.2	KNO <sub>3</sub> + KH <sub>2</sub> PO <sub>4</sub>
47.1	0.0	NH <sub>4</sub> NO <sub>3</sub>	12.0	13.7	KNO <sub>3</sub>
			13.9	13.0	"
			15.7	12.6	"
			16.4	12.5	KNO <sub>3</sub> + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>
0.0	15.0	KH <sub>2</sub> PO <sub>4</sub>	17.7	11.4	NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>
3.3	16.5	"	28.1	6.2	"
6.5	17.8	"	38.4	3.9	"
8.0	18.4	"	48.8	2.4	"
11.4	18.5	NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>	52.7	1.6	NH <sub>4</sub> NO <sub>3</sub>
13.2	17.5	"	53.5	0.0	"
15.0	16.5	"			
17.0	14.4	"			
27.5	8.1	"			Results at 20°
38.0	5.0	"	0.0	18.2	KH <sub>2</sub> PO <sub>4</sub>
48.5	2.9	"	3.2	19.1	"
59.2	1.2	NH <sub>4</sub> NO <sub>3</sub> + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>	6.4	19.8	"
59.6	0.0	NH <sub>4</sub> NO <sub>3</sub>	7.9	20.1	"
			11.0	20.5	"
			12.7	20.5	NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>
			14.4	19.5	"
0.0	21.4	KH <sub>2</sub> PO <sub>4</sub>	16.4	17.8	"
3.1	21.8	"	18.3	16.3	"
6.2	22.3	"	26.8	10.4	"
7.7	22.5	"	37.4	6.3	"
10.7	22.8	"	48.2	3.6	"
12.3	23.0	"	58.6	2.2	"
13.6	22.8	NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>	63.0	1.0	NH <sub>4</sub> NO <sub>3</sub> + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>
15.6	21.8	"	65.0	0.0	NH <sub>4</sub> NO <sub>3</sub>
18.4	19.6	"			
23.0	15.4	"			
25.9	13.3	"			
36.7	8.2	"			Additional Data
47.7	4.4	"	(-5.6°)	6.8	Ice + KNO <sub>3</sub> + KH <sub>2</sub> PO <sub>4</sub>
58.0	3.3	"	(-8.7°)	18.3	Ice + KNO <sub>3</sub> + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>
68.9	1.3	NH <sub>4</sub> NO <sub>3</sub> + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>	(-15.8°)	40.4	Ice + NH <sub>4</sub> NO <sub>3</sub> + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>
69.7	0.0	NH <sub>4</sub> NO <sub>3</sub>			



# K KALIUM

## SOLUBILITY OF MONO POTASSIUM PHOSPHATE IN AQUEOUS SOLUTIONS OF SALTS AT 25° (Apfel, 1911)

Salt	Gms. salt per 100 gms. sat. sol.	Gms. $\text{KH}_2\text{PO}_4$ per 100 gms. sat. sol.	Salt	Gms. salt per 100 gms. sat. sol.	Gms. $\text{KH}_2\text{PO}_4$ per 100 gms. sat. sol.
None	0.0	20.15	$\text{KNO}_3$	5.56	16.33
$\text{K}_2\text{SO}_4$	1.39	19.46	"	12.03	14.03
"	3.13	18.24	$\text{CH}_3\text{COOK}$	4.91	17.43
"	6.27	17.70	"	9.62	14.43
"	6.79	17.02	$\text{K}_2\text{CO}_3^*$	1.66 ( 3.22?)	23.01
"	6.27	16.74	"	5.74 (11.48?)	31.85

\*In the case of the solubility in aq.  $\text{K}_2\text{CO}_3$  carbon dioxide is liberated and the results do not show equilibrium.

## THE SYSTEM POTASSIUM DIHYDROGEN PHOSPHATE - UREA - WATER (Polosin, Sachparonoy, 1947)

The results are also given in mole %.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{KH}_2\text{PO}_4$	$\text{CO}(\text{NH}_2)_2$		$\text{KH}_2\text{PO}_4$	$\text{CO}(\text{NH}_2)_2$	
Results at $-10^\circ$			Results at $0^\circ$		
0.0	30.70	Ice	12.15	0.0	$\text{KH}_2\text{PO}_4$
2.00	29.70	"	10.65	8.93	"
2.92	27.10	"	9.95	18.10	"
6.86	23.80	"	8.80	27.36	"
7.60	27.72	$\text{KH}_2\text{PO}_4$	5.60	37.70	$\text{CO}(\text{NH}_2)_2$
6.16	31.60	$\text{CO}(\text{NH}_2)_2$	2.45	38.80	"
2.69	32.60	"	0.0	39.80	"
0.0	33.50	"			
Results at $10^\circ$			Results at $20^\circ$		
14.95	0.0	$\text{KH}_2\text{PO}_4$	18.20	0.0	$\text{KH}_2\text{PO}_4$
13.25	8.67	"	15.85	8.41	"
11.60	17.68	"	10.40	17.32	"
10.00	27.00	"	11.40	26.58	"
8.20	36.70	"	9.20	36.30	"
7.40	41.65	"	8.00	41.40	"
5.06	43.70	$\text{CO}(\text{NH}_2)_2$	7.60	46.20	"
2.20	45.10	"	4.57	49.20	$\text{CO}(\text{NH}_2)_2$
0.0	46.00	"	1.97	50.60	"
			0.0	51.80	"
Results at $25^\circ$			Results at $35^\circ$		
19.80	0.0	$\text{KH}_2\text{PO}_4$	22.90	0.0	$\text{KH}_2\text{PO}_4$
17.10	8.29	"	19.70	8.03	"
14.40	17.12	"	16.70	16.66	"
12.20	26.34	"	14.40	25.80	"
9.70	36.10	"	11.20	35.50	"
8.50	41.15	"	9.80	40.55	"
8.00	46.00	"	8.70	45.65	"
4.32	52.00	$\text{CO}(\text{NH}_2)_2$	8.00	50.60	"
1.86	53.40	"	3.82	57.50	$\text{CO}(\text{NH}_2)_2$
0.0	54.50	"	1.64	59.00	"
			0.0	59.50	"
Invariant Points					
0.0	33.00	Ice + $\text{CO}(\text{NH}_2)_2$			
0.0	53.30	$\alpha\text{-CO}(\text{NH}_2)_2 + \beta\text{-CO}(\text{NH}_2)_2$			
11.70	0.0	Ice + $\text{KH}_2\text{PO}_4$			
7.00	29.70	Ice + $\text{CO}(\text{NH}_2)_2 \cdot \text{KH}_2\text{PO}_4$			
7.20	37.50	$\alpha\text{-CO}(\text{NH}_2)_2 + \beta\text{-CO}(\text{NH}_2)_2 + \text{KH}_2\text{PO}_4$			

SOLUBILITY OF POTASSIUM DIHYDROGEN PHOSPHATE IN  
AQUEOUS SOLUTIONS OF URETHAN AT 25°  
(Palitzsch, 1928, 1929)

Gm. Mols. per 1000 gms. H <sub>2</sub> O		Solid Phase
KH <sub>2</sub> PO <sub>4</sub>	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>	
1.82	0.0	KH <sub>2</sub> PO <sub>4</sub>
1.29	1.1225	"
0.75	5.401	"
0.139	22.25	"

POTASSIUM ACID PHOSPHATE KH<sub>2</sub>PO<sub>4</sub>·H<sub>3</sub>PO<sub>4</sub>

PO

SOLUBILITY OF POTASSIUM ACID PHOSPHATE, KH<sub>2</sub>PO<sub>4</sub>·H<sub>3</sub>PO<sub>4</sub>, IN WATER  
(Parravano and Mieli, 1908)

Determinations by Synthetic (sealed tube) Method.

t°	Gms. KH <sub>2</sub> PO <sub>4</sub> ·H <sub>3</sub> PO <sub>4</sub> per 100 gms. sat. sol.	Solid Phase
- 0.6	3.37	Ice
- 2.5	12.13	"
- 6.7	29.43	"
- 9.2	36.98	"
-13 Eutec.	44.0	" + KH <sub>2</sub> PO <sub>4</sub>
0 (?)	45.8	KH <sub>2</sub> PO <sub>4</sub>
+10.9	50.3	"
65.2	68.44	"
78	72.43	"
87.5	77.6	"
105.5	85.9	"
120 tr. pt.	92.1	" + KH <sub>2</sub> PO <sub>4</sub> ·H <sub>3</sub> PO <sub>4</sub>
135	96.1	KH <sub>2</sub> PO <sub>4</sub> ·H <sub>3</sub> PO <sub>4</sub>
139	100	

SOLUBILITY OF POTASSIUM ACID PHOSPHATE, KH<sub>2</sub>PO<sub>4</sub>·H<sub>3</sub>PO<sub>4</sub>, IN  
ANHYDROUS PHOSPHORIC ACID  
(Parravano and Mieli, 1908)

Determinations by Synthetic (sealed tube) Method.

t°	Gms. per 100 gms. sat. solution	
	KH <sub>2</sub> PO <sub>4</sub> ·H <sub>3</sub> PO <sub>4</sub>	= KH <sub>2</sub> PO <sub>4</sub>
38.5	18.17	10.56
84	58.42	33.97
110	77.53	45.08
126.5	92.26	51.90

## K KALIUM

### POTASSIUM METAPHOSPHATE $KPO_3$

Madorsky and Clark, 1940 produced potassium metaphosphate from the action of  $H_3PO_4$  on KCl at  $120^\circ-130^\circ$ . The product was washed to remove soluble impurities, and the solubility of  $KPO_3$  in water was found to be 0.0041 gms. per 100 ml. of saturated solution at  $25^\circ$ .

### PO POTASSIUM HYPOPHOSPHATE, HYPOPHOSPHITE

SOLUBILITY IN WATER  
(Salzer-Liebig's Ann. 211, 1, 82)

Salt	Formula	Gms. Salt per 100 gms. $H_2O$	
		Cold	Hot
Potassium Hypophosphate	$K_4P_2O_6 \cdot 8H_2O$	400	--
" Hydrogen Hypophosphate	$K_3HP_2O_6 \cdot 3H_2O$	200	--
" Di Hydrogen Hypophosphate	$K_2H_2P_2O_6 \cdot 3H_2O$	33	100
" Tri Hydrogen Hypophosphate	$KH_3P_2O_6$	66.6	200
" Penta Hydrogen Hypophosphate	$K_3H_5(P_2O_6)_2 \cdot 2H_2O$	40	125
" Hydrogen Phosphite	$KH_2PO_3$	172 ( $20^\circ$ )	--
" Hypophosphite	$KH_2PO_2$	200 ( $25^\circ$ )	333
" Hypophosphite	$KH_2PO_2^*$	14.3 ( $25^\circ$ )	28

\*Solvent alcohol.

Melting points are given for the following:

$KPO_3 + LiPO_3$	(Bergman and Sholokhovich, 1953)
$KPO_3 + K_2SO_4$	( " " " )
$2KPO_3 + Li_2SO_4 \rightleftharpoons K_2SO_4 + 2LiPO_3$	( " " " )
	(Bergman, Kislova and Sholokhovich, 1953)
$KPO_3 + NaPO_3$	(Morey, 1954)
$KPO_3 + K_4P_2O_7$	(Morey, 1954)(Parravano and Calcagni, 1908, 1910)
$4KPO_3 + Na_4P_2O_7 \rightleftharpoons K_4P_2O_7 + 4NaPO_3$	(Morey, Boyd, Jr., England, and Chen, 1955)
$KPO_3 + Ba_2B_4O_7$	(Leontjewa, 1937)
$K_4P_2O_7 + K_3PO_4 + K_2TiO_3$	(Belyaev and Sigida, 1958a)
$K_4P_2O_7 + TiO_2 + K_2TiO_3$	( " " " )
$K_4P_2O_7 + 4LiTiO_3 \rightleftharpoons 4KTiO_3 + Li_4P_2O_7$	( " " " )
$K_4P_2O_7 + 2Na_2WO_4 \rightleftharpoons 2K_2WO_4 + Na_4P_2O_7$	(Sholokhovich and Bergman, 1954)
$K_4P_2O_7 + K_2SO_4$	(Bergman and Sholokhovich, 1954)
$K_4P_2O_7 + K_2CrO_4$	( " " " )
$K_4P_2O_7 + K_2MoO_4$	( " " " )
$K_4P_2O_7 + K_2WO_4$	( " " " )

### POTASSIUM PHOSPHOTUNGSTATE

1000 cc. sat. solution of potassium phosphotungstate in water contain 0.135 gm. of the compound at  $20^\circ$ . (Moser and Ritschel, 1925)

POTASSIUM BROMO PERRHENATE  $K_2ReBr_6$   
 POTASSIUM CHLORO PERRHENATE  $K_2ReCl_6$

RESULTS OF RULFS AND MEYER, 1955:

Salt	Solvent	Temp.	Solubility	
			Moles per liter	Gms. per liter
KReBr <sub>6</sub>	3.0 N HBr	25°	0.144	107
KReCl <sub>6</sub>	0.01 N HCl	25°	0.175	83.3

POTASSIUM PERRHENATE  $KReO_4$

ReO

SOLUBILITY OF POTASSIUM PERRHENATE IN WATER  
 (Holemann and Kleese, 1938)

The previous determinations, at temperatures up to 100°, by Puschin and Kovac, 1931; Lewino, Noddack and Noddack, 1931; and Roth and Becker, 1932, although varying among themselves, given when plotted, average values which agree closely with the present very careful determinations. The determinations above 100° were made by the synthetic method. The solid phase is  $KReO_4$  in all cases.

t°	d. of sat. solution	Gms. $KReO_4$ per 100 gms. sat. sol.	t°	Gms. $KReO_4$ per 100 gms. sat. sol.
- 0.06 (Eutec)		0.34	109	12.6
0	--	0.36*	112	14.0
+10.5	1.0028	0.62	154	26.3
25.0	1.0067	1.19	194	36.7
30	--	1.47*	220	50.7
40	--	2.22*	239	59.9
50	--	3.21*	290	71.9
	1.0128	3.19	335	80.1
60	1.0210	4.38	366	84.6
75	1.0303	6.95	401	89.3
85	1.0412	8.98	445	94.4
99	1.060	12.20	456	95.4
			470	96.8
			498	97.4
			518 m. pt.	100.0

\*Smith, 1946

Data for the partition of potassium perrhenate between nitromethane and water at 25° are given by Friedman and Haugen, 1954, 1956.

1 liter 89.7 Wt. percent Ethyl Alcohol,  $C_2H_5OH$ , dissolve 0.302 gm.  $KReO_4$  at 18.5°. (Tollert, 1932)

POTASSIUM SULFIDE  $K_2S$

S

Fusion-point data are given for the following systems:

$K_2S + K_2SO_4$  (Garibeu, Kolb and Kroll, 1938)  
 $K_2S + S$  (Thomas and Rule, 1917; Pearson and Robinson, 1931)

# K KALIUM

## 50 POTASSIUM SULFITE $K_2SO_3$

### SOLUBILITY OF POTASSIUM SULFITE IN WATER

The results of Foerster, Brosche and Norberg-Schultz, 1924 show a solubility nearly independent of temperature. Holz1's (1937) data indicate a steady increase up to 100°. F, B and N.S. made their determinations in an atmosphere of hydrogen.

Solid Phase ICE (F.B. & N.-S.)		Solid Phase $K_2SO_3$			
		F., B. and N.-S.		Holzl	
t°	Gms. $K_2SO_3$ per 100 gms. sat. sol.	t°	Gms. $K_2SO_3$ per 100 gms. sat. sol.	t°	Gms. $K_2SO_3$ per 100 gms. Sat. sol.
- 1.69	5.78	-30	51.0	0	47.52
- 2.71	9.20	-15	51.3	11.5	48.06
- 4.10	13.37	- 6.7	51.45	25	49.01
- 5.74	17.57	- 3.9	51.35	33	49.99
- 6.84	20.02	+ 0.1	51.4	40	50.37
-10.88	26.70	24.0	51.37	65.3	52.27
-14.06	30.6	30.0	51.76	80	53.15
-31.0	44.0	54.4	51.90	100	55.53
-45.5 Eutec.	51.0	97.2	52.88		

### THE SYSTEM POTASSIUM SULFITE - POTASSIUM HYDROXIDE - WATER (Holzl, 1937)

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
t°	$K_2O$	$K_2SO_3$		t°	$K_2O$	$K_2SO_4$	
0	0.0	47.52	$K_2SO_3$	40	0.0	50.37	$K_2SO_3$
"	40.71	0.43	" + $KOH \cdot 2H_2O$	"	48.32	0.40	" + $KOH \cdot H_2O$
"	41.01	0.0	$KOH \cdot 2H_2O$	"	48.71	0.0	$KOH \cdot H_2O$
11.5	0.0	48.06	$K_2SO_3$	65.3	0.0	52.27	$K_2SO_3$
"	42.41	0.48	" + $KOH \cdot 2H_2O$	"	50.14	0.45	" + $KOH \cdot H_2O$
"	42.87	0.0	$KOH \cdot 2H_2O$	"	50.65	0.0	$KOH \cdot H_2O$
25	0.0	49.01	$K_2SO_3$	80	0.0	53.15	$K_2SO_3$
"	45.03	0.47	" + $KOH \cdot 2H_2O$	"	51.50	0.39	" + $KOH \cdot H_2O$
"	45.51	0.0	$KOH \cdot 2H_2O$	"	51.81	0.0	$KOH \cdot H_2O$
33	0.0	49.99	$K_2SO_3$	100	0.0	55.53	$K_2SO_3$
"	47.81	0.37	" + $KOH \cdot H_2O$	"	54.29	0.40	" + $KOH \cdot H_2O$
"	48.16	0.0	$KOH \cdot H_2O + KOH \cdot \frac{1}{2}H_2O$	"	54.67	0.0	$KOH \cdot H_2O$
"	48.29	0.0	" + $KOH \cdot 2H_2O$				

THE SYSTEM POTASSIUM SULFITE - SULFUROUS ACID - WATER  
(Holzl, 1937)

Gms. per 100 gms. sat. sol.				Gms. per 100 gms. sat. sol.			
t°	H <sub>2</sub> SO <sub>3</sub>	K <sub>2</sub> SO <sub>3</sub>	Solid Phase	t°	H <sub>2</sub> SO <sub>3</sub>	K <sub>2</sub> SO <sub>3</sub>	Solid Phase
0	0.44	50.36	K <sub>2</sub> SO <sub>3</sub> +K <sub>2</sub> S <sub>2</sub> O <sub>5</sub> ·2/3H <sub>2</sub> O	40	2.64	53.01	K <sub>2</sub> SO <sub>3</sub> +K <sub>2</sub> S <sub>2</sub> O <sub>5</sub>
0	7.49	14.06	K <sub>2</sub> S <sub>2</sub> O <sub>5</sub> ·2/3H <sub>2</sub> O	65.3	4.37	55.12	" "
11.5	1.11	50.96	K <sub>2</sub> SO <sub>3</sub> + K <sub>2</sub> S <sub>2</sub> O <sub>5</sub>	80	5.48	55.82	" "
25	1.83	51.92	" "	100	7.0	56.60	" "

SOLUBILITY OF POTASSIUM SULFITE IN AQUEOUS SOLUTIONS  
OF TERTIARY BUTYL ALCOHOL AT 30°  
(Ginnings and Robbins, 1930)

Wt. Percent (CH <sub>3</sub> ) <sub>3</sub> COH in aq. solvent	Gms. K <sub>2</sub> SO <sub>3</sub> per 100 gms. sat. sol.	Wt. Percent (CH <sub>3</sub> ) <sub>3</sub> COH in Aq. Solvent	Gms. K <sub>2</sub> SO <sub>3</sub> per 100 gms. sat. sol.
0.0	51.76	9.1	9.8
0.4	34.2	16.1	5.8
0.9	26.7	18.9	4.8
3.5	17.0	39.3	1.8
5.9	13.3	57.8	0.7

POTASSIUM PYROSULFITE K<sub>2</sub>S<sub>2</sub>O<sub>5</sub>  
(METABISULFITE)

50

SOLUBILITY IN WATER  
(Foerster, Brosche and Norberg-Schultz, 1924)

The numerous determinations of the authors were plotted and the following values read from the curves.

Results for K <sub>2</sub> S <sub>2</sub> O <sub>5</sub>			Results for K <sub>2</sub> S <sub>2</sub> O <sub>5</sub> ·2/3H <sub>2</sub> O		
t°	Gms. K <sub>2</sub> S <sub>2</sub> O <sub>5</sub> per 100 gms. sat. sol.	Solid Phase	t°	Gms. K <sub>2</sub> S <sub>2</sub> O <sub>5</sub> per 100 gms. sat. sol.	Solid Phase
- 1.07	3.73	Ice	- 1.0	4.0	Ice
- 2.0	6.8	"	- 2.0	7.5	"
- 4.0	13.8	"	- 4.0	13.5	"
- 5.0	17.5	"	- 5.0	16.0	"
- 5.6 Eutec.	19.5	" + K <sub>2</sub> S <sub>2</sub> O <sub>5</sub>	- 6.0 Eutec.	18.0	" + K <sub>2</sub> S <sub>2</sub> O <sub>5</sub> ·2/3H <sub>2</sub> O
-30	20.7	K <sub>2</sub> S <sub>2</sub> O <sub>5</sub>	- 4.0	19.2	K <sub>2</sub> S <sub>2</sub> O <sub>5</sub> ·2/3H <sub>2</sub> O
0.0	22.1	"	- 3.0	19.9	"
+ 2.0	22.8	"	- 2.0	20.5	"
10.0	26.5	"	0.0	21.7	"
20.0	30.8	"	+ 2.0	22.8	"
25.0	32.8	"	4.0	24.1	"
30.0	34.8	"	6.0	25.1	"
40.0	39.0	"	8.0	26.2	"
50.0	42.5	"	10.0	27.4	"
60.0	46.0	"	15.0	30.1	"
80.0	51.9	"	20.0	33.2	"
94.0	55.5	"			

100 gms. liquid Sulfur Dioxide saturated with Potassium Pyrosulfite contain 0.35 gm. K<sub>2</sub>S<sub>2</sub>O<sub>5</sub> at 0°.  
(Jander and Wickert, 1936)

POTASSIUM SODIUM SULFITE KNa<sub>2</sub>H(SO<sub>3</sub>)<sub>2</sub>·4H<sub>2</sub>O

100 gms. H<sub>2</sub>O dissolve 69 gms. of the salt at 15°. (Schwicker, 1889)

## K KALIUM

SO POTASSIUM SULFATE  $K_2SO_4$ 

## SOLUBILITY OF POTASSIUM SULFATE IN WATER

The very closely agreeing determinations of Caven and Johnston, 1927, 1928; Wright, 1927; Flottmann, 1928; Blasdale, 1923; Hill and Moskowitz, 1929; Starrs and Storck, 1930; Malhorta and Suri, 1930; Benrath and Wazelle, 1929; Babajewa, 1913; Rakowski and Babajewa, 1931; Schroeder and Schlackmann, 1934; Mulder, 1864; Andrae, 1884; Trevor, 1891; Tilden and Shenstone 1884; Berkeley, 1904; Anosov and Byzova, 1947; and Benrath, Gjedebø, Schiffers and Wunderlich, 1937 (over 100°) were plotted, and values read from the curve. The monohydrate was found by Shulgina, Khar-chuk and Yanat'eva, 1950, 1955, and the results below 10° are by these authors.

t°	Gms. $K_2SO_4$ per 100 gms. sat. sol.	t°	Gms. $K_2SO_4$ per 100 gms. sat. sol.	t°	Gms. $K_2SO_4$ per 100 gms. sat. sol.
Solid Phase ICE			Solid Phase $K_2SO_4$		
- 0.5	1.97	0	6.9*	101.1†	19.5
- 1.0	4.00	10	8.5	120	20.9
- 1.5	6.23	15	9.2	143	22.4
- 1.7	6.79	20	10.0	170	24.8
ICE + $K_2SO_4 \cdot H_2O$		25	10.75	179	25.4
		30	11.5	208	25.7
- 1.8	7.09	40	12.9	245	25.9
ICE + $K_2SO_4$		50	14.2	292	26.0
		60	15.4	310	23.3
- 1.9	7.29*	70	16.55	327	16.2
$K_2SO_4 \cdot H_2O$		80	17.6	337	12.3
		90	18.6	344	8.36
0.0	7.20	100	19.4	357	3.9
+ 5.5	7.49				
7.0	7.77				
9.1	7.97				
9.5	8.17				
9.6	8.40				
$K_2SO_4 \cdot H_2O$ + $K_2SO_4$			* = Metastable.		
			† = Normal boiling point.		
9.7	8.48				

Data for the Solubility of Potassium Sulfate in Water at 25° and under pressures up to 10,000 bars (metric atmospheres) are given by Adams, 1932.

At 500°, 400 bars 0.002 wt. %  $K_2SO_4$  dissolves in steam.  
(Ellis and Fyfe, 1957)

THE SYSTEM POTASSIUM SULFATE - WATER - HYDROGEN PEROXIDE AT 20°  
(Pani and Terrey, 1955)

Only pure  $K_2SO_4$  exists as the solid phase.

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
$K_2SO_4$	$H_2O_2$	$K_2SO_4$	$H_2O_2$	$K_2SO_4$	$H_2O_2$
10.00	0.00	23.12	15.57	31.41	28.17
13.78	4.12	23.89	18.45	35.93	33.66
16.78	8.35	24.83	20.11	41.09	39.29
19.40	12.10	28.31	24.12	44.36	43.85

Results at 25°  
(Akerlof and Turck, 1935)

50

Wt. percent $H_2O_2$ in Aq. Solvent	Gm. Mols. $K_2SO_4$ per 1000 gms. solvent
0.0	0.6905
15.72	1.287
31.43	1.945

THE SYSTEM POTASSIUM SULFATE - SULFURIC ACID - WATER

Results at 0°  
(D'Ans, 1909a)

Mols. per 1000 Gms. Sat. Sol.		Solid Phase	Mols. per 1000 Gms. Sat. Sol.		Solid Phase
$K_2SO_4$	$H_2SO_4$		$K_2SO_4$	$H_2SO_4$	
0.53	0.37	$K_2SO_4$	0.61	2.12	$K_a + K_b$
0.64	0.75	"	0.54	2.29	$K_b$
0.74	1.08	" + $K_3H(SO_4)_2$	0.53	2.30	" + $KHSO_4$
0.73	1.13	$K_3H(SO_4)_2$	0.43	2.48	$KHSO_4$
0.71	1.44	"	0.28	3.04	"
0.69	1.66	"	0.12	4.43	"
0.69	1.88	" + $K_a$	0.09	5.27	"

$K_a$  and  $K_b$  are acid sulfates between  $K_3H(SO_4)_2$  and  $KHSO_4$ . Their compositions were not determined.

Results at 18°  
(Stortenbecker, 1902)

Mols. per 100 Mols. $K_2SO_4 + H_2SO_4 + H_2O$		Solid Phase	Mols. per 100 Mols. $K_2SO_4 + H_2SO_4 + H_2O$		Solid Phase
$K_2SO_4$	$H_2SO_4$		$K_2SO_4$	$H_2SO_4$	
1.10	0	$K_2SO_4$	2.80	5.79	$K_2SO_4 \cdot 3KHSO_4$
1.59	0.95	"	2.61	5.61	$K_2SO_4 \cdot 6KHSO_4$
2.49	2.70	"	2.25	6.19	" + $KHSO_4$
2.75	3.17	$K_2SO_4 \cdot KHSO_4$	1.08	7.94	$KHSO_4$
2.75	3.74	"	0.77	9.2	"
2.83	5.08	"	0.44	22.7	"

(Cont.)



## K KALIUM

## THE SYSTEM POTASSIUM SULFATE - SULFURIC ACID - WATER--Cont.

Results at 25°  
(D'Ans, 1909a, 1913; see also Herz, 1911-12)

Mols. per 1000 Gms. Sat. Sol.			Solid Phase	Mols. per 1000 Gms. Sat. Sol.			Solid Phase
	K <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>			K <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub> +SO <sub>3</sub>	
1.27	1.31		K <sub>2</sub> SO <sub>4</sub> + K <sub>3</sub> H(SO <sub>4</sub> ) <sub>2</sub>	0.250	8.10		KH <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub> ·H <sub>2</sub> O
1.33	1.99		K <sub>3</sub> H(SO <sub>4</sub> ) <sub>2</sub> + Ky	0.352	8.15		"
1.24	2.03		Ky	0.364	8.16		" + KH <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
1.13	2.17		"	0.341	8.29		KH <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
1.04	2.35		" + KHSO <sub>4</sub>	0.322	8.33		"
1.032	2.345		KHSO <sub>4</sub>	0.325	8.45		"
0.67	2.83		"	0.346	6.62		"
0.22	4.13		"	0.384	8.57		"
0.15	5.36		"	0.412	8.71		"
				0.583	8.82		"
				0.880	8.65		" + KHS <sub>2</sub> O <sub>7</sub>
0.171	6.42		KHSO <sub>4</sub>	0.890	8.63		KHS <sub>2</sub> O <sub>7</sub> (unstable)
0.190	6.60		"	0.882	8.70		"
0.266	6.91		" + KH <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub> ·H <sub>2</sub> O	0.561	8.96		"
0.182	7.26			0.365	9.80		"
0.157	7.62			0.43	9.78		"
0.167	7.88			0.665	9.80		"
0.201	8.00			0.937	9.66		"

Ky = an acid sulfate between K<sub>3</sub>H(SO<sub>4</sub>)<sub>2</sub> and KHSO<sub>4</sub> of which the exact composition was not determined.

Results at higher temperatures:  
(Babajewa, 1931)

Results at 30°		Results at 50°		Results at 75°		Solid Phase at each temperature
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
H <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	
0.0	11.50	0.0	14.16	0.0	17.10	K <sub>2</sub> SO <sub>4</sub>
5.38	15.70	4.92	18.66	6.77	24.27	"
8.75	18.80	7.45	20.09	8.07	25.55	"
11.22	20.80	11.60	26.03	8.96	26.38	"
—	—	14.40	29.61	12.43	31.24	"
12.00	22.00	16.40	32.80	18.03	40.43	" + K <sub>2</sub> SO <sub>4</sub> ·KHSO <sub>4</sub>
17.61	22.56	19.37	33.80	18.80	40.81	K <sub>2</sub> SO <sub>4</sub> ·KHSO <sub>4</sub>
20.95	22.99	21.49	35.37	21.03	42.76	"
21.20	24.80	22.40	36.40	—	—	" + K <sub>2</sub> SO <sub>4</sub> ·6KHSO <sub>4</sub>
23.49	17.64	23.21	31.66	—	—	K <sub>2</sub> SO <sub>4</sub> ·6KHSO <sub>4</sub> + KHSO <sub>4</sub>
28.41	10.83	23.73	30.47	24.40	46.38	K <sub>2</sub> SO <sub>4</sub> ·KHSO <sub>4</sub> + KHSO <sub>4</sub>
33.92	6.43	24.42	28.15	25.16	42.82	KHSO <sub>4</sub>
37.38	3.56	27.63	22.03	26.97	37.27	"
52.20	2.18	32.49	14.25	30.05	28.80	"
54.59	2.00	36.80	9.27	40.00	13.98	"
63.16	3.35	43.79	6.34	54.23	8.88	"
68.93	4.84	—	—	60.48	9.50	"
—	—	56.13	4.41	—	—	Kx
—	—	63.98	5.75	—	—	KHSO <sub>4</sub>
—	—	68.08	9.96	—	—	"
75.67	4.12	72.00	19.78	—	—	"
—	—	74.52	13.41	—	—	Kx

Kx is perhaps the hydrate K<sub>2</sub>SO<sub>4</sub>·KHSO<sub>4</sub>·H<sub>2</sub>O.

POTASSIUM BISULFATE  $\text{KHSO}_4$ 

30

SOLUBILITY OF POTASSIUM BISULFATE IN WATER  
(Kremers, 1854; Platt and Hudson, 1926)

t°	Gms. $\text{KHSO}_4$ per 100 gms. sat. sol.	t°	Gms. $\text{KHSO}_4$ per 100 gms. sat. sol.	t°	Gms. $\text{KHSO}_4$ per 100 gms. sat. sol.
0	26.6	35	36.6	60	43.3
15	31.3	40	37.9	65	44.6
20	32.7	45	38.2	70	46.1
25	34.0	50	40.3	75	47.8
30	35.4	55	41.7	100	54.9

Cryoscopic data for solutions of  $\text{K}_2\text{SO}_4$  in pure  $\text{H}_2\text{SO}_4$ , up to 0.12 molal are given by Gillespie and Oubridge, 1956.

THE SYSTEM POTASSIUM SULFATE - BORIC ACID - WATER  
(Perova, 1938, 1954)

[See also Vol. I, p. 271]

The data are also reported in molar units. The eutectic occurs at  $-2.0^\circ$ ; 6.6%  $\text{K}_2\text{SO}_4$ , 3.1%  $\text{H}_3\text{BO}_3$ .

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
H <sub>3</sub> BO <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>		H <sub>3</sub> BO <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>	
Results at 0°			Results at 10°--Cont.		
2.59	0.0	H <sub>3</sub> BO <sub>3</sub>	3.80	5.77	H <sub>3</sub> BO <sub>3</sub>
2.70	1.94	"	3.90	6.72	"
2.90	3.88	"	4.00	9.64	"
2.99	4.85	"	4.60	9.56	"
3.08	5.80	"	4.62	9.62	"
3.20	6.78	"	4.70	9.90	H <sub>3</sub> BO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>
3.25	7.50	H <sub>3</sub> BO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>	0.0	8.45	K <sub>2</sub> SO <sub>4</sub>
0.0	6.89	K <sub>2</sub> SO <sub>4</sub>	Results at 15°		
Results at 5°			4.20	0.0	H <sub>3</sub> BO <sub>3</sub>
			4.22	1.91	"
3.08	0.0	H <sub>3</sub> BO <sub>3</sub>	4.34	3.82	"
3.10	1.93	"	4.40	4.78	"
3.30	3.86	"	4.46	5.73	"
3.30	4.83	"	4.54	6.68	"
3.39	5.79	"	5.00	9.59	"
3.50	6.76	"	5.32	10.41	"
4.0	9.20	H <sub>3</sub> BO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>	2.62	9.78	H <sub>3</sub> BO <sub>3</sub> + K <sub>2</sub> SO <sub>4</sub>
0.0	7.67	K <sub>2</sub> SO <sub>4</sub>	0.0	9.22	K <sub>2</sub> SO <sub>4</sub>
Results at 10°			Results at 20°		
3.50	0.0	H <sub>3</sub> BO <sub>3</sub>	4.86	0.0	H <sub>3</sub> BO <sub>3</sub>
3.58	1.92	"	4.90	1.90	"
3.65	3.85	"	5.00	3.80	"
3.73	4.81	"	5.08	4.74	"

(Cont.)

## K KALIUM

## THE SYSTEM POTASSIUM SULFATE - BORIC ACID - WATER—Cont.

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
$H_3BO_3$	$K_2SO_4$			$H_3BO_3$	$K_2SO_4$		
Results at 20°—Cont.				Results at 50°—Cont.			
5.12	5.69	$H_3BO_3$		10.9	9.0	$H_3BO_4$	
5.20	6.63	"		11.2	10.2	"	
5.60	9.44	"		11.8	12.4	"	
5.90	10.35	"		12.2	14.5	"	
5.30	10.53	$H_3BO_3 + K_2SO_4$		13.6	18.00	$H_3BO_4 + K_2SO_4$	
0.0	10.00	$K_2SO_4$		4.0	15.80	$K_2SO_4$	
50				0.0	14.16	"	
Results at 25°				Results at 70°			
5.60	0.0	$H_3BO_3$					
5.60	1.88	"		15.8	0.0	$H_3BO_4$	
5.65	3.77	"		15.6	1.6	"	
5.70	4.71	"		15.6	3.4	"	
5.80	5.64	"		15.8	5.0	"	
5.90	6.59	"		16.0	8.3	"	
6.35	9.36	"		16.0	9.0	"	
6.80	10.24	"		16.8	11.5	"	
7.20	10.80	$H_3BO_3 + K_2SO_4$		17.0	13.0	"	
3.40	10.72	$K_2SO_4$		14.5	19.3	"	
0.0	10.75	"		18.0	20.4	$H_3BO_4 + K_2SO_4$	
Results at 30°				16.6	8.0	$K_2SO_4$	
				0.0	16.6	"	
6.4	0.0	$H_3BO_3$		Results at 90°			
6.2	1.95	"					
6.35	3.90	"		23.0	0.0	$H_3BO_3$	
6.50	5.80	"		22.3	1.5	"	
7.0	9.20	"		22.8	3.0	"	
7.6	10.0	"		22.5	4.6	"	
8.2	12.8	$H_3BO_4 + K_2SO_4$		22.6	7.7	"	
0.0	11.48	$K_2SO_4$		22.8	8.4	"	
Results at 50°				23.2	10.8	"	
				23.4	12.3	"	
10.35	0.0	$H_3BO_4$		26.7	23.4	$H_3BO_3 + K_2SO_4$	
10.00	1.80	"		14.4	21.2	$K_2SO_4$	
10.1	3.90	"		18.7	22.0	"	
10.4	5.30	"		22.6	6.0	"	
				0.0	18.6	"	

SOLUBILITY OF POTASSIUM SULFATE IN AQUEOUS SOLUTIONS OF POTASSIUM  
HYDROXIDE AT 25°

(D'Ans and Schreiner, 1910)

Mols. per 1000 Gms. Sat. Sol.		Gms. per 100 gms. sat. sol.		Mols. per 1000 Gms. Sat. Sol.		Gms. per 100 gms. sat. sol.	
$(KOH)_2$	$K_2SO_4$	KOH	$K_2SO_4$	$(KOH)_2$	$K_2SO_4$	KOH	$K_2SO_4$
0	0.617	0	10.75	2.86	0.035	32.06	0.61
0.258	0.433	2.892	7.544	3.42	0.009	38.33	0.16
0.433	0.280	4.854	4.878	4.809	0	53.51	0
1.13	0.137	12.67	2.386				

## SOLUBILITY OF POTASSIUM SULFATE IN AQUEOUS AMMONIA SOLUTIONS

Most of the data are by Guyer, Bieler, and Orelli, 1940 and were estimated from curves given by the authors. The values at 25° are by Hill and Louchs, 1937. Additional data at 20° are given in the table following.

% NH <sub>3</sub> in solvent	Gms. K <sub>2</sub> SO <sub>4</sub> per 100 gms. solvent				
	-30°	-10°	0°	23°	25°
0	--	--	--	--	12.11
5	--	2.2	--	4.7	--
7	--	--	2.7	--	--
10	--	1.2	0.75	2.0	--
14.09	--	--	--	--	1.303
15	0.25	0.6	0.5	1.0	--
18.32	--	--	--	--	0.642
20	0.2	0.2	0.4	0.6	--
22.44	--	--	--	--	0.423
24.87	--	--	--	--	0.220
27.07	--	--	--	--	0.149
40	0.2	0.1	0.4	0.5	--
60	0.2	0.1	0.4	0.5	--
80	0.2	0.1	0.3	0.5	--

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SOLUBILITY OF POTASSIUM SULFATE IN AQUEOUS AMMONIA SOLUTIONS AT 20°  
(Girard, 1885)

Gms. NH <sub>3</sub> per 100 cc. solution	0	5.2*	6.086	15.37	24.69	31.02
Gms. K <sub>2</sub> SO <sub>4</sub> per 100 cc. solution	10.80	4.52	4.10	0.83	0.14	0.04

\*(Konowalow, 1899b).

SOLUBILITY OF POTASSIUM SULFATE IN POTASSIUM ACETATE SOLUTIONS  
(Fox, 1909)

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
K <sub>2</sub> SO <sub>4</sub>	CH <sub>3</sub> COOK	K <sub>2</sub> SO <sub>4</sub>	CH <sub>3</sub> COOK
6.65	6.11	2.35	15.59
5.09	8.68	1.23	20.12
3.99	11.29	0.39	29.95

SOLUBILITY OF POTASSIUM SULFATE IN AQUEOUS SOLUTIONS OF POTASSIUM  
CHLORIDE, BROMIDE, AND IODIDE  
(Blarez, 1891)

Interpolated from the original results.

Grams Halogen Salt per 100 cc. Solution	Grams K <sub>2</sub> SO <sub>4</sub> per 100 cc. in Aq. Solutions of:		
	KCl at 12.5°	KBr at 14°	KI at 12.5°
0	9.9	10.16	9.9
2	8.3	9.1	9.2
4	7.0	8.2	8.4
6	5.7	7.4	7.7
8	4.6	6.6	7.2
10	3.5	6.0	6.6
12	--	5.5	6.0

# K KALIUM

## THE SYSTEM $K_2SO_4 + BaCO_3 \rightleftharpoons K_2CO_3 + BaSO_4 (+ H_2O)$ (Meyerhoffer, 1905)

	Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
	K <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> CO <sub>3</sub>		K <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> CO <sub>3</sub>	
	Results at 25°			Results at 80°		
	10.76	0	K <sub>2</sub> SO <sub>4</sub> + BaSO <sub>4</sub>	0.613	2.49	BaCO <sub>3</sub> + BaSO <sub>4</sub>
	6.76	5.85	"	1.39	4.88	"
	3.92	12.6	"	7.1	15.33	" + K <sub>2</sub> SO <sub>4</sub>
	2.485	17.81	" + BaCO <sub>3</sub>			
	1.72	22.1	K <sub>2</sub> SO <sub>4</sub> + BaCO <sub>3</sub>			
	0.0886	28.5	"			
	0.023	53.1	" + K <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O	0.797	2.36	BaCO <sub>3</sub> + BaSO <sub>4</sub>
	0	53.2	K <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O + BaCO <sub>3</sub>	1.83	4.51	"
	0.602	7.35	BaCO <sub>3</sub> + BaSO <sub>4</sub>	9.42	13.6	" + K <sub>2</sub> SO <sub>4</sub>
	0.173	2.85	"			

SO

## THE SYSTEM POTASSIUM SULFATE - POTASSIUM BROMIDE - WATER AT 20° (Dolique, 1945)

Gms. per 100 Gms. $H_2O$			Solid Phase	Gms. per 100 Gms. $H_2O$			Solid Phase
KBr	$K_2SO_4$	Density		KBr	$K_2SO_4$	Density	
66.16	0.0	1.373	KBr	35.93	2.14	1.238	$K_2SO_4$
65.32	0.50	1.373	"	30.00	2.91	1.200	"
64.66	0.91	1.374	" + $K_2SO_4$	22.31	4.06	1.163	"
62.95	0.92	1.369	$K_2SO_4$	20.00	4.35	1.156	"
60.00	1.03	1.350	"	13.73	5.31	1.128	"
50.00	1.30	1.321	"	10.00	6.15	1.114	"
40.00	1.76	1.270	"	5.00	7.62	1.098	"
				0.0	11.11	1.081	"

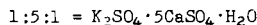
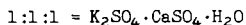
## THE SYSTEM POTASSIUM SULFATE - POTASSIUM VANADATE - WATER AT 25° (Trujillo and Pastor, 1951)

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
$KVO_3$	$K_2SO_4$		$KVO_3$	$K_2SO_4$	
9.74	--	$KVO_3$	2.86	9.73	$KVO_3$
8.70	1.20	"	2.66	10.75	"
7.22	2.99	"	2.48	10.93	"
6.13	4.27	"	2.47	10.98	"
4.95	5.56	"	2.42	11.19	$KVO_3 + K_2SO_4$
4.04	7.06	"	2.02	11.20	$K_2SO_4$
3.96	7.41	"	1.37	11.46	"
3.82	7.69	"	0.99	11.70	"
3.31	8.75	"	0.49	12.10	"
3.28	9.00	"	--	12.51	"

THE SYSTEM POTASSIUM SULFATE - CALCIUM SULFATE - WATER AT 55°  
(Bodaleva and Lepeshkov, 1956)

These data agree with and extend those of Hill, 1934 (Vol. I, p. 671-2).

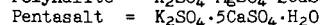
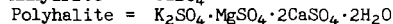
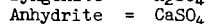
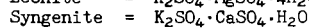
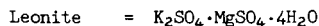
Sat. Sol. wt. %			Sat. Sol. Wt. %		
K <sub>2</sub> SO <sub>4</sub>	CaSO <sub>4</sub>	Solid Phase	K <sub>2</sub> SO <sub>4</sub>	CaSO <sub>4</sub>	Solid Phase
0.0	0.212	CaSO <sub>4</sub> ·2H <sub>2</sub> O	15.05	0.0	K <sub>2</sub> SO <sub>4</sub>
0.51	0.161	"	2.57	0.139	1:5:1
0.99	0.154	"	3.10	0.133	"
11.30	0.155	"	4.43	0.124	"
2.42	0.157	"	5.40	0.114	" + 1:1:1
3.55	0.168	"	2.15	0.148	" + CaSO <sub>4</sub>
4.73	0.180	" + 1:1:1	0.0	0.161	CaSO <sub>4</sub>
5.20	0.131	1:1:1	0.92	0.144	"
6.45	0.086	"	1.52	0.145	"
9.35	0.048	"	3.12	0.153	"
13.01	0.027	"	4.75	0.166	" + 1:1:1
14.87	0.020	" + K <sub>2</sub> SO <sub>4</sub>	1.75	0.154	1:5:1 + CaSO <sub>4</sub> ·2H <sub>2</sub> O



THE SYSTEM K<sub>2</sub>SO<sub>4</sub> - CaSO<sub>4</sub> - MgSO<sub>4</sub> - H<sub>2</sub>O AT 55°  
(Bodaleva and Lepeshkov, 1956)

(Selected data)

Sat. Sol. Wt. %			Solid Phase
K <sub>2</sub> SO <sub>4</sub>	MgSO <sub>4</sub>	CaSO <sub>4</sub>	
15.05	0.0	0.0	K <sub>2</sub> SO <sub>4</sub>
0.0	34.94	0.0	MgSO <sub>4</sub> ·6H <sub>2</sub> O
13.80	17.97	0.0	K <sub>2</sub> SO <sub>4</sub> + Leonite
4.25	34.06	0.0	Leonite + MgSO <sub>4</sub> ·6H <sub>2</sub> O
5.30	4.11	0.118	Syngenite + Pentasalt + Polyhalite
2.27	0.93	0.153	Pentasalt + Anhydrite
13.75	18.10	0.018	Syngenite + K <sub>2</sub> SO <sub>4</sub> + Leonite
7.46	11.53	0.055	Polyhalite + Syngenite
9.48	23.02	0.0	Leonite + Polyhalite
3.40	15.42	0.123	Polyhalite + Anhydrite
3.80	5.30	0.160	Anhydrite + Pentasalt + Polyhalite



# K KALIUM

## POTASSIUM CHROMIUM SULFATE $K_2Cr(SO_4)_2$

THE SYSTEM POTASSIUM CHROMIUM SULFATE - AMMONIUM CHROMIUM SULFATE -  
WATER AT 25°

(Hill, Smith, and Ricci, 1940)

Saturated Solution Wt. %		Solid Phase Wt. %		Solid Phase
$CrNH_4(SO_4)_2$	$CrK(SO_4)_2$	$CrNH_4(SO_4)_2$	$CrK(SO_4)_2$	
13.67	0.0	—	0.0	Solid Solution of $CrNH_4(SO_4)_2 \cdot 12H_2O$ + $CrK(SO_4)_2 \cdot 12H_2O$
10.28	4.612	43.12	12.08	
6.85	9.40	30.26	25.26	
4.852	12.14	21.91	34.15	
2.986	14.75	13.52	42.76	
1.162	17.30	5.226	51.32	
0.0	18.79	0.0	56.71	

## SO POTASSIUM FERRO SULFATE $K_2Fe(SO_4)_2$

SOLUBILITY OF THE THREE HYDRATES OF POTASSIUM FERROSULFATE  
IN WATER AT DIFFERENT TEMPERATURES

(Kuster and Thiel, 1899)

t°	$K_2SO_4 \cdot FeSO_4 \cdot 6H_2O$			$K_2SO_4 \cdot FeSO_4 \cdot 4H_2O$			$K_2SO_4 \cdot FeSO_4 \cdot 2H_2O$		
	cc. N/10KMnO <sub>4</sub>	Gms.	per 100 cc. sol.	cc. N/10KMnO <sub>4</sub>	Gms.	per 100 cc. sol.	cc. N/10KMnO <sub>4</sub>	Gms.	per 100 cc. sol.
	per 2 cc. Solution	$K_2SO_4 \cdot FeSO_4$		per 2 cc. Solution	$K_2SO_4 \cdot FeSO_4$		per 2 cc. Solution	$K_2SO_4 \cdot FeSO_4$	
0.5	12.4	18.36		15.5	22.84		15.4	22.79	
17.2	17.0	25.16		18.1	26.79		21.6	31.98	
40.1	24.8	36.72		21.9	32.41		27.6	40.86	
60	29.0	42.93		24.1	35.68		28.8	42.63	
80	30.6	45.29		27.3	40.46		28.6	42.34	
90	—	—		29.6	43.82		28.9	42.73	
95	—	—		29.8	44.11		27.7	41.01	

THE SYSTEM POTASSIUM SULFATE - LITHIUM SULFATE - WATER  
(Druzhinin and Yanko, 1954; Yanko and Druzhinin, 1955; Campbell  
and Kartzmark, 1958)

Druzhinin and Yanko studied the system at 0, 25, and 50° and found the double salt  $K_2SO_4 \cdot Li_2SO_4$  at each temperature. This salt forms limited solid solutions with  $Li_2SO_4$  (2% at 25°), and the limits of the solid solutions expand with increasing temperature. Campbell and Kartzmark thought the double salt solid to be "pure", but their tie-line data also show some solid solutions. C. and K. were apparently unaware of the earlier results.

Some results for solutions saturated with two solids at 20°, 60°, 98° are given by Spielrein, 1913, but they do not seem to be in very good agreement with those given below.

(Cont.)

## Results at 25°

Author	Saturated Solution Wt. %		Wet Residue Wt. %		Solid Phase
	Li <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	Li <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	
CK	25.5	0.0	—	—	Li <sub>2</sub> SO <sub>4</sub> ·H <sub>2</sub> O
CK	25.8	0.2	—	—	"
YD	25.85	1.03	66.20	0.69	"
CK	26.0	0.4	71.2	0.1	"
CK	26.7	2.3	61.3	16.8	" + K <sub>2</sub> SO <sub>4</sub> ·Li <sub>2</sub> SO <sub>4</sub>
CK	26.5	2.2	51.7	21.9	" + "
CK	26.5	2.4	37.0	45.0	K <sub>2</sub> SO <sub>4</sub> ·Li <sub>2</sub> SO <sub>4</sub>
CK	24.6	2.8	35.8	46.0	"
YD	20.93	3.25	35.05	45.95	"
CK	18.1	4.1	34.0	42.8	"
YD	13.05	8.09	31.35	45.99	"
CK	12.1	9.2	35.1	55.5	"
CK	12.0	9.2	32.0	49.0	"
CK	11.9	9.0	31.6	48.1	"
YD	10.70	10.46	30.32	54.39	"
CK	11.0	10.3	25.4	61.2	" + K <sub>2</sub> SO <sub>4</sub>
CK	10.6	10.7	8.8	65.0	K <sub>2</sub> SO <sub>4</sub>
CK	8.5	10.1	7.4	63.6	"
CK	5.1	10.2	4.1	76.2	"
CK	4.4	9.9	3.7	72.7	"
CK	0.0	10.7	—	—	"

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## THE SYSTEM POTASSIUM SULFATE - MAGNESIUM SULFATE - WATER

Bozza, 1934, also gives a compilation with diagrams of the available data upon this system at temperatures between 0° and 100° calculated to the terms proposed by Janecke. Additional data are given by Weston, 1922; Levi, 1923; Tabler, 1855 and others. Results at the freezing points are given by Fialkov and Chernogorenko, 1956.

K = K<sub>2</sub>SO<sub>4</sub>; M<sub>7</sub> = MgSO<sub>4</sub>·7H<sub>2</sub>O; M<sub>6</sub> = MgSO<sub>4</sub>·6H<sub>2</sub>O; M<sub>1</sub> = MgSO<sub>4</sub>·H<sub>2</sub>O;  
 S = Schonite = MgSO<sub>4</sub>·K<sub>2</sub>SO<sub>4</sub>·6H<sub>2</sub>O; L = Leonite = MgSO<sub>4</sub>·K<sub>2</sub>SO<sub>4</sub>·4H<sub>2</sub>O;  
 D = MgSO<sub>4</sub>·K<sub>2</sub>SO<sub>4</sub>·2H<sub>2</sub>O; B = Langbenite = K<sub>2</sub>SO<sub>4</sub>·2MgSO<sub>4</sub>

Results at 0°  
(Benrath & Benrath, 1930)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	MgSO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>			MgSO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	
1.025	0.0	6.68	K	1.192	11.79	6.76	S
1.061	1.26	7.03	"	1.265	20.78	3.03	S + M <sub>7</sub>
1.108	4.17	7.51	"	—	21.09 L	3.42 L	" + "
1.115	4.59	7.77	K + S	1.271	20.74	7.93*	M <sub>7</sub>
—	8.73 L	7.86 L	" + "	1.274	20.68	4.34*	"
1.163	8.60	7.85	S	1.259	20.94	2.17	"
1.165	8.94	7.53	"	1.236	20.82	0.0	"

\*Metastable

L = Levi, 1923.

(Cont.)



# K KALIUM

## THE SYSTEM POTASSIUM SULFATE - MAGNESIUM SULFATE - WATER--Cont.

K =  $K_2SO_4$ ;  $M_7 = MgSO_4 \cdot 7H_2O$ ;  $M_6 = MgSO_4 \cdot 6H_2O$ ;  $M_1 = MgSO_4 \cdot H_2O$ ;  
 S = Schonite =  $MgSO_4 \cdot K_2SO_4 \cdot 6H_2O$ ; L = Leonite =  $MgSO_4 \cdot K_2SO_4 \cdot 4H_2O$ ;  
 D =  $MgSO_4 \cdot K_2SO_4 \cdot 2H_2O$ ; B = Langbenite =  $K_2SO_4 \cdot 2MgSO_4$

### Results at 25°

(Benrath & Benrath, 1929(a))

(Van Klooster, 1917)

	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
		$MgSO_4$	$K_2SO_4$			$MgSO_4$	$K_2SO_4$	
SO	1.088	0.0	10.75	K	--	0.0	10.77	K
	1.123	2.60	10.86	"	--	4.0	11.03	"
	1.149	5.05	10.85	"	--	7.8	11.10	"
	1.230	12.61	10.99	K + S	--	10.69	10.84	"
	1.249	14.28	9.89	S	--	12.06	10.77	"
	1.267	17.02	9.18	"	--	12.68	10.70	K + S
	1.294	20.32	7.32	"	--	12.88	10.51	S
	1.347	26.02	4.90	S + $M_7$	--	13.26	10.34	"
	1.324	26.61	2.11	$M_7$	--	14.27	9.63	"
	1.305	26.65	0.0	"	--	16.36	8.43	"
					--	18.76	7.02	"
					--	26.39	4.02	S + $M_7$
					--	26.36	3.76	$M_7$
					--	26.57	2.34	"
					--	26.67	1.68	"
					--	26.76	0.0	"

### Results at 30°

(Starrs and Clark, 1930)

### Results at 35°

(Bayliss, Cole, Ewers, and Jones, 1947)

--	0.0	11.6	K	--	0.0	12.1	K
--	4.03	12.0	"	--	3.82	12.2	"
--	9.45	12.0	"	1.148	5.04B	12.40B	"
--	12.2	11.7	"	--	7.16 B	12.28 B	"
--	13.3	11.5	K + S	--	7.83	12.6	"
--	13.9	10.9	S	1.242	13.13 B	11.67 B	"
--	19.0	8.21	"	--	13.7	12.1	K + S
--	22.6	6.32	"	1.250	14.40 B	11.90 B	" + "
--	25.9	4.97	"	--	16.15 B	10.20 B	S
--	27.2	4.47	S + $M_7$	--	17.6	9.67	"
--	27.0	3.82	$M_7$	1.283	17.82 B	9.33 B	"
--	27.1	3.99	"	1.284	20.37 B	7.55 B	"
--	28.1	0.0	"	--	21.7	7.40	"
				--	24.60 B	5.61 B	"
				--	25.8	5.53	"
				--	28.4	4.40	S + $M_7$
				1.360	28.45 B	4.35 B	" + "
				--	28.6	2.31	$M_7$
				1.336	28.41 B	1.78 B	"
				1.332	29.20 B	0.0 B	"
				--	29.4	0.0	"

B = Bozza, 1934.

(Cont.)

## THE SYSTEM POTASSIUM SULFATE - MAGNESIUM SULFATE - WATER--Cont.

$K = K_2SO_4$ ;  $M_7 = MgSO_4 \cdot 7H_2O$ ;  $M_6 = MgSO_4 \cdot 6H_2O$ ;  $M_1 = MgSO_4 \cdot H_2O$ ;  
 $S = \text{Schonite} = MgSO_4 \cdot K_2SO_4 \cdot 6H_2O$ ;  $L = \text{Leonite} = MgSO_4 \cdot K_2SO_4 \cdot 4H_2O$ ;  
 $D = MgSO_4 \cdot K_2SO_4 \cdot 2H_2O$ ;  $B = \text{Langbenite} = K_2SO_4 \cdot 2MgSO_4$

Results at 50°  
(Benrath and Benrath, 1929a)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	MgSO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	
1.087	0.0	14.14	K
1.148	5.05	14.13	"
1.255	13.86	13.47	"
1.292	16.96	13.10	K + D
1.296	17.36	13.06	D
1.322	21.88	10.32	"
1.337	24.39	8.14	"
1.370	28.59	5.98	"
1.394	32.35	4.30	D + M <sub>6</sub>
1.380	32.76	2.60	M <sub>6</sub>
1.383	33.50	0.0	"

Results at 55°  
(Bodaleva and Lepeshkov, 1956)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	MgSO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	
--	0.0	15.05	K
--	1.99	14.40	"
--	4.80	14.51	"
--	8.46	14.85	"
--	12.23	14.53	"
--	14.39	14.30	"
--	17.97	14.05	K + L
--	18.26	13.21	L
--	21.86	10.23	"
--	25.10	7.91	"
--	28.51	6.27	"
--	31.31	5.30	"
--	33.11	4.86	"
--	34.06	4.25	L + M <sub>6</sub>
--	34.94	--	M <sub>6</sub>
--	34.35	2.47	"

SO

Results at 66°  
(Benrath and Sichel Schmidt, 1931)

--	0.0	16.16	K
--	7.73	15.01	"
--	14.01	14.37	"
--	17.08	14.46	K + D
--	19.33	13.04	D
--	26.97	7.67	"
--	32.53	5.86	"
--	33.89	4.48	"
--	35.66	4.01	D + M <sub>1</sub>
--	35.40	2.08	M <sub>1</sub>
--	35.52	0.0	"

Results at 75°  
(Benrath and Sichel Schmidt, 1931) (Luk'yanova, Sokol and Sokolova, 1956)

1.095	0.0	17.05	K	--	0.0	17.30	K
1.151	8.51	16.13	"	--	16.60	16.24	"
1.225	12.70	15.70	"	--	17.18	16.73	K + D
1.302	17.18	15.22	" + D	--	17.32	16.32	" + "
1.320	18.12	14.09	D	--	22.05	12.59	D
1.351	23.32	11.14	"	--	27.80	9.20	"
1.402	26.44	8.70	"	--	31.21	6.99	D + B
1.419	30.70	7.71	D + B	--	31.70	6.39	B
1.421	31.66	5.44	B	--	32.57	5.30	"
1.424	32.13	4.41	"	--	33.20	4.67	"
1.449	35.54	4.02	B + M <sub>1</sub>	--	34.45	3.69	"
1.437	35.23	2.30	M <sub>1</sub>	--	35.33	3.56	"
1.435	37.11	1.25	"	--	35.56	3.67	B + M <sub>1</sub>
1.432	37.30	0.0	"	--	36.28	2.76	M <sub>1</sub>
				--	37.59	1.31	"
				--	37.70	0.0	"

(Cont.)

# K KALIUM

## THE SYSTEM POTASSIUM SULFATE - MAGNESIUM SULFATE - WATER--Cont.

$K = K_2SO_4$ ;  $M_7 = MgSO_4 \cdot 7H_2O$ ;  $M_6 = MgSO_4 \cdot 6H_2O$ ;  $M_1 = MgSO_4 \cdot H_2O$ ;  
 $S = \text{Schonite} = MgSO_4 \cdot K_2SO_4 \cdot 6H_2O$ ;  $L = \text{Leonite} = MgSO_4 \cdot K_2SO_4 \cdot 4H_2O$ ;  
 $D = MgSO_4 \cdot K_2SO_4 \cdot 2H_2O$ ;  $B = \text{Langbenite} = K_2SO_4 \cdot 2MgSO_4$

### Results at 85° (Starrs and Storck, 1930)

	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase		d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
		MgSO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>				MgSO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	
S0	--	6.08	18.25	K		--	24.66	9.56	B
	--	13.60	17.71	"		--	27.74	6.58	"
	--	17.33	16.94	K + L		--	32.01	3.27	B + M <sub>1</sub>
	--	19.97	14.86	L		--	32.9	0.0	M <sub>1</sub>
	--	25.49	17.16	L + B					

### Results at 100°

At 100° this system was also studied by Campbell, Downs and Samis, 1934, but their results give a curve which differs considerably from that of Benrath and of Starrs and Storck. Their values for the triple points are shown in parentheses.

#### (Benrath and Benrath, 1930)

1.119	0.0	19.42	K
1.217	7.34	19.46	"
1.339	16.25	18.75*	"
--	18.00	18.84*	"
1.305	14.47	18.64	K + B
1.304	18.12	14.26	B
1.319	22.63	9.04	"
1.332	27.44	5.54	"
1.361	31.00	3.31	B + M <sub>1</sub>
1.367	33.27	0.0	M <sub>1</sub>

#### (Starrs and Storck, 1930)

--	0.0	19.53	K
--	8.69	19.83	"
--	15.64	19.03*	"
--	17.33	18.68*	"
--	13.75	19.00	K + B
--	(21.9)	(14.0)	" + "
--	16.49	14.98	B
--	20.71	10.40	"
--	25.60	6.50	"
--	29.90	3.69	B + M <sub>1</sub>
--	(34.0)	(3.4)	" + "
--	31.75	0.0	M <sub>1</sub>
--	(33.5)	(0.0)	"

\*Metastable

THE SYSTEM  $K_2SO_4 - MgSO_4 - Mg(OH)_2 - H_2O$  AT  $100^\circ$   
(Sugi and Nakayama, 1958)

Ks =  $K_2SO_4$ Ms. 1 =  $MgSO_4 \cdot H_2O$ Lang. = Langbeinite =  $K_2SO_4 \cdot 2MgSO_4$ B.M.S. = Basic magnesium sulfate  $MgSO_4 \cdot 5Mg(OH)_2 \cdot 3H_2O$ T.S. = Triple salt  $K_2SO_4 \cdot 2MgSO_4 \cdot Mg(OH)_2 \cdot 2H_2O$ 

Gms. per 100 gms. $H_2O$			Solid Phase	Gms. per 100 gms. $H_2O$			Solid Phase
$K_2SO_4$	$MgSO_4$	$Mg(OH)_2$		$K_2SO_4$	$MgSO_4$	$Mg(OH)_2$	
24.59	—	0.0197	Ks + $Mg(OH)_2$	0.888	58.22	0.0661	T.S. + Ms. 1 + B.M.S.
26.52	5.317	0.0018	Ks + T.S. + B.M.S.	—	49.36	0.0520	Ms. 1 + B.M.S.
26.90	5.295	0.0029	"	1.393	48.94	0.0232	T.S. + B.M.S.
(26.71	5.306	0.0024	" (mean))	1.152	44.87	0.1109	"
26.32	7.115	**	Ks + T.S.	1.456	42.44	0.0489	"
27.59	10.97	0.0071	"	1.599	37.44	0.0384	"
27.15	12.16	**	"	1.872	33.62	0.0527	"
29.17	21.43	**	Ks + T.S. + Lang.	1.869	32.91	0.0266	"
28.88	21.09	**	"	3.453	27.19	0.0201	"
(29.02	21.26		" (mean))	3.130	24.29	0.0150	"
27.93	22.42	**	T.S. + Lang.	5.733	16.31	0.0117	"
18.63	28.88	**	"	6.141	15.03	0.0069	"
10.36	36.76	0.0028	"	8.883	10.20	0.0045	"
5.001	46.59	0.0044	"	11.29	8.832	0.0035	"
3.614	51.58		"	15.22	6.606	0.0029	"
3.789	54.09	0.0082	"	17.38	6.478	0.0030	"
3.176	55.91	0.0073	T.S. + Lang. + Ms. 1	22.10	6.262	0.0024	"
2.725	57.16	0.0149	"	23.89	5.205	0.0009	"
2.702	56.46	0.0092	"				
(2.886	56.54	0.0106	" (mean))				
0.938	61.06	0.0669	T.S. + Ms. 1 + B.M.S. (supersaturation)				

50

THE SYSTEM  $K_2SO_4 - MgSO_4 - H_3BO_3 - H_2O$   
(Perova, 1953)

H =  $H_3BO_3$  K =  $K_2SO_4$  S =  $K_2SO_4 \cdot MgSO_4 \cdot 6H_2O$   $M_{12} = MgSO_4 \cdot 12H_2O$   $M_7 = MgSO_4 \cdot 7H_2O$ 

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
$H_3BO_3$	$K_2SO_4$	$MgSO_4$		$H_3BO_3$	$K_2SO_4$	$MgSO_4$	
At $0^\circ$				At $15^\circ$			
2.59	--	--	H	4.20	--	--	H
3.25	7.50	--	H + K	4.80	10.5	--	H + K
--	6.89	--	K	--	9.22	--	K
3.00	7.73	1.77	H + K	4.5	9.76	2.24	H + K
2.30	8.00	7.19	H + K	3.2	9.75	6.96	H + K
--	7.55	8.90	K + S	--	9.90	10.10	K + S
2.00	8.20	9.90	H + K + S	3.40	10.45	9.00	H + K + S
2.00	6.27	13.02	H + S	2.60	7.21	15.29	H + S
1.10	3.62	17.58	H + S	2.00	4.40	21.45	H + S
--	3.30	20.80	$M_{12}$ + S	--	3.45	24.40	$M_7$ + S
0.70	2.80	19.10	$M_{12}$ + S + H	1.32	2.80	22.73	$M_7$ + S + H
0.90	1.51	20.65	$M_{12}$ + H	1.30	1.74	23.46	$M_7$ + H
--	--	21.00	$M_{12}$	2.40	--	23.95	$M_7$ + H
1.6	--	20.80	$M_{12}$ + H	--	--	25.00	$M_7$

(Cont.)

## K KALIUM

THE SYSTEM  $K_2SO_4 - MgSO_4 - H_3BO_3 - H_2O$ —Cont.

$H = H_3BO_3$   $K = K_2SO_4$   $S = K_2SO_4 \cdot MgSO_4 \cdot 6H_2O$   $M_{12} = MgSO_4 \cdot 12H_2O$   $M_7 = MgSO_4 \cdot 7H_2O$

Gms. per 100 gms. sat. sol.				Gms. per 100 gms. sat. sol.			
H <sub>3</sub> BO <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>	MgSO <sub>4</sub>	Solid Phase	H <sub>3</sub> BO <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>	MgSO <sub>4</sub>	Solid Phase
At 25°							
5.60	--	--	H	2.80	8.13	16.80	H + S
6.50	12.00	--	H + K	2.30	4.65	22.65	H + S
--	10.75	--	K	--	3.60	27.00	M <sub>7</sub> + S
5.80	10.98	2.52	K + H	1.77	2.90	25.26	M <sub>7</sub> + S + H
4.08	10.55	6.82	K + H	1.80	1.92	25.38	M <sub>7</sub> + H
--	11.60	11.30	K + S	3.00	--	26.00	M <sub>7</sub> + H
4.30	11.30	10.50	K + S + H	--	--	26.80	M <sub>7</sub>

Data for the system  $K_2SO_4 + MgSO_4 + (NH_4)_2SO_4 + H_2O$  at 30° are given by Weston, 1922 and recalculated by Jancke, 1937, 1938.

THE SYSTEM  $K_2SO_4 + MgSO_4 + Na_2SO_4 + H_2O$   
Results of Bayliss, Cole, Ewers, and Jones, 1947 at 35°

Gms. per 100 gms. $H_2O$				Solid Phase
$Na_2SO_4$	$K_2SO_4$	$MgSO_4$		
44.05	7.65	5.30		$Na_2SO_4$ + G
42.10	7.45	7.55		"
40.90	7.65	9.30		"
38.85	7.65	12.90		"
36.50	7.55	16.50		"
36.10	7.55	17.55		$Na_2SO_4$ + G + A
36.60	5.50	17.30		$Na_2SO_4$ + A
36.80	2.15	17.15		"
34.30	7.65	18.10		G + A
29.90	8.10	21.85		"
24.50	8.50	26.00		"
21.35	8.80	29.20		G + A + S
17.95	9.95	27.60		G + S
15.00	11.00	25.85		"
9.30	13.55	21.85		"
7.00	15.20	20.05		"
5.75	16.15	18.15		$K_2SO_4$ + G + S
2.90	15.85	18.90		$K_2SO_4$ + S
5.75	16.05	15.15		$K_2SO_4$ + G
5.30	16.15	11.20		"
6.15	15.85	5.75		"
20.95	8.70	30.15		A + S
17.80	7.95	33.20		"
13.95	6.60	37.40		"
12.75	6.50	39.80		$MgSO_4 \cdot 7H_2O$ + A + S
13.10	3.30	39.20		$MgSO_4 \cdot 7H_2O$ + A
9.05	6.60	41.30		$MgSO_4 \cdot 7H_2O$ + S
4.50	6.60	41.40		"

(Cont.)

## Results of Yanat'eva and Orlova, 1956 at 55°

A "new phase" was found which appears to be a solid solution of molar ratio  $K_2SO_4/Na_2SO_4 > 3, < 3.6$ . (Glaserite  $\leq 3.0$ )

Gms. per 100 gms. sat. sol.			Solid Phase	SO
$Na_2SO_4$	$K_2SO_4$	$MgSO_4$		
5.60	14.30	--	$K_2SO_4 + G$	
28.95	6.20	--	$Na_2SO_4 + G$	
23.49	--	12.93	$Na_2SO_4 + A$	
5.37	--	33.66	$MgSO_4 \cdot 6H_2O + A$	
--	4.25	34.06	$MgSO_4 \cdot 6H_2O + L$	
--	14.05	17.97	$K_2SO_4 + L$	
4.94	13.91	3.40	$K_2SO_4 + G$	
4.33	13.30	7.53	" + "	
4.21	13.17	14.60	" + "	
4.05	12.96	15.64	$K_2SO_4 + G + L$	
9.57	8.55	19.55	$G + L$	
12.61	7.12	20.25	$G + L + A$	
17.40	6.58	15.75	$G + A$	
17.74	6.52	14.81	" + "	
21.45	6.11	12.40	$G + Na_2SO_4 + A$	
22.15	6.02	10.58	$G + Na_2SO_4$	
26.80	6.30	3.39	" + "	
8.86	5.70	25.30	$A + L$	
4.80	3.68	31.65	$A + L + MgSO_4 \cdot 6H_2O$	

A = Astrakanite =  $MgSO_4 \cdot Na_2SO_4 \cdot 4H_2O$

G = Glaserite =  $Na_2SO_4 \cdot 3K_2SO_4$

S = Schonite =  $MgSO_4 \cdot K_2SO_4 \cdot 6H_2O$

L = Leonite =  $K_2SO_4 \cdot MgSO_4 \cdot 4H_2O$

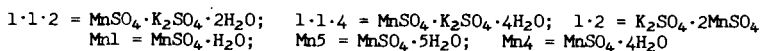
Data are given for the reciprocal salt pair  $K_2SO_4 + Mg(NO_3)_2 \rightleftharpoons MgSO_4 + K_2(NO_3)_2$  at 0° and 99.5°, Benrath and Benrath, 1930; at 25° and 50°, Benrath and Benrath, 1929a; at 75°, Benrath and Sichelschmidt, 1931.

Data for the system  $K_2SO_4 + MgCl_2 \rightleftharpoons 2KCl + MgSO_4 (+ H_2O)$  at 100° are given by Campbell, Downes, and Samis, 1934.

Weston, 1922 gives complete data for the quaternary system  $(NH_4)_2SO_4 + MgSO_4 + K_2SO_4 + H_2O$ . The results are expressed in terms of the  $H_2O$  required for the solution of 100 gm. quantities of various mixtures of the three salts.

## K KALIUM

THE SYSTEM POTASSIUM SULFATE - MANGANESE SULFATE - WATER  
 0° - Caven and Johnston, 1927; 25° Caven and Johnston, 1926;  
 17.5 to 97° - Benrath, 1930



Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
MnSO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	Solid Phase	MnSO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	Solid Phase
At 0°			At 50°		
0.0	6.82	K <sub>2</sub> SO <sub>4</sub>	0.0	14.17	K <sub>2</sub> SO <sub>4</sub>
6.21	7.75	"	2.77	15.02	"
8.21	7.97	"	7.36	15.11	"
11.80	8.48	"	11.78	15.34	" + 1:1:2
13.68	8.88	" + 1:1:4	14.43	13.40	1:1:2
17.39	7.60	1:1:4	16.45	12.34	"
23.64	5.54	"	17.17	11.85	"
25.50	5.00	"	18.30	11.55	"
27.62	4.48	"	18.70	11.41	" + 1:2
30.28	4.00	"	21.52	9.51	1:2
34.30	3.35	"	24.82	7.30	"
34.38	2.81	"	27.9	5.85	"
34.53	1.85	"	35.22	3.49	" + Mnl
34.49	1.68	"	37.3	0.0	Mnl
34.78	0.00	"			
At 17.5°			At 55°		
14.85	10.85	K <sub>2</sub> SO <sub>4</sub> + Mn5	10.50	15.91	K <sub>2</sub> SO <sub>4</sub> + 1:1:2
			16.71	12.83	1:2 + "
			33.6	3.1	" + Mnl
At 25°			At 66°		
39.10	0.0	Mn4	8.63	16.75	K <sub>2</sub> SO <sub>4</sub> + 1:1:2
39.03	0.43	"	11.35	14.77	1:2 + "
38.54	1.87	"			
38.42	2.46	"	At 80°		
38.21	3.03	"	0.0	17.92	K <sub>2</sub> SO <sub>4</sub>
37.92	4.15	" + 1:1:4	3.38	18.60	"
37.28	4.20	1:1:4	5.41	18.40	"
35.58	4.30	"	5.84	18.40	" + 1:2
30.47	5.27	"	6.16	17.13	1:2
19.27	10.06	"	6.92	13.80	"
16.58	12.31	" + K <sub>2</sub> SO <sub>4</sub>	8.81	10.82	"
15.22	12.04	K <sub>2</sub> SO <sub>4</sub>	14.57	6.66	"
6.36	11.27	"	16.65	6.19	"
0.00	12.59	"	20.42	4.85	"
			29.58	2.61	" + Mnl
			30.24	0.0	Mnl
At 30°			At 97°		
15.46	12.25	K <sub>2</sub> SO <sub>4</sub> + 1:1:4	0.0	19.42	K <sub>2</sub> SO <sub>4</sub>
33.64	5.50	1:1:4 + 1:2	2.09	19.78	"
At 35°			3.63	19.89	" + 1:2
			4.05	16.84	1:2
15.65	13.10	K <sub>2</sub> SO <sub>4</sub> · 1:1:2	4.31	12.80	"
30.40	6.6	1:1:4 + 1:2	5.46	9.68	"
At 40°			7.08	7.25	"
			11.65	6.00	"
14.26	13.78	K <sub>2</sub> SO <sub>4</sub> + 1:1:2	17.0	4.18	"
27.18	7.22	1:2 + "	25.92	2.48	" + Mnl
34.66	3.34	" + "	28.49	0.0	Mnl

THE SYSTEM POTASSIUM SULFATE - AMMONIUM SULFATE - WATER  
(Bovalini and Fabria, 1936)  
(Weston, 1922 at 25°, 30°; Calvo and Simons, 1952 at 25°)

Additional data at 0° and 50° are given by Janecke, 1929; at 30° by Dolique and Pauc, 1948a. Fock, 1897 gives results at seven temperatures from 14° to 47°. Bergman and Shelokhovitch, 1942 studied the system from the eutectic to 30°. See also Kazandzhyan, Galstyan and Mkhifaryan, 1954.

Gms. per 100 gms. sat. solution			Gms. per 100 gms. sat. solution		
$K_2SO_4$ $(NH_4)_2SO_4$		Wt. % $K_2SO_4$ in Mixed Crystals composing Solid Phase	$K_2SO_4$ $(NH_4)_2SO_4$		Wt. % $K_2SO_4$ in Mixed Crystals composing Solid Phase
Results at -3.3 (Eutec.)			Results at 30° (W.)--Cont.		
6.802	6.201	95.6	2.4	40.9	12.2
Results at -13.63°			1.2	42.7	3.3
4.448	30.54	83.15	0.0	44.2	0.0
Results at -17.82°			Results at 35°		
2.568	36.46	33.9	11.80	5.450	99.5
Results at -18.76°			9.651	13.42	89.1
1.447	38.29	6.32	9.072	19.41	80.9
Results at 0°			7.134	28.50	72.3
6.513	7.222	99.1	5.468	34.32	63.6
6.429	12.894	97.8	3.860	38.60	54.1
6.010	18.98	96.1	2.191	42.22	26.0
5.245	25.23	90.1	0.698	43.30	5.2
4.790	30.71	72.8	Results at 50°		
3.925	31.69	71.6	13.27	6.09	98.9
2.928	35.21	52.0	10.05	19.67	89.6
2.688	36.99	32.7	7.5	29.06	81.6
2.431	38.82	11.6	6.09	35.54	70.9
0.852	40.90	5.1	5.49	36.35	64.2
Results at 25° (C. and S.)			4.41	39.91	40.0
10.79	0.0	100.0	3.652	40.03	33.0
9.35	12.22	85.6	0.790	45.23	4.1
9.03	13.99	80.8	0.580	45.49	1.6
8.04	19.37	76.6	Results at 70°		
7.15	23.42	51.0	16.04	4.58	98.7
6.02	28.25	40.9	14.61	9.64	97.2
5.09	32.25	39.3	11.98	20.01	92.2
4.26	35.67	39.2	9.28	27.65	82.8
4.15	35.86	28.3	7.149	34.14	73.9
4.14	35.81	20.3	5.061	39.49	53.0
3.83	36.92	15.5	3.23	43.21	36.8
2.82	39.28	10.2	1.19	45.66	11.1
2.47	39.88	6.8	Results at 96.5°		
2.06	40.62	5.8	17.56	11.82	93.6
0.0	43.41	0.0	9.59	32.30	69.5
Results at 30° (W.)			7.04	39.23	47.8
11.2	0.0	100.0	Result at 103.6° (b. pt.)		
10.7	8.4	98.2	17.10	12.62	86.2
9.1	18.5	74.2	Result at 106.7° (b. pt.)		
6.4	31.0	61.3	8.62	37.23	49.2
5.9	33.5	43.6	Result at 107.2° (b. pt.)		
4.1	37.8	28.7	6.69	42.53	35.0



## K KALIUM

THE SYSTEM  $K_2SO_4 - (NH_4)_2SO_4 - Na_2SO_4 - H_2O$  AT  $0^\circ$ ,  $25^\circ$ ,  $40^\circ$   
(Belopolsky and Shpunt, 1945)

$\gamma$ -Glaserite =  $K_3Na(SO_4)_2$  forming solid solutions with  $Na_2SO_4$ .  
 $(K, NH_4)_2SO_4$  = Continuous solid solutions of  $K_2SO_4$  +  $(NH_4)_2SO_4$ .

SO

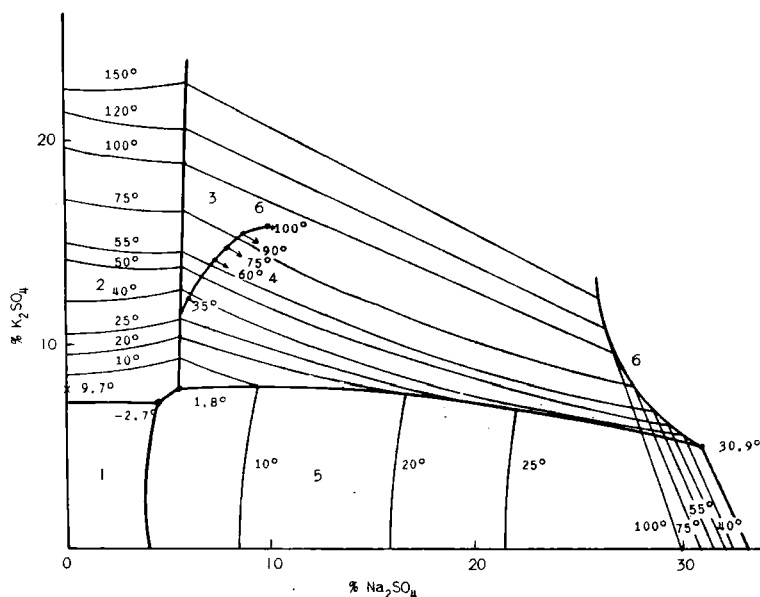
Gms. per 100 gms. sat. sol.			Gms. per 100 gms. Solid			Solid Phase
Na <sub>2</sub> SO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	
Results at 0°						
7.60	29.37	0.0	--	--	--	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub> ·(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·4H <sub>2</sub> O
8.29	27.55	2.37	--	--	--	"
8.00	26.87	3.26	--	--	--	"
7.97	27.08	3.14	--	--	--	"
7.53	24.28	4.05	--	--	--	" + (K, NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
4.47	38.22	0.0	--	--	--	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + Na <sub>2</sub> SO <sub>4</sub> ·(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·4H <sub>2</sub> O
5.00	36.90	0.82	--	--	--	Na <sub>2</sub> SO <sub>4</sub> ·(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·4H <sub>2</sub> O + (NH <sub>4</sub> , K) <sub>2</sub> SO <sub>4</sub>
5.02	35.35	1.93	--	--	--	"
5.52	33.54	2.59	--	--	--	"
6.30	31.39	3.03	--	--	--	"
6.32	26.24	3.90	--	--	--	"
7.06	24.84	4.07	--	--	--	"
5.67	0.0	7.42	--	--	--	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O + (K, NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
5.46	0.0	7.80	--	--	--	"
7.11	15.60	5.40	--	--	--	"
Results at 25°						
22.25	0.0	6.60	30.12	0.0	68.68	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O + γ-Glaserite
23.30	4.86	5.20	33.22	1.40	32.41	"
22.95	6.15	4.60	--	--	--	"
25.25	12.25	2.84	38.16	14.18	18.06	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O + γ-Glaserite + Na <sub>2</sub> SO <sub>4</sub> ·(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·4H <sub>2</sub> O
24.85	13.09	1.95	--	--	--	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub> ·(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·4H <sub>2</sub> O
25.13	14.09	0.0	--	--	--	"
7.70	38.45	0.0	--	--	--	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + Na <sub>2</sub> SO <sub>4</sub> ·(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·4H <sub>2</sub> O
7.88	37.22	0.89	--	--	--	Na <sub>2</sub> SO <sub>4</sub> ·(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·4H <sub>2</sub> O + (K, NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
8.26	35.47	1.85	14.30	66.77	11.31	"
8.58	34.27	2.44	26.38	43.43	22.88	Na <sub>2</sub> SO <sub>4</sub> ·(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·4H <sub>2</sub> O + (K, NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + γ-Glaserite
20.67	15.60	3.18	--	--	--	Na <sub>2</sub> SO <sub>4</sub> ·(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·4H <sub>2</sub> O + γ-Glaserite
16.20	21.06	3.23	--	--	--	"
12.99	26.11	2.73	30.96	29.13	27.49	"
5.90	0.0	10.48	--	--	--	γ-Glaserite + (K, NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
6.02	5.12	9.99	10.24	1.51	88.10	"
5.91	8.39	9.51	14.13	4.58	82.49	"
6.04	9.12	9.61	9.74	2.04	87.99	"
6.17	11.10	8.94	16.32	2.60	81.45	"
6.15	15.55	8.12	15.65	8.25	75.95	"
6.03	19.61	7.01	13.53	13.52	71.57	"
5.85	23.58	5.88	13.12	16.95	68.51	"
5.66	24.24	6.22	7.55	18.51	73.11	"
5.48	30.72	4.42	--	--	--	"
5.64	30.59	3.44	--	--	--	"
Results at 40°						
30.31	0.0	5.32	36.87	1.07	59.91	Na <sub>2</sub> SO <sub>4</sub> + γ-Glaserite
28.43	4.39	4.84	39.93	2.00	59.15	"
26.79	8.48	4.12	41.62	2.89	53.73	"
25.15	12.27	3.70	43.93	4.36	50.00	"
22.69	17.87	3.40	41.20	19.75	27.39	Na <sub>2</sub> SO <sub>4</sub> + γ-Glaserite + Na <sub>2</sub> SO <sub>4</sub> ·(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·4H <sub>2</sub> O
23.06	19.35	0.0	--	--	--	Na <sub>2</sub> SO <sub>4</sub> + Na <sub>2</sub> SO <sub>4</sub> ·(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·4H <sub>2</sub> O
10.34	38.26	0.0	--	--	--	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + Na <sub>2</sub> SO <sub>4</sub> ·(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·4H <sub>2</sub> O
11.05	35.57	1.69	17.81	67.73	8.39	Na <sub>2</sub> SO <sub>4</sub> ·(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·4H <sub>2</sub> O + (K, NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
11.34	34.96	1.78	12.65	59.65	24.94	Na <sub>2</sub> SO <sub>4</sub> ·(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·4H <sub>2</sub> O + (K, NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + γ-Glaserite
19.44	21.53	2.65	34.22	27.23	23.98	Na <sub>2</sub> SO <sub>4</sub> ·(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·4H <sub>2</sub> O + γ-Glaserite
17.04	25.08	2.28	31.72	26.90	28.09	"
14.56	28.65	2.04	30.39	28.14	30.73	"
5.93	0.0	12.42	14.66	0.0	85.27	γ-Glaserite + (K, NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
5.80	4.61	11.63	12.90	1.84	84.89	"
5.84	8.70	11.03	10.24	3.24	86.84	"
5.66	15.50	9.74	--	--	--	"
5.20	26.55	6.79	10.58	19.51	69.17	"
7.82	35.53	3.54	16.14	42.80	39.46	"

Data on the system  $K_2SO_4 + 2NH_4NO_3 \rightleftharpoons 2KNO_3 + (NH_4)_2SO_4 (+H_2O)$  at  $0^\circ$ ,  $25^\circ$ ,  $50^\circ$  are given by Janecke, 1929.

Data on the system  $K_2SO_4 + (NH_4)_2CrO_4 \rightleftharpoons K_2CrO_4 + (NH_4)_2SO_4 (+H_2O)$  are given by Ishikawa, 1926.

### THE SYSTEM POTASSIUM SULFATE - SODIUM SULFATE - WATER

The system has been studied by a large number of investigators, with good agreement among the results. The double salt glaserite,  $(3K_2SO_4 \cdot Na_2SO_4)$  is stable at all temperatures above  $1.8^\circ$ . This double salt forms solid solutions with  $Na_2SO_4$  but not with  $K_2SO_4$ . Recent work of Yanat'eva and Orlova (1956) indicates that above  $35^\circ$  glaserite may also form solid solutions with  $K_2SO_4$ . The following diagram is adapted SO from the composite drawn by these authors:



1 = ice    2 =  $K_2SO_4$     3 = Solid solution ( $3:1 + K_2SO_4$ )    4 = Glaserite ( $3:1 + Na_2SO_4$ )  
 5 =  $Na_2SO_4 \cdot 10H_2O$     6 =  $Na_2SO_4$

# K KALIUM

Extensive data at various temperatures are given by Blasdale, 1923; Teeple, 1929; Cornec and Krombach, 1928, 1929; D'ans, 1915; Amadori, 1920; and Okada, 1914 and others. The results given below are typical of the values obtained:

Data of Cornec and Krombach, 1928, 1929 at various temperatures:

t°	d. of sat. sol.	Gms. per 100 gms. sat. solution		Solid Phase
		Na <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	
0	1.120	5.26	7.75	K <sub>2</sub> SO <sub>4</sub> + Na10
1.8	1.120	5.4	7.8	" + "
10	1.160	9.75	7.53	Gl + "
20	1.128	5.40	8.99	" + K <sub>2</sub> SO <sub>4</sub>
"	1.228	17.24	6.94	" + Na10
"	1.139	5.51	10.33	" + K <sub>2</sub> SO <sub>4</sub>
28	1.314	26.26	5.49	" + Na10
"	1.144	5.47	11.37	" + K <sub>2</sub> SO <sub>4</sub>
30.9	1.363	31.07	4.80	" + Na
34.0	1.357	30.73	5.03	" + "
50	1.339	29.40	5.85	" + "
"	1.157	5.68	13.77	" + K <sub>2</sub> SO <sub>4</sub>
75	1.322	27.84	7.38	" + Na
"	1.167	5.64	16.43	" + K <sub>2</sub> SO <sub>4</sub>
100	1.315	26.97	9.15	" + Na
"	1.173	5.52	18.80	" + K <sub>2</sub> SO <sub>4</sub>

Na = Na<sub>2</sub>SO<sub>4</sub>; Na10 = Na<sub>2</sub>SO<sub>4</sub>·10H<sub>2</sub>O; Gl = Glaserite; 3K<sub>2</sub>SO<sub>4</sub>·Na<sub>2</sub>SO<sub>4</sub>, a double salt capable of dissolving Na<sub>2</sub>SO<sub>4</sub> but not K<sub>2</sub>SO<sub>4</sub> to form solid solutions (mixed crystals) with a variation in content of K<sub>2</sub>SO<sub>4</sub> from 78.6 to 61.8 percent.

Data of  
Makarov and Druzhinin, 1937  
At 25°

Data of  
Bayliss, Cole, Ewers, and Jones, 1947  
At 35°

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. solid		Gms. per 100 gms. H <sub>2</sub> O		Gms. per 100 gms. H <sub>2</sub> O	
Na <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>
21.92	0.0	44.25	0.0	13.80	0.0 (K)	11.10	19.45 (G)
20.35	6.60	44.25	0.0	14.05	1.10 (K)	10.65	19.95 (G)
20.18	7.11	25.00	75.00	14.00	2.55 (K)	10.15	24.65 (G)
19.93	7.06	24.20	75.80	14.30	2.50 (K)	10.05	26.80 (G)
15.94	8.25	23.21	76.79	14.40	3.60 (K)	9.55	29.30 (G)
11.65	9.07	22.00	78.00	14.80	4.75 (K)	9.15	33.15 (G)
7.96	9.91	21.50	78.50	14.75	5.15 (K)	9.00	34.85 (G)
*5.43	11.44	21.40	78.60	14.45	6.10 (K)	8.30	40.30 (G)
0.0	10.76	0.0	100.0	14.70	7.00 (K,G)	7.45	48.00 (G,N)
				13.45	9.00 (G)	3.95	48.15 (N)
				12.60	12.25 (G)	2.30	47.85 (N)
				11.90	14.50 (G)	0.0	49.15 (N)

\*Solutions containing 0-5% Na<sub>2</sub>SO<sub>4</sub> are in equilibrium with pure K<sub>2</sub>SO<sub>4</sub>.

K = Solid Phase K<sub>2</sub>SO<sub>4</sub>  
G = Solid Phase Glaserite  
N = Solid Phase Na<sub>2</sub>SO<sub>4</sub>

Data of Yanat'eva and Orlova, 1956 at 55°:

Sat. Sol. Wt. %		Solid Phase Wt. %		Solid Phase
K <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	
14.98	--	--	--	K <sub>2</sub> SO <sub>4</sub>
14.52	5.05	89.20	0.51	"
14.30	5.60	74.10	10.55	K <sub>2</sub> SO <sub>4</sub> + "new" solid solution
14.26	5.62	75.50	14.01	" "
14.12	6.03	68.51	16.42	"new" solid solution
14.05	6.72	66.00	17.50	" " "
13.55	7.35	68.20	19.02	Glaserite
13.12	8.05	70.12	20.20	"
12.83	8.80	68.50	20.80	"
11.55	11.62	64.50	22.36	"
9.10	19.00	62.45	25.20	"
7.45	24.85	63.00	27.81	"
6.50	28.00	61.80	29.78	"
6.20	28.95	42.80	37.50	Glaserite + Na <sub>2</sub> SO <sub>4</sub>
6.15	28.99	40.80	45.20	" + "
--	31.60	--	--	Na <sub>2</sub> SO <sub>4</sub>

30

Data of Itkina and Kokhova, 1956a at 150°:

Sat. Sol. wt. %		Solid Phase Wt. %		Solid Phase
K <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	
21.8	--	--	--	K <sub>2</sub> SO <sub>4</sub>
22.3	3.2	80.9	1.2	"
22.9	5.0	76.8	11.3	K <sub>2</sub> SO <sub>4</sub> + Glaserite
22.7	5.4	71.3	17.7	" + "
20.9	6.9	68.2	17.4	Glaserite
19.4	8.9	69.4	17.8	"
15.0	18.0	69.6	21.2	"
14.8	19.0	62.0	21.5	"
12.9	24.0	61.5	24.0	"
12.2	25.6	56.0	27.4	"
12.2	26.0	56.2	28.7	"
11.6	26.9	53.2	31.3	Glaserite + Na <sub>2</sub> SO <sub>4</sub>
11.7	26.9	49.1	32.0	" + "
12.1	27.4	29.5	53.3	" + "
8.1	28.2	--	--	Na <sub>2</sub> SO <sub>4</sub>
4.0	29.1	1.5	81.2	"
--	29.9	--	--	"

# K KALIUM

## THE SYSTEM $K_2SO_4 - Na_2SO_4 - H_2SO_4$ AT $12.6^\circ$ (Montemartini and Losens, 1928)

d. of sat. solution	Gms. per 100 gms. sat. sol.			Solid Phase
	$Na_2SO_4$	$K_2SO_4$	$H_2SO_4$	
1.1862	3.64	13.58	0.0	$3K_2SO_4 \cdot Na_2SO_4$
1.2680	4.77	17.59	10.96	"
1.3846	10.75	18.84	18.12	$5K_2SO_4 \cdot Na_2SO_4$
1.4870	14.12	18.34	20.53	" + $K_2SO_4 \cdot KHSO_4 \cdot H_2O$ + $Na_2SO_4 \cdot NaHSO_4 \cdot 5H_2O$
1.4882	21.84	9.02	23.98	$K_2SO_4 \cdot KHSO_4 \cdot 5H_2O$ + $Na_2SO_4 \cdot NaHSO_4 \cdot 5H_2O$ + traces of $5K_2SO_4 \cdot Na_2SO_4$
1.4802	22.86	3.54	29.12	$KHSO_4 \cdot H_2O$ + $NaHSO_4 \cdot H_2O$
1.4126	9.56	1.64	36.88	" "
1.4760	3.12	1.02	52.24	" "
1.5800	3.54	1.43	60.65	$KHSO_4 \cdot H_2SO_4 \cdot H_2O$ + $NaHSO_4$
1.6642	4.26	2.02	69.96	$KHSO_4 \cdot H_2SO_4$ + $NaHSO_4 \cdot H_2SO_4$
1.7806	5.40	3.02	80.72	" "
1.9260	9.30	6.72	83.68	$NaHSO_4 \cdot KHSO_4 \cdot 2H_2SO_4$

Cornec and Krombach, 1928, 1929 give data for equilibrium in water, including densities, of potassium and sodium sulfates and nitrates at  $50^\circ$  to  $90^\circ$ .

Complete experimental data for equilibrium in aqueous solutions of mixtures of potassium and sodium sulfates, nitrates and chlorides (including densities) at temperatures between  $0^\circ$  and  $90^\circ$  are given by Cornec and Krombach, 1929 and Cornec, Krombach and Spack, 1930. These authors have made use, whenever necessary, of the results for ternary and quaternary systems previously reported from their own laboratory or by others, including Cretien, 1929; Cornec and Hering, 1925-7; Cornec and Krombach, 1929; Meyerhoffer and Saunders, 1899; d'Ans, 1915 and Blasdale, 1918.

Data for the system  $K_2SO_4 + Na_2SO_4 + K_2CO_3 + Na_2CO_3(+H_2O)$  at  $35^\circ$ ,  $50^\circ$  and  $75^\circ$  are given by Teeple, 1929.

## 50 POTASSIUM NEODYMIUM SULFATE $KNd(SO_4)_2$

100 gms.  $H_2O$  sat. with Potassium Neodymium Sulfate,  $KNd(SO_4)_2 \cdot H_2O$ , contain 1.7 gm.  $KNd(SO_4)_2$  at  $0^\circ$  and 1.3 gms. at  $20^\circ$ . (Meyer and Kittlemann, 1931).

THE SYSTEM POTASSIUM SULFATE, NICKEL  
SULFATE AND WATER AT DIFFERENT TEMPERATURES  
(Benrath, 1932)

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
t°	K <sub>2</sub> SO <sub>4</sub>	NiSO <sub>4</sub>		t°	K <sub>2</sub> SO <sub>4</sub>	NiSO <sub>4</sub>	
0	6.80	0.14	K <sub>2</sub> SO <sub>4</sub> + 1.1.6	40	2.08	33.35	NiSO <sub>4</sub> ·6H <sub>2</sub> O + 1.1.6
"	1.09	21.62	NiSO <sub>4</sub> ·7H <sub>2</sub> O + 1.1.6	55	14.76	1.2	K <sub>2</sub> SO <sub>4</sub> + 1.1.6
25	1.18	29.52	" " "	"	2.30	35.0	NiSO <sub>4</sub> ·6H <sub>2</sub> Oβ + 1.1.6
30	1.30	32.4	" " "+"	88	2.99	41.19	"
			NiSO <sub>4</sub> ·6H <sub>2</sub> Oα	100	20.21	5.19	K <sub>2</sub> SO <sub>4</sub> + 1.1.6
40	13.15	0.51	K <sub>2</sub> SO <sub>4</sub> + 1.1.6	"	3.60	42.1	NiSO <sub>4</sub> ·6H <sub>2</sub> Oβ + 1.1.6

SO

1.1.6 = K<sub>2</sub>SO<sub>4</sub>·NiSO<sub>4</sub>·6H<sub>2</sub>O

SOLUBILITY OF POTASSIUM NICKEL SULFATE IN WATER  
(Lattey, 1923)

Gms. K <sub>2</sub> Ni(SO <sub>4</sub> ) <sub>2</sub> per 100 gms.			Solid Phase	Gms. K <sub>2</sub> Ni(SO <sub>4</sub> ) <sub>2</sub> per 100 gms.			Solid Phase
t°	sat. sol.			t°	sat. sol.		
0	3.26		K <sub>2</sub> Ni(SO <sub>4</sub> ) <sub>2</sub> ·6H <sub>2</sub> O	40	8.97		K <sub>2</sub> Ni(SO <sub>4</sub> ) <sub>2</sub> ·6H <sub>2</sub> O
10	4.31		"	50	11.02		"
15	4.93		"	60	13.33		"
20	5.61		"	70	15.88		"
25	6.36 (6.44)*		"	80	18.68		"
30	7.17		"	90	21.74		"
				100	25.04		"

\*Locke, 1902

SOLUBILITY OF MIXTURES OF POTASSIUM AND LEAD SULFATES AND OF  
POTASSIUM AND STRONTIUM SULFATES IN WATER  
(Barre, 1909)

Results for K <sub>2</sub> SO <sub>4</sub> + PbSO <sub>4</sub>			Results for K <sub>2</sub> SO <sub>4</sub> + SrSO <sub>4</sub>		
Gms. K <sub>2</sub> SO <sub>4</sub> per 100 Gms.			Gms. K <sub>2</sub> SO <sub>4</sub> per 100 Gms.		
t°	Sat. Sol.	Solid Phase	t°	Sat. Sol.	Solid Phase
7	0.56	PbSO <sub>4</sub> ·K <sub>2</sub> SO <sub>4</sub>	17.5	1.27	K <sub>2</sub> SO <sub>4</sub> ·SrSO <sub>4</sub> + SrSO <sub>4</sub>
17	0.62	"	50	1.88	"
50	1.09	"	75	2.71	"
75	1.37	"	100	3.90	"
100	1.69	"			

## K KALIUM

THE SYSTEM POTASSIUM SULFATE - PRASEODIMIUM SULFATE - WATER AT 25°  
(Restaino, 1934)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
Pr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>		Pr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>	
--	4.07	5K <sub>2</sub> SO <sub>4</sub> ·Pr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·2H <sub>2</sub> O	0.32	0.88	3K <sub>2</sub> SO <sub>4</sub> ·Pr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·2H <sub>2</sub> O
--	4.01		0.40	0.67	3K <sub>2</sub> SO <sub>4</sub> ·2Pr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·8H <sub>2</sub> O
--	3.20	4½K <sub>2</sub> SO <sub>4</sub> ·Pr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·H <sub>2</sub> O	0.52	0.34	--
0.16	1.47	4K <sub>2</sub> SO <sub>4</sub> ·Pr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·H <sub>2</sub> O	1.87	0.27	K <sub>2</sub> SO <sub>4</sub> ·Pr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·2H <sub>2</sub> O
0.18	1.03	3K <sub>2</sub> SO <sub>4</sub> ·Pr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·2H <sub>2</sub> O	2.63	0.19	--

THE SYSTEM POTASSIUM SULFATE - URANYL SULFATE - WATER AT 25°  
(Colani, 1928)

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Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
UO <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>		UO <sub>2</sub> SO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	
0.0	10.40	K <sub>2</sub> SO <sub>4</sub>	31.69	1.91	K <sub>2</sub> (UO <sub>2</sub> )(SO <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O
0.91	10.67	"	35.97	1.79	"
1.59	11.02	"	39.73	1.77	"
2.39	11.17	"	51.70	0.71	K <sub>2</sub> (UO <sub>2</sub> ) <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·5H <sub>2</sub> O
2.41	9.01	K <sub>2</sub> (UO <sub>2</sub> )(SO <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O	59.20	0.54	"
2.43	7.31	"	61.50	0.45	"
4.73	3.50	"	61.25	0.23	UO <sub>2</sub> SO <sub>4</sub> ·3H <sub>2</sub> O
9.91	2.69	"	61.18	0.0	"

THE SYSTEM POTASSIUM SULFATE - ZINC SULFATE - WATER AT VARIOUS TEMPERATURES  
(Benrath, 1930; Caven and Johnston, 1926 at 25°)

t°	Gms. per 100 gms. sat. sol.		Solid Phase	t°	Gms. per 100 gms. sat. sol.		Solid Phase
	ZnSO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>			ZnSO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	
0	0.0	6.88	K <sub>2</sub> SO <sub>4</sub> + 1:1:6	80	13.46	17.77	K <sub>2</sub> SO <sub>4</sub>
"	3.68	2.91	1:1:6	"	13.67	18.14	" + 1:1:6
"	29.83	0.99	1:1:6 + ZnSO <sub>4</sub> ·7H <sub>2</sub> O	"	14.32	16.91	1:1:6
12	0.37	9.69	K <sub>2</sub> SO <sub>4</sub> + 1:1:6	"	16.29	14.36	"
"	32.60	1.82	1:1:6 + ZnSO <sub>4</sub> ·7H <sub>2</sub> O	"	21.04	13.15	"
25	0.0	10.59	K <sub>2</sub> SO <sub>4</sub>	"	23.00	12.17	"
"	1.11	10.71	"	"	27.30	10.26	"
"	1.91	10.94	" + 1:1:6	"	31.00	8.60	"
"	4.73	6.52	1:1:6	"	36.84	6.51	"
"	5.40	5.99	"	"	38.38	6.60	" + ZnSO <sub>4</sub> ·H <sub>2</sub> O
"	25.11	3.19	"	"	38.62	6.02	ZnSO <sub>4</sub> ·H <sub>2</sub> O
"	33.01	2.27	"	"	38.92	3.59	"
"	35.58	1.95	"	"	40.56	0.0	"
"	36.00	1.82	"	100	0.0	19.42	K <sub>2</sub> SO <sub>4</sub>
"	36.39	1.85	1:1:6 + ZnSO <sub>4</sub> ·7H <sub>2</sub> O	"	9.05	20.50	"
"	36.42	1.44	ZnSO <sub>4</sub> ·7H <sub>2</sub> O	"	10.16	21.43	"
"	36.61	0.0	"	"	23.18	20.07	" + 1:1:6
41	3.18	13.78	K <sub>2</sub> SO <sub>4</sub> + 1:1:6	"	24.96	19.13	1:1:6
"	40.30	2.50	1:1:6 + ZnSO <sub>4</sub> ·6H <sub>2</sub> O	"	24.40	18.85	"
50	4.34	14.28	K <sub>2</sub> SO <sub>4</sub> + 1:1:6	"	25.82	17.69	"
"	43.20	2.15	1:1:6 + ZnSO <sub>4</sub> ·6H <sub>2</sub> O	"	30.62	15.08	"
68	39.90	4.20	" + ZnSO <sub>4</sub> ·H <sub>2</sub> O	"	36.70	13.51	" + ZnSO <sub>4</sub> ·H <sub>2</sub> O
80	0.0	17.55	K <sub>2</sub> SO <sub>4</sub>	"	36.95	7.15	ZnSO <sub>4</sub> ·H <sub>2</sub> O
"	2.07	17.87	"	"	38.85	2.23	"
"	8.48	18.17	"	"	37.71	0.0	"
"	11.80	18.24	"				

1:1:6 = K<sub>2</sub>SO<sub>4</sub>·ZnSO<sub>4</sub>·6H<sub>2</sub>O

## SOLUBILITY OF POTASSIUM ZINC SULFATE IN WATER

t°	Gms. $K_2Zn(SO_4)_2$ per 100 gms. sat. sol.	Author
6.8	9.91 (d. = 1.0707)	Ploin, 1926
"	8.02	Haber-Chowis, 1926
25	11.72	Hill, Durham and Ricci, 1940
"	11.64	Locke, 1902

The distribution of ponceau red between the solution and mixed crystals with potassium sulfate has been studied by Ioffe and Nikitin (1942a) at 0°, and by Ioffe, 1958.

## SOLUBILITY OF POTASSIUM SULFATE IN AQUEOUS SOLUTIONS OF METHYL ALCOHOL

Results at 20° (Barkan, 1955)		Results at 25° (Akerlof and Turck, 1935)		50
(Figures in parentheses are the solubilities when solutions are also saturated with benzene.)		(Also see Weber, 1929; table p. 324)		
Wt. % $CH_3OH$ in solvent	Gms. $K_2SO_4$ per 100 gms. sat. sol.	Wt. Percent $CH_3OH$ in Aq. Solvent	Gm. Mols. $K_2SO_4$ per 1000 gms. Aq. Solvent	
9.5	5.50 (5.30)	0.0	0.6905	
18.7	2.70 (2.58)	9.7	0.3049	
27.5	1.525 (1.230)	15.09	0.1933	
37	1.410 (0.151)	21.30	0.1134	
47	0.294 (0.096)	29.99	0.0536	
		40.10	0.0221	
		59.94	0.00342	

## SOLUBILITY OF POTASSIUM SULFATE IN AQUEOUS ETHYL ALCOHOL

t°	Wt. % $C_2H_5OH$ in solvent	Gms. $K_2SO_4$ per 100 gms. sat. sol.	Author
15	10	3.90	(Schiff, 1861)
	20	1.46	"
	30	0.56	"
	40	0.21	"
(Figures in parenthesis are solubilities in solutions simultaneously sat. with benzene)			
20	10.8	4.21 (4.77)	(Barkan, 1955)
	19.2	1.71 (2.05)	"
	30.4	0.83 (0.91)	"
	40.5	0.295 (0.425)	"
	50	0.130 (0.137)	"
Gms. $K_2SO_4$ per 100 gms. solvent			
20	50	0.14	(Wright, 1927)
		0.120*	(Grinberg and Zemlyakova, 1948)
25 (See Table following)			
40	40	0.16	(Gerardin, 1865)
60	40	0.21	"
80	40	0.92	"
100	50	0.51	(Wright, 1927)

\*100 gms. of a saturated solution in 50% ethyl alcohol saturated with benzene contain 0.128 gms.  $K_2SO_4$  at 20°. (Grinberg and Zemlyakova, 1948)



# K KALIUM

## THE SYSTEM $K_2SO_4 - C_2H_5OH - H_2O$ AT $25^\circ$ (Fox and Gauge, 1910)

(See also data by Weber, 1929 in table p. 324)

Gms. per 100 Gms. Sat. Solution			Gms. per 100 Gms. Sat. Solution		
$K_2SO_4$	$C_2H_5OH$	$H_2O$	$K_2SO_4$	$C_2H_5OH$	$H_2O$
9.17	1.35	89.48	2.66	15.26	82.08
6.90	4.80	88.30	1.83	20.50	77.67
4.96	7.80	87.24	0.97	26.91	72.12
4.32	9.70	85.98	0.41	35.97	63.62
3.57	12.34	84.09	0.22	43.90	55.88
2.71	14.51	82.78	0.016	69.26	30.72

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## SOLUBILITY OF POTASSIUM SULFATE IN AQUEOUS SOLUTIONS OF ETHYLENE GLYCOL

At  $25^\circ$   
(Fox and Gauge, 1910)

Gms. per 100 Gms. Sat. Solution		d. of sat. sol.
$K_2SO_4$	$(CH_2OH)_2$	
9.67	3.16	1.0881
7.69	9.79	1.0812
5.74	18.47	1.0737
3.57	32.11	1.0651
1.83	49.03	1.0627
		1.0646
		1.0708
		1.0823
		1.1060

At  $30^\circ$   
(Trimble, 1931)

Gms. per 100 gms. sat. sol.	
$CH_2OHCH_2OH$	$K_2SO_4$
0.0	11.14
4.21	9.84
9.01	8.11
18.64	5.66
28.91	3.67
38.58	2.41
49.75	1.45
65.62	0.63
100.00	0.00

## SOLUBILITY OF POTASSIUM SULFATE IN AQUEOUS SUGAR SOLUTIONS AT $25^\circ$ (Fox and Gauge, 1910)

### Aq. Sucrose Solutions

Gms. per 100 Gms. Sat. Solution	
$K_2SO_4$	$C_{12}H_{22}O_{11}$
9.65	9.56
8.65	18.55
7.42	28.16
6.35	37.24
5.21	47.55
4.24	57.00

### Aq. Mannitol Solutions

Gms. per 100 Gms. Sat. Solution	
$K_2SO_4$	$(CHOH)_4(CH_2OH)_2$
10.32	3.20
9.61	8.35
9.19	11.26
8.66	14.30
8.35	17.22

100 gms. water dissolve 10.4 gms.  $K_2SO_4$  + 219 gms. sugar at  $31.25^\circ$ ,  
or 100 gms. sat. solution contain 3.18 gms.  $K_2SO_4$  + 66.74 gms. sugar.  
(Kohler, 1897)

SOLUBILITY OF POTASSIUM SULFATE AT 25°  
(Fox and Gauge, 1910)

## In Aqueous Chloral Hydrate Solutions

Gms. per 100 Gms. Sat. Solution		
K <sub>2</sub> SO <sub>4</sub>	CCl <sub>3</sub> CH(OH) <sub>2</sub>	H <sub>2</sub> O
9.13	6.44	84.43
8.41	9.09	82.50
7.79	12.38	79.83
7.31	13.20	79.49
5.88	22.07	72.05
4.54	33.15	62.31
3.36	44.40	52.24
2.92	47.30	49.78
2.00	62.82	35.18
1.75	70.28	27.97
1.40	80.36	18.24
1.08	85.26	13.66

## In Aqueous Glycerol Solutions

Gms. per 100 Gms. Sat. Solution		
K <sub>2</sub> SO <sub>4</sub>	(CH <sub>2</sub> CH) <sub>2</sub> CHOH	H <sub>2</sub> O
8.87	8.96	82.17
7.69	13.36	78.95
6.47	20.34	73.19
5.83	24.15	70.02
4.44	33.73	61.83
3.65	40.40	55.95
3.38	43.52	53.10
2.69	50.18	47.13
2.07	57.22	40.71
1.53	67.94	30.53
0.98	78.18	20.84
0.73	98.28	0.99

SO

## SOLUBILITY OF POTASSIUM SULFATE IN AQUEOUS ACETONE SOLUTIONS

At 20° (Barkan, 1955)			At 25° (Fox and Gauge, 1910)*		
Wt. % Acetone in Solvent	Wt. % K <sub>2</sub> SO <sub>4</sub> in Sat. Sol.	Wt. % K <sub>2</sub> SO <sub>4</sub> in sat. sol. also saturated with benzene	Gms. per 100 Gms. Sat. Sol.		
			K <sub>2</sub> SO <sub>4</sub>	(CH <sub>3</sub> ) <sub>2</sub> CO	H <sub>2</sub> O
10.8	5.625	5.865	7.20	4.92	87.88
20	2.455	2.655	5.02	10.06	84.92
28	0.826	1.325	2.96	16.23	80.81
38	0.510	0.849	1.50	24.31	74.19
50	0.10	0.1485	0.47	37.19	62.34
60	0.039	0.090	0.20	46.29	53.51
			0.03	62.40	37.57

\*Also see data of Weber, 1929 in table p. 324.

SOLUBILITY OF K<sub>2</sub>SO<sub>4</sub> IN AQUEOUS PYRIDINE SOLUTIONS AT 25°  
(Fox and Gauge, 1910)

Gms. per 100 Gms. Sat. Solution		
K <sub>2</sub> SO <sub>4</sub>	CH < (CH·CH) <sub>2</sub> > N	H <sub>2</sub> O
7.95	4.23	87.82
4.77	13.90	81.33
2.75	24.51	72.74
1.47	34.19	64.34
0.45	46.29	53.26
0.12	55.93	43.95
0.006	75.90	24.09

# K KALIUM

## SOLUBILITY OF POTASSIUM SULFATE IN AQUEOUS ACETIC ACID AND IN AQUEOUS PHENOL SOLUTIONS AT 25° (Rothmund and Wilsmore, 1902)

In Aq. Acetic Acid				In Aq. Phenol*			
Mols. per liter		Grams per liter		Mols. per liter		Grams per liter	
CH <sub>3</sub> COOH	K <sub>2</sub> SO <sub>4</sub>	CH <sub>3</sub> COOH	K <sub>2</sub> SO <sub>4</sub>	C <sub>6</sub> H <sub>5</sub> OH	K <sub>2</sub> SO <sub>4</sub>	C <sub>6</sub> H <sub>5</sub> OH	K <sub>2</sub> SO <sub>4</sub>
0.0	0.6714	0.0	117.0	0.0	0.6714	0.0	117.0
0.07	0.6619	4.2	115.4	0.032	0.6598	3.01	115.0
0.137	0.6559	8.22	114.4	0.064	0.6502	6.02	113.3
0.328	0.6350	19.68	110.8	0.127	0.6310	11.94	110.0
0.578	0.6097	34.68	106.3	0.236	0.6042	22.19	105.3
1.151	0.5556	69.06	96.87	0.308	0.5834	28.97	101.7
2.183	0.4743	128.58	82.70	0.409	0.5572	38.46	97.2
				0.464	0.5480	43.63	95.5
				0.498 (sat.)	0.5377	46.82	93.8

\*Also see data by Weber, 1929 in table following.

100 gms. 95% formic acid dissolve 36.5 gms. K<sub>2</sub>SO<sub>4</sub> at 21°. (Aschan, 1913)  
100 gms. 95% formic acid dissolve 14.6 gms. KHSO<sub>4</sub> at 19.3°. ( " )

## SOLUBILITY OF POTASSIUM SULFATE IN AQUEOUS SOLUTIONS OF VARIOUS COMPOUNDS AT 25° (Weber, 1929)

Aqueous Solution of:	Gm. Mols. K <sub>2</sub> SO <sub>4</sub> per liter in Aq. Solution of:			
	0.125 Normality	0.25 Normality	0.5 Normality	1.0 Normality
Water alone	0.5562	0.5562	0.5562	0.5562
Cane Sugar	0.5537	0.5555	0.5532	0.5430
Mannite	0.5518	0.5538	0.5496	0.5421
Methyl Alcohol	0.5415	0.5295	0.5000	0.4518
Acetonitrile	0.5398	0.5259	0.4381	0.4332
Ethyl Alcohol	0.5356	0.5187	0.4783	0.4023
Acetone	0.5313	0.5086	0.4574	0.3827
Methyl Acetate	0.5408	0.5249	0.4938	0.4336
Propyl Alcohol	0.5311	0.5068	0.4577	0.3861
Methyl Ethyl Ketone	0.5308	0.5030	0.4545	0.3744
Diethyl Amine	0.5293	0.5040	0.4623	0.3662
Phenol	0.5291	0.5030	0.4556	--
Aniline	0.5224	0.5079 (1)	--	--
Paraldehyde	0.5229	0.4931	0.4287	--
Ethyl Acetate	0.5365	0.5186	0.4828	--
Butyric Acid	0.5410	0.5292	0.5055	0.4618
Ter. Amyl Alcohol	0.5178	0.4797	0.4141	0.3153
Valerianic Acid	0.5392	0.5236	--	--
Iso Amyl Alcohol	0.5158	0.5065 (2)	--	--
Hexyl Alcohol	0.5476 (3)	0.5407 (4)	--	--

(1) = 0.2 Normality instead of 0.25;

(2) = 0.185 Normality instead of 0.25;

(3) = 0.0208 Normality instead of 0.125;

(4) = 0.0416 Normality instead of 0.25.

THE SYSTEM POTASSIUM SULFATE - UREA - WATER  
(Blidin, 1947)

t°	Gms. CO(NH <sub>2</sub> ) <sub>2</sub> per 100 gms.	Gms. K <sub>2</sub> SO <sub>4</sub> per 100 gms.	Solid Phase	t°	Gms. CO(NH <sub>2</sub> ) <sub>2</sub> per 100 gms.	Gms. K <sub>2</sub> SO <sub>4</sub> per 100 gms.	Solid Phase
	Sat. Sol.	Sat. Sol.			Sat. Sol.	Sat. Sol.	
-12.4	31.1	3.8	I + U	-8	20	4.9	I
-9.0	35	0.0	U	-7.2	19.3	3.1	"
-8.6	34.2	1.9	"	-6.8	19.7	1.50	"
-8.2	33.9	3.2	"	-6.4	20.0	0.0	"
-6.0	35.0	3.4	"	-4.6	10	4.9	"
-3.0	36.6	3.1	"	-1.2	0.0	5.0	"
-2.0	40.0	0.0	"	-8.6	18.6	6.1	I + K
-1.2	39.0	2.4	"	1.0	18.4	6.7	K
-0.4	37.9	5.1	"	5.0	32.9	5.5	"
11.0	45.0	3.0	"	12.0	18.2	7.4	"
20.0	50.0	2.8	"	13.0	37.7	5.66	"
24.0	52.5	2.8	"	16.0	32.8	6.0	"
-7.6	33.1	4.9	U + K	22.0	18.0	8.1	"
-0.2	37.8	5.2	" + "	25.0	32.8	6.1	"
-8.2	18.9	5.3	I	25.0	37.7	6.0	"

I = Ice

U = CO(NH<sub>2</sub>)<sub>2</sub>K = K<sub>2</sub>SO<sub>4</sub>

THE SYSTEM POTASSIUM SULFATE - URETHAN - WATER AT 25°  
(Palitzsch, 1928, 1929)

Gm. Mols. per 1000 gms. H <sub>2</sub> O		Solid Phase
K <sub>2</sub> SO <sub>4</sub>	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>	
0.690	0.0	K <sub>2</sub> SO <sub>4</sub>
0.468	1.1225	"
0.026	23.49	"
0.016	50.45	"

Melting point data are given for:

K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> SO <sub>4</sub>	(Kendall and Landon, 1920; Cambi and Bozza, 1923)
K <sub>2</sub> SO <sub>4</sub> + K <sub>2</sub> WO <sub>4</sub>	(Amadori, 1913; Belyaev and Nesterova, 1952; Kialova, Posypaiko and Bergman, 1955)
K <sub>2</sub> SO <sub>4</sub> + NH <sub>4</sub> NO <sub>3</sub>	(Bowen, 1926)
K <sub>2</sub> SO <sub>4</sub> + NaCl	(Sackur, 1911-12)
K <sub>2</sub> SO <sub>4</sub> + Na <sub>2</sub> SO <sub>4</sub>	(Janecke, 1908; Nacken, 1907 (b)(c); Sackur, 1911- 12; Hilmy, 1953; Bellanca and Carapezzi, 1951a)
K <sub>2</sub> SO <sub>4</sub> + HbCl	(Dombrowskaya, 1933)
K <sub>2</sub> SO <sub>4</sub> + Rb <sub>2</sub> SO <sub>4</sub>	( " " )
E <sub>2</sub> SO <sub>4</sub> + SrSO <sub>4</sub>	(Grahmann, 1913; Calcagni, 1912, 1912a)
K <sub>2</sub> SO <sub>4</sub> + Na <sub>2</sub> SO <sub>4</sub>	(Ferrier and Bellanca, 1940; Bredig, 1942)
K <sub>2</sub> SO <sub>4</sub> + PbSO <sub>4</sub>	( " " )
K <sub>2</sub> SO <sub>4</sub> + PbSO <sub>4</sub> + Na <sub>2</sub> SO <sub>4</sub>	( " " )

(Cont.)

## K KALIUM

Melting point data--Cont.

$K_2SO_4 + Ti_2Cl_2 + Ti_2(NO_3)_2$	(Rostovskii, 1940)
$K_2SO_4 + PbWO_4 \rightleftharpoons K_2WO_4 + PbSO_4$	(Belyaev and Nesterova, 1952)
$K_2SO_4 + Li_2SO_4$	(Hilmy, 1953; Bergman, Kislova and Posypaiko, 1955; Akopov and Bergman, 1955b; Naken, 1907)
$K_2SO_4 + (NH_4)_2SO_4$	(Hilmy, 1953)
$K_2SO_4 + Li_2SO_4 + Na_2SO_4$	(Akopov and Bergman, 1954, 1954d)
$K_2SO_4 + Li_2SO_4 + Ti_2SO_4$	( " " " 1954, 1957)
$K_2SO_4 + CaSO_4$	(Mukimov, Krylova, and Bergman, 1949)
$K_2SO_4 + CaSO_4 + MgSO_4$	( " " " " )
$K_2SO_4 + Na_2SO_4 + CdSO_4$	(Bakumskaya and Bergman, 1956a)
$K_2SO_4 + Li_2SO_4 + CdSO_4$	(Bergman and Bakumskaya, 1956a)
$K_2SO_4 + Na_2SO_4 + MgSO_4$	(Mukimov, Krilova and Filippova, 1949)
$K_2SO_4 + MgSO_4$	( " " " " )
$K_2SO_4 + 2LiNO_3 \rightleftharpoons 2KNO_3 + Li_2SO_4$	(Bukhalova, Sholokhovitch and Bergman, 1950)
$K_2SO_4 + Li_2WO_4 \rightleftharpoons K_2WO_4 + Li_2SO_4$	(Bergman, Kislova and Sholokhovitch, 1953; Bergman and Kislova, 1955)
$3K_2SO_4 + 2Li_3PO_4 \rightleftharpoons 2K_3PO_4 + 3Li_2SO_4$	(Bergman and Sholokhovitch, 1953)
$K, Na \text{ II } SO_4, F, CO_3$	(Bergman and Rubleva, 1957a)
$K_2SO_4 + V_2O_5$	(Boreskov, Illarionov, Ozerov and Kildisheva, 1954)
$K_2S_2O_7 + KHSO_4$	(Cambi and Bozza, 1923)
$K_2S_2O_7 + V_2O_5$	(Boreskov, Illarionov, Ozerov and Kildisheva, 1954)

## SO POTASSIUM METHYL SULFATE $K(CH_3)SO_4$

THE SYSTEM  $KCH_3SO_4 - H_2O$   
(Illingsworth and Howard, 1884)

t° of Solidifi- cation	Gms. $K(CH_3)SO_4$ per 100 Gms. Sol.	Solid Phase	t° of Solidifi- cation	Gms. $K(CH_3)SO_4$ per 100 Gms. Sol.	Solid Phase
- 2.3	10	Ice	-11.8	39.84	Ice + $K(CH_3)SO_4$
- 3.6	15	"	-11.5	40	$K(CH_3)SO_4$
- 5	20	"	0	47.1	"
- 8	30	"	+12.3	54.8	"

## POTASSIUM ETHYL SULFATE $KC_2H_5 \cdot SO_4$ $\alpha$ and $\beta$ forms

SOLUBILITY OF POTASSIUM ETHYL SULFATE IN WATER  
(Hammick and Mullaby, 1921)

This compound is dimorphous. On crystallizing from methyl alcohol or water there first appear tufts of long feathery crystals which redissolve as the solution cools and give place to the ordinary foliated form. Analysis showed no difference in composition between the two forms. The temperatures were determined at which the edges of crystals, present in synthetic mixtures contained in sealed tubes, changed from rounded to sharp or vice versa. No matter at what temperature crystallization

occurred the unstable  $\beta$  form was always the first to separate. It was easy to distinguish which solid phase was present at the different temperatures. The transition point was found to be at  $51.8^\circ$ . The ice curve was determined by the freezing-point method.

$t^\circ$	Gms. $\text{KC}_2\text{H}_5\text{SO}_4$ per 100 gms. sat. sol.	Solid Phase	$t^\circ$ of solution for		Gms. $\text{KC}_2\text{H}_5\text{SO}_4$ per 100 gms. sat. sol.
			$\alpha$ form	$\beta$ form	
- 1.195	5.480	Ice	-4.5	-13.5	49.5
- 1.142	6.37	"	-1.9	--	51.946
- 2.130	9.434	"	+8.7	- 5.2	58.81
- 2.98	12.953	"	21.0	+12.1	66.6
- 3.22	13.770	"	26.0	20.1	70.015
- 4.93	19.808	"	35.0	32.0	75.29
- 6.68	25.953	"	39.9	38.2	77.99
- 9.55	33.714	"	45.5	45.0	80.084
-12.9 (eutec.)	--	" + $\alpha$ form	51.14	51.1	82.04
-15.2 "	--	" + $\beta$ "	59.46		84.44
			65.8		85.47
			69.1		86.23
			81.3		87.94
			91.2		89.62

Earlier results of Illingworth and Howard, 1884:

$t^\circ$ of Solidifi- cation	Gms. $\text{K}(\text{C}_2\text{H}_5)\text{SO}_4$ per 100 Gms. Sol.	Solid Phase	$t^\circ$ of Solidifi- cation	Gms. $\text{K}(\text{C}_2\text{H}_5)\text{SO}_4$ per 100 Gms. Sol.	Solid Phase
- 2.2	10	Ice	-14.2	45.01	Ice + $\text{K}(\text{C}_2\text{H}_5)\text{SO}_4$
- 4.9	20	"	- 6	50	$\text{K}(\text{C}_2\text{H}_5)\text{SO}_4$
- 8.2	30	"	0	53.71	"
-12.1	40	"	+15	62.35	"

100 gms. methyl alcohol dissolve 1.72 gms. potassium ethyl sulfate at  $15^\circ$  and 13.87 gms. at the b. pt. ( $65.8^\circ$ ). (Henstock, 1934)

SOLUBILITY OF POTASSIUM ETHYL SULFATE IN MIXTURES OF  
METHYL ALCOHOL AND ACETONE AT  $20^\circ$   
(Henstock, 1934)

The results are given only in the form of a diagram from which the following approximate values were read.

Percent Acetone in Mixed Solvent	Gms. $\text{K}(\text{C}_2\text{H}_5)\text{SO}_4$ per 100 gms. Solvent	Percent Acetone in Mixed Solvent	Gms. $\text{K}(\text{C}_2\text{H}_5)\text{SO}_4$ per 100 gms. Solvent
0 (= $\text{CH}_3\text{OH}$ )	2.2	60	2.25
10	2.55	70	1.75
20	2.8	80	1.25
30	2.95	90	0.70
40	2.8	100 (= $\text{CH}_3\text{COCH}_3$ )	0.0

# K KALIUM

## SO POTASSIUM AMYL SULFATE $K(C_5H_{11})SO_4$

THE SYSTEM  $K(C_5H_{11})SO_4 - H_2O$   
(Illingworth and Howard, 1884)

t° of Solidification	Gms. $K(C_5H_{11})SO_4$ per 100 gms. sol.	Solid Phase
- 1.9	10	Ice
- 4.3	20	"
- 5.4	24	" + $K(C_5H_{11})SO_4$
- 4.8	25	$K(C_5H_{11})SO_4$
0	33.44	"
+17.3	59.46	"

## POTASSIUM PHENYL SULFATES

SOLUBILITY OF EACH SEPARATELY IN WATER AND ALCOHOL  
(Burkhardt and Lapworth, 1926)

Compound	Formula	Solvent	t°	Gms. compd. per 100 gms. $H_2O$
Potassium phenyl sulfate	$C_6H_5O_4SK$	Water	17	16.28
" " "	"	Alcohol	17	0.704
" <u>m</u> carboxy phenyl sulfate	$C_7H_5O_6SK$	Water	17	3.2
" naphthyl " "	$C_{10}H_7O_4SK$	"	17	2.5
" " " "	$C_{10}H_7O_4SK \cdot 4H_2O$	"	17	1.43
" " sulfate	$C_6H_5NHC_2H_4 \cdot OSO_3 \cdot K$	"	15	23*

\*Gms. per 100 cc. soln. (Saunders, 1922).

## SO POTASSIUM PERSULFATE $K_2S_2O_8$

SOLUBILITY IN WATER  
(Tarugi, 1904)

The results in parentheses are the averages of a large number of determinations by Pajetta (1906). This investigator employed constant agitation for various lengths of time. Tarugi approached equilibrium from above as well as below but stirred the solutions only at intervals. The determination of the dissolved persulfate was made by boiling a measured volume of the clear saturated solution for 20 min. and titrating the  $H_2SO_4$  liberated, according to the equation  $K_2S_2O_8 + H_2O = K_2SO_4 + H_2SO_4$ . Tarugi also reports that the presence of a number of sodium and other salts in solution, does not appreciably alter the solubility of  $K_2S_2O_8$  in water.

t°	Gms. $K_2S_2O_8$ per 100 cc. Sat. Sol.	t°	Gms. $K_2S_2O_8$ per 100 cc. Sat. Sol.	t°	Gms. $K_2S_2O_8$ per 100 cc. Sat. Sol.
0	1.620	15	3.140 (3.7)	30	7.190 (7.7)
	1.77*	20	4.490	35	8.540
5	2.156	25	5.840	40	9.890
10	2.600				

\*Gms. per 100 gms.  $H_2O$  (Marshall, 1891)

SOLUBILITY OF POTASSIUM PERSULFATE IN SATURATED AQUEOUS SALT  
SOLUTIONS AT 12°  
(Pajetta, 1906)

An excess of the salt and of  $K_2S_2O_8$  was, in each case, added to water and the mixture stirred at constant temperature for 10 to 20 hours.

Salt	Gms. $K_2S_2O_8$ per 100 Gms. Sat. Sol.	Salt	Gms. $K_2S_2O_8$ per 100 Gms. Sat. Sol.
Water alone	3.196	$K_2SO_4$	0.798
$Na_2SO_4 \cdot 10H_2O$	6.238	$KHSO_4$	0.336
$NaHSO_4$	8.842	$KNO_3$	0.904
$Na_2HPO_4 \cdot 12H_2O$	4.766	$K_2CO_3$	0.0146
$Na_2B_4O_7 \cdot 10H_2O$	3.825	$KHCO_3$	0.317
$NaNO_3$	19.302	$MgSO_4 \cdot 7H_2O$	2.990
$Na_2CO_3 \cdot 10H_2O$	5.682	$CaSO_4 \cdot 2H_2O$	3.384
$NaHCO_3$	5.042		

Additional determinations made with salt solutions of lower concentrations than saturation, gave the following results at 12.5°.

Salt	Gms. Salt per 100 Gms. $H_2O$	Gms. $K_2S_2O_8$ per 100 Gms. sat. sol.	Salt	Gms. Salt per 100 Gms. $H_2O$	Gms. $K_2S_2O_8$ per 100 Gms. sat. sol.
$Na_2CO_3$	2.304	4.297	$NaHSO_4$	5.218	4.556
$NaHCO_3$	3.652	4.230	$NaNO_3$	3.696	4.613
$Na_2SO_4 \cdot 10H_2O$	7	4.554	$Na_2HPO_4$	3.086	4.446

0.01 gms. of  $K_2S_2O_8$  are dissolved in 100 gms. of a saturated solution in furfural at 25°.

(Trimble, 1941)

POTASSIUM THIOSULFATE  $K_2S_2O_3$

50

SOLUBILITY IN WATER  
(Jo, 1911, 1912)

t°	Gms. $K_2S_2O_3$ per 100 Gms. $H_2O$	Solid Phase	t°	Gms. $K_2S_2O_3$ per 100 Gms. $H_2O$	Solid Phase
0	96.1	$K_2S_2O_3 \cdot 2H_2O$	56.1	234.5	$K_2S_2O_3 \cdot H_2O + 3K_2S_2O_3 \cdot H_2O$
17	150.5	$3K_2S_2O_3 \cdot 5H_2O$	60	238.3	$3K_2S_2O_3 \cdot H_2O$
20	155.4	"	65	245.8	"
25	165.0	"	70	255.2	"
30	175.7	"	75	268.0	"
35	202.4	" + $K_2S_2O_3 \cdot H_2O$	78.3	292.0	" + $K_2S_2O_3$
40	204.7	$K_2S_2O_3 \cdot H_2O$	80	293.1	$K_2S_2O_3$
45	208.6	"	85	298.5	"
50	215.2	"	90	312.0	"
55	227.7	"			



# K KALIUM

## POTASSIUM SODIUM THIOSULFATE $\text{KNaS}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$

100 gms.  $\text{H}_2\text{O}$  dissolve 213.7 gms.  $\text{KNaS}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$  (a) at  $15^\circ$ .

100 gms.  $\text{H}_2\text{O}$  dissolve 205.3 gms.  $\text{KNaS}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$  (b) at  $15^\circ$ .  
(Schwicker, 1889)

## 50 POTASSIUM THIONATES

SOLUBILITY OF EACH SEPARATELY IN WATER  
(Results for Dithionate by deBaat, 1926; for the others  
by Kurtenacker and Fluss, 1933)

Gms. per 100 gms. sat. solution

$t^\circ$	K DiThionate $\text{K}_2\text{S}_2\text{O}_6$	K Trithionate $\text{K}_2\text{S}_3\text{O}_6$	K Tetrathionate $\text{K}_2\text{S}_4\text{O}_6$	K Pentathionate $\text{K}_2\text{S}_5\text{O}_6$ ( $\cdot 1\frac{1}{2} \text{H}_2\text{O}$ )
0	2.52	8.14	12.60	15.50
12	4.28	--	--	--
20	6.23	18.43	23.18	24.78
30	8.54	--	--	--

THE SYSTEM POTASSIUM TRITHIONATE - POTASSIUM TETRATHIONATE - WATER  
(Kurtenacker and Fluss, 1933)

$t^\circ$	Gms. per 100 gms. sat. sol.		Solid Phase	$t^\circ$	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{K}_2\text{S}_3\text{O}_6$	$\text{K}_2\text{S}_4\text{O}_6$			$\text{K}_2\text{S}_3\text{O}_6$	$\text{K}_2\text{S}_4\text{O}_6$	
0	6.68	12.00	$\text{K}_2\text{S}_4\text{O}_6 + \text{K}_2\text{S}_3\text{O}_6$	20	14.51	14.17	$\text{K}_2\text{S}_3\text{O}_6$
20	1.80	21.85	$\text{K}_2\text{S}_4\text{O}_6$	"	16.70	11.94	"
"	2.30	21.60	"	"	16.23	5.75	"
"	6.86	18.82	"	"	17.67	2.37	"
"	11.50	18.90	"	"	6.68	12.00	"
"	13.26	18.65	" + $\text{K}_2\text{S}_3\text{O}_6$				

THE SYSTEM POTASSIUM TETRATHIONATE - POTASSIUM PENTATHIONATE - WATER  
(Kurtenacker and Fluss, 1933)

$t^\circ$	Gms. per 100 gms. sat. sol.		Solid Phase	$t^\circ$	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{K}_2\text{S}_4\text{O}_6$	$\text{K}_2\text{S}_5\text{O}_6$			$\text{K}_2\text{S}_4\text{O}_6$	$\text{K}_2\text{S}_5\text{O}_6$	
0	4.71	14.49	$\text{K}_2\text{S}_4\text{O}_6 + \text{K}_2\text{S}_5\text{O}_6 \cdot 1\frac{1}{2}\text{H}_2\text{O}$	20	10.53	19.81	$\text{K}_2\text{S}_4\text{O}_6$
20	2.53	21.39	$\text{K}_2\text{S}_5\text{O}_6 \cdot 1\frac{1}{2}\text{H}_2\text{O}$	"	11.71	17.62	"
"	5.86	20.59	"	"	14.03	14.30	"
"	7.53	20.19	"	"	17.39	8.70	"
"	10.34	20.86	"	"	18.93	6.44	"
"	10.88	20.10	" + $\text{K}_2\text{S}_4\text{O}_6$	"	22.46	0.82	"

THE SYSTEM POTASSIUM TRITHIONATE - POTASSIUM PENTATHIONATE - WATER  
(Kurtenacker and Fluss, 1933)

t°	Gms. per 100 gms. sat. sol.		Phase	t°	Gms. per 100 gms. sat. sol.		Solid Phase
	K <sub>2</sub> S <sub>3</sub> O <sub>6</sub>	K <sub>2</sub> S <sub>5</sub> O <sub>6</sub>			K <sub>2</sub> S <sub>3</sub> O <sub>6</sub>	K <sub>2</sub> S <sub>5</sub> O <sub>6</sub>	
0	7.6	2.87	K <sub>2</sub> S <sub>3</sub> O <sub>6</sub> + K <sub>2</sub> S <sub>5</sub> O <sub>6</sub> · 1½H <sub>2</sub> O + S	20	10.84	9.98	K <sub>2</sub> S <sub>3</sub> O <sub>6</sub> + S
20	6.35	7.20	K <sub>2</sub> S <sub>5</sub> O <sub>6</sub> · 1½H <sub>2</sub> O + S	"	14.04	3.74	"
"	8.13	8.17	"	"	14.12	4.37	"
"	10.50	8.72	" + K <sub>2</sub> S <sub>3</sub> O <sub>6</sub> + S	"	14.99	2.46	"

High accuracy is not claimed for the above results since the polythionates begin to decompose after short periods of shaking.

POTASSIUM SULFAMATE KSO<sub>3</sub>NH<sub>2</sub>

SON

SOLUBILITY OF POTASSIUM SULFAMATE IN WATER  
(Ricci and Selikson, 1947, 1952)

t°	Gms. KSO <sub>3</sub> NH <sub>2</sub> per 100 gms. sat. sol.	Density	Solid Phase
9	31.44	1.222	KSO <sub>3</sub> NH <sub>2</sub>
20	40.05	--	"
25	43.73	1.327	"
35	50.38	--	"
45	56.40	--	"

Data for the system Potassium Sulfate - Potassium Sulfamate - Water at 25° are given by Ricci and Selikson, 1952. The system forms neither compounds nor solid solutions. The invariant solution contains 2.17% K<sub>2</sub>SO<sub>4</sub>, 42.03% KSO<sub>3</sub>NH<sub>2</sub> and has a density of 1.335. Both solids are anhydrous.

THE SYSTEM POTASSIUM SULFAMATE - AMMONIUM SULFAMATE - WATER  
(Ricci and Selikson, 1952)

The system was studied in detail at all three temperatures. Limited solid solutions of Roozebooms type 5 are formed.

Sat. Sol. Wt. %		Density	% KSO <sub>3</sub> NH <sub>2</sub> in Solid (extrapolated)	Solid Phase
NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>	KSO <sub>3</sub> NH <sub>2</sub>			
At 9°				
62.26	0.00	1.347	0	NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>
52.63	9.82*	1.375	27.9	Solid Solution I
45.60	15.64	1.380		Solid Sol. I + II
0.0	31.44	1.222	100	KSO <sub>3</sub> NH <sub>2</sub>

\*region of minimum water content.

(Cont.)

# K KALIUM

## THE SYSTEM POTASSIUM SULFAMATE - AMMONIUM SULFAMATE - WATER--Cont.

Sat. Sol. Wt. %		Density	% KSO <sub>3</sub> NH <sub>2</sub> in solid (extrapolated)	Solid Phase
NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>	KSO <sub>3</sub> NH <sub>2</sub>			
At 25°				
68.90	0.00	1.391	0	NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>
65.76	3.55	1.403	6.6	Solid Sol. I
62.69	6.77	1.414	12.8	"
59.82	9.95*	1.422	20.7	"
55.37	14.08	1.435	33.1	"
53.07	16.37	1.439	38.8	"
50.59	18.52	1.443	45.9	"
49.00	19.79	1.447	51.2	"
48.20	20.46	1.446		Solid Sol. I + II
47.00	20.76	1.442	90.9	Solid Sol. II
46.69	21.25	1.439	94.6	"
44.24	22.09	1.432	94.5	"
31.61	27.07	1.388	99.1	"
26.63	29.22	1.375	97.9	"
21.15	31.85	1.360	99.0	"
14.88	35.25	1.347	100.9	"
10.59	37.52	1.340	99.8	"
0.00	43.72	1.338	100	KSO <sub>3</sub> NH <sub>2</sub>
At 45°				
76.54	0.00		0	NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>
57	20*		40	Solid Sol. I
50.56	26.24			Solid Sol. I + II
0.00	56.40		100	KSO <sub>3</sub> NH <sub>2</sub>

\*region of minimum water content.

Results for the system  $2\text{KSO}_3\text{NH}_2 + (\text{NH}_4)_2\text{SO}_4 \rightleftharpoons \text{K}_2\text{SO}_4 + 2\text{NH}_4\text{SO}_3\text{NH}_2 (+\text{H}_2\text{O})$  at 25° are given by Ricci and Selikson, 1952. Since  $\text{K}_2\text{SO}_4$  and  $(\text{NH}_4)_2\text{SO}_4$  form continuous solid solutions, there is only one invariant point in equilibrium with 3 solid solutions.

## SbS POTASSIUM ANTIMONY SULFIDE K<sub>3</sub>SbS<sub>4</sub>

### SOLUBILITY IN WATER (Donk, 1908)

t °	Gms. K <sub>3</sub> SbS <sub>4</sub> per 100 gms. sat. sol.	Solid Phase	t °	Gms. K <sub>3</sub> SbS <sub>4</sub> per 100 gms. sat. sol.	Solid Phase
- 1.3	9.5	Ice	-34	62.0	Ice + K <sub>3</sub> SbS <sub>4</sub> ·6H <sub>2</sub> O
- 2.6	17.1	"	-10	65.5	K <sub>3</sub> SbS <sub>4</sub> ·6H <sub>2</sub> O
- 4.0	24.2	"	- 4.5	69.1	"
- 7.2	35.4	"	0	75.4	K <sub>3</sub> SbS <sub>4</sub> ·4H <sub>2</sub> O
-10.6	42.9	"	+10	76.2	"
-13.5	48.8	"	30	75.1	"
-18.5	52.6	"	50	77.7	K <sub>3</sub> SbS <sub>4</sub> ·3H <sub>2</sub> O
-28.8	59.6	"	80	79.2	"

THE SYSTEM  $K_3SbS_4 - KOH - H_2O$  AT  $30^\circ$   
(Donk, 1908)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$K_3SbS_4$	KOH		$K_3SbS_4$	KOH	
75.0	0	$K_3SbS_4 \cdot 5H_2O$	19.8	40.5	$K_3SbS_4$
68.4	3.4	$K_3SbS_4 \cdot 3H_2O$	11.5	49.9	" + $KOH \cdot 2H_2O$
56.8	11.0	"	9.4	49.9	$KOH \cdot 2H_2O$
50.9	16.1	$K_3SbS_4$	0	56.3	"
37.7	25.5	"			

SOLUBILITY OF POTASSIUM SULFOANTIMONATE IN AQ. METHYL ALCOHOL AT  $15^\circ$  SbS  
(Donk, 1908)

Composition of the Liquid Layers

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 Gms.			
			Alcoholic Layer		Aqueous Layer	
$K_3SbS_4$	$CH_3OH$		$K_3SbS_4$	$CH_3OH$	$K_3SbS_4$	$CH_3OH$
0.5	99.5	$K_3SbS_4$	5.0	82.5	62.5	8.0
0.45	99.5	"	4.9	76.3	--	--
1.5	93.9	"	7.0	66.9	--	--
1.8	92.0	"	13.6	54.0	--	--
			19.1	45.5	--	--
Two liquid layers formed here.			--	--	31.1	31.3
62.7	7.5	$K_3SbS_4 \cdot 9H_2O$	--	--	41.1	22.2
68.4	3.5	"	--	--	47.2	18.2
75.5	0	"	--	--	57.2	11.1
Two liquid layers formed here.						
0.5	98.1	$K_3SbS_4 \cdot 9H_2O$				

SOLUBILITY OF POTASSIUM SULFOANTIMONATE IN AQ. ETHYL ALCOHOL  
(Donk, 1908)

Results at  $10^\circ$

Gms. per 100 Gms. Sat. Sol.		Solid Phase
$K_3SbS_4$	$C_2H_5OH$	
0	94.0	$K_3SbS_4 \cdot 5H_2O$
0	90.5	"
Two Liquid Layers Formed Here.		
69.2	0.8	$K_3SbS_4 \cdot 5H_2O$
76.1	0	"

Results at  $30^\circ$

Gms. per 100 gms. sat. sol.		Solid Phase
$K_3SbS_4$	$C_2H_5OH$	
0	97	$K_3SbS_4 \cdot 3H_2O$
Two Liquid Layers Formed Here		
75.1	0	$K_3SbS_4 \cdot 3H_2O$

(Cont.)

# K KALIUM

## SOLUBILITY OF POTASSIUM SULFOANTIMONATE IN AQ. ETHYL ALCOHOL--Cont.

Results at 10°				Results at 30°			
Composition of the Liquid Layers Gms. per 100 Gms.				Composition of the Liquid Layers Gms. per 100 Gms.			
Alcoholic Layer		Aqueous Layer		Alcoholic Layer		Aqueous Layer	
K <sub>3</sub> SbS <sub>4</sub>	C <sub>2</sub> H <sub>5</sub> OH	K <sub>3</sub> SbS <sub>4</sub>	C <sub>2</sub> H <sub>5</sub> OH	K <sub>3</sub> SbS <sub>4</sub>	C <sub>2</sub> H <sub>5</sub> OH	K <sub>3</sub> SbS <sub>4</sub>	C <sub>2</sub> H <sub>5</sub> OH
0	85.0	67.4	1.1	0	93.1	70.5	±0.5
2.2	54.7	49.0	3.4	0	85.6	65.2	1.2
4.2	46.9	45.6	3.8	2.2	56.8	47.8	5.7
27.4	16.0	--	--	8.5	41.1	37.1	9.2
--	--	12.7	31.1				

## SeO POTASSIUM SELENITE K<sub>2</sub>SeO<sub>3</sub>

### SOLUBILITY OF POTASSIUM SELENITE IN WATER (Janickis, 1932; Janickis and Gutmanaitis, 1936)

t°	d. of sat. sol.	Gms. K <sub>2</sub> SeO <sub>3</sub> per 100 gms. sat. sol.	Solid Phase
- 0.262	1.007	1.02	Ice
- 0.50	1.015	2.02	"
- 0.97	1.029	3.99	"
- 2.375	1.075	9.54	"
- 5.03	1.148	17.87	"
-13.0	1.282	32.01	"
-23.6	1.452	45.13	"
-43.5 (Eutec.)	--	58.00	" + K <sub>2</sub> SeO <sub>3</sub> ·4H <sub>2</sub> O
-20.5	--	59.98	K <sub>2</sub> SeO <sub>3</sub> ·4H <sub>2</sub> O
- 9.7	--	61.14	"
- 0.2	--	62.76	"
+10.5	--	65.11	"
13.5	--	65.83	"
19.5	--	67.00	"
24.3 (gr. pt.)	--	68.5	" + K <sub>2</sub> SeO <sub>3</sub>
0	--	68.45*	K <sub>2</sub> SeO <sub>3</sub>
20.3	--	68.48*	"
43.1	--	68.52	"
60.1	--	68.70	"
100.6	--	68.53	"

\*Metastable

POTASSIUM BISELENITE  $\text{KHSeO}_3$ 

SeO

POTASSIUM PYROSELENITE  $\text{K}_2\text{Se}_2\text{O}_5$ 

SOLUBILITY OF POTASSIUM BISELENITE AND PYROSELENITE, IN WATER  
(Janickis, 1932; Janickis and Gutmanaitis, 1936)

t°	d. of sat. sol.	Gms. K <sub>2</sub> Se <sub>2</sub> O <sub>5</sub> per 100 gms.	Solid Phase	t°	Gms. K <sub>2</sub> Se <sub>2</sub> O <sub>5</sub> per 100 gms.	Solid Phase
		sat. sol.			sat. sol.	
- 0.166	1.003	0.63	Ice	12.8	77.21	KHSeO <sub>3</sub>
- 0.365	1.010	1.565	"	18.9	78.18	"
- 0.694	1.023	3.09	"	23.0	78.70	"
- 1.342	1.047	6.04	"	25.2	79.31*	"
- 3.17	1.119	14.12	"	30.6	80.04*	"
- 6.285	1.237	25.55	"	24	79.0 (?)	" + K <sub>2</sub> Se <sub>2</sub> O <sub>5</sub>
-14.3	1.466	43.13	"	27.2	79.21	K <sub>2</sub> Se <sub>2</sub> O <sub>5</sub>
-22.7	1.6055	52.55	"	31.7	79.41	"
-57.0(?)	--	70.0(?)	" + KHSeO <sub>3</sub>	50.4	80.39	"
-20.6	--	73.52	KHSeO <sub>3</sub>	69.6	82.45	"
-10.5	--	74.29	"	90.8	83.72	"
+ 0.2	--	75.87	"	102.8	84.47	"

\*Metastable

POTASSIUM TETRA SELENITE  $\text{KH}_3(\text{SeO}_3)_2$ 

SOLUBILITY OF POTASSIUM TETRA SELENITE IN WATER  
(Janickis, 1932; Janickis and Gutmanaitis, 1936)

t°	d. of sat. sol.	Gms. KH <sub>3</sub> (SeO <sub>3</sub> ) <sub>2</sub> per 100 gms. sat. sol.	Solid Phase	t°	Gms. KH <sub>3</sub> (SeO <sub>3</sub> ) <sub>2</sub> per 100 gms. sat. sol.	Solid Phase
-0.128	1.003	0.59	Ice	- 6.9	46.52	KH <sub>3</sub> (SeO <sub>3</sub> ) <sub>2</sub>
-0.288	1.009	1.467	"	0.0	53.57	
-0.544	1.019	2.905	"	+11.9	63.20	"
-1.027	1.040	5.69	"	20.3	68.65	"
-2.302	1.102	13.43	"	31.0	75.71	"
-4.10	1.202	24.62	"	40.2	80.30	"
-7.42	1.399	42.3	"	50.8	85.55	"
-8.0	--	46.0	" + KH <sub>3</sub> (SeO <sub>3</sub> ) <sub>2</sub>	59.4	89.65	"

## K KALIUM

SeO POTASSIUM SELENATE  $K_2SeO_4$ 

## SOLUBILITY IN WATER

The results of Etard, 1894 and of Meyer and Aulich, 1928 agree. Those of Friend, 1929 average about 1% higher at all temperatures. (Friend shook the mixtures for 2 hours - Meyer and Aulich for 4 to 6 hours). Individual determinations of other workers at 20°, 25° lie between the earlier values. The following values were taken from cruves drawn through the original results.

t°	Gms. $K_2SeO_4$ per 100 gms. sat. sol.			t°	Gms. $K_2SeO_4$ per 100 gms. sat. sol.	
	M. & A.	Etard	Friend		M. & A.	Friend
-20	51.5	51.5	--	30	53.1	53.95
- 5	--	51.7	--	40	53.55	54.15
0	51.8	--	53.55	50	53.95	54.4
+ 5	--	52.0	--	60	54.3	54.7
10	52.2	--	53.55	70	54.55	55.0
12	--	--	(53.5) <sup>a</sup>	85	54.85	55.6
18	--	52.6	--	97	(54.9) <sup>e</sup>	--
20	52.6	(52.1) <sup>b</sup>	53.7	100	55.0	56.2
25	52.85 (53.3) <sup>d</sup>	(53.26) <sup>c</sup>	53.8			

<sup>a</sup>Tutton, 1907

<sup>b</sup>Pani and Terrey, 1955

<sup>c</sup>Hill, Soth, and Ricci, 1940

<sup>d</sup>Other data of Meyer and Aulich, 1928

<sup>e</sup>Etard, 1894

THE SYSTEM POTASSIUM SELENATE - HYDROGEN PEROXIDE - WATER AT 20°  
(Pani and Terrey, 1955)

The 1:1 peroxide salt is formed.

Sat. Soln. Wt. %		Wet Residue Wt. %		Solid Phase
$K_2SeO_4$	$H_2O_2$	$K_2SeO_4$	$H_2O_2$	
52.1	0.00	94.3	0.00	$K_2SeO_4$
53.7	4.20	92.3	0.70	"
54.3	5.20	94.0	0.65	"
54.8	6.01	92.6	1.00	"
55.9	8.56	91.4	1.60	"
56.4	8.93	94.7	1.13	"
56.2	10.81	87.8	10.98	$K_2SeO_4 \cdot H_2O_2$
55.0	13.60	82.2	13.36	"
54.5	16.19	81.3	13.83	"
54.5	18.49	79.6	14.46	"
54.2	20.98	79.4	14.97	"
54.5	24.82	80.8	15.29	"
54.9	26.11	79.5	16.31	"
55.9	30.00	79.0	17.43	"

THE SYSTEM POTASSIUM SELENATE - MAGNESIUM SELENATE - WATER AT 25°  
(Hill, Soth and Ricci, 1940)

The earlier data of Meyer and Aulich, 1928 indicated a smaller region of stability of the double salt. M. & A.'s results for the solubility of magnesium selenate are also incorrect, in view of the work of Klein, 1940.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
MgSeO <sub>4</sub>	K <sub>2</sub> SeO <sub>4</sub>		MgSeO <sub>4</sub>	K <sub>2</sub> SeO <sub>4</sub>	
0.0	53.26	K <sub>2</sub> SeO <sub>4</sub>	20.04	12.76	1:1:6
0.191	52.88	K <sub>2</sub> SeO <sub>4</sub> + 1:1:6	24.08	9.79	"
0.35	50.48	1:1:6	31.11	5.77	"
1.52	41.54	"	34.38	3.58	MgSeO <sub>4</sub> ·6H <sub>2</sub> O + 1:1:6
5.68	29.55	"	35.74	0.0	MgSeO <sub>4</sub> ·6H <sub>2</sub> O
13.91	18.30				

1:1:6 = MgSeO<sub>4</sub>·K<sub>2</sub>SeO<sub>4</sub>·6H<sub>2</sub>O

THE SYSTEM POTASSIUM SELENATE - SODIUM SELENATE - WATER AT 25°  
(Meyer and Aulich, 1928)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
K <sub>2</sub> SeO <sub>4</sub>	Na <sub>2</sub> SeO <sub>4</sub>		K <sub>2</sub> SeO <sub>4</sub>	Na <sub>2</sub> SeO <sub>4</sub>	
53.3	0.0	K <sub>2</sub> SeO <sub>4</sub>	23.24	28.52	K <sub>2</sub> SeO <sub>4</sub>
45.20	7.21	"	21.86	31.29	" + Na <sub>2</sub> SeO <sub>4</sub>
37.72	12.76	"	19.87	31.78	Na <sub>2</sub> SeO <sub>4</sub>
30.02	19.90	"	17.42	32.34	"
26.80	25.36	"	0.0	36.40	"

POTASSIUM NEODYMIUM SELENATE KNd(SeO<sub>4</sub>)<sub>2</sub>·4H<sub>2</sub>O

SeO

100 gms. H<sub>2</sub>O sat. with KNd(SeO<sub>4</sub>)<sub>2</sub>·4H<sub>2</sub>O contain 15.0 gms. KNd(SeO<sub>4</sub>)<sub>2</sub>  
at 0° and 25.0 gms. at 20°. (Meyer and Kittlemann, 1931)

POTASSIUM FLUOSILICATE K<sub>2</sub>SiF<sub>6</sub>

SiF

SOLUBILITY IN WATER

(Carter, 1930; also Ryss, 1947; Pierrat, 1921; Wassilieff and Martinoff, 1935; Ricci and Skarulis, 1951 as noted.)

The solutions were usually shaken for a few hours and then allowed to stand overnight.

t°	Gms. K <sub>2</sub> SiF <sub>6</sub> per 100 cc. sat. sol.	t°	Gms. K <sub>2</sub> SiF <sub>6</sub> per 100 cc. sat. sol.	t°	Gms. K <sub>2</sub> SiF <sub>6</sub> per 100 cc. sat. sol.
0	0.077	25	0.177 (0.15)(R.&S.)*	60	0.377 (R.)*
14	0.09 (P.)	35	0.246	70	0.420
16	0.132	40	0.220 (R.)*	78	0.462
17	0.1147 (W.M.)	45	0.268	88	0.500
20	0.113 (R.)*	55	0.322	100	~ 0.82 (R.)*

\*Gms. per 100 gms. H<sub>2</sub>O



# K KALIUM

## SOLUBILITY OF POTASSIUM FLUOSILICATE IN SATURATED $\text{KNO}_3$ AND $\text{KCl}$ SOLUTION (Wassilieff and Martinoff, 1935)

The determinations were made at room temperature, about  $17^\circ$ . The mixtures were frequently shaken during several hours and then allowed to stand overnight. The dissolved  $\text{K}_2\text{SiF}_6$  was determined by titration with 0.1 n  $\text{NaOH}$  using phenolphthaline as indicator, bringing the solution nearly to the boiling point at the end of the titration.

Solvent	Gms. $\text{K}_2\text{SiF}_6$ per 100 cc. sat. sol.
Water	0.1147
Aq. Sat. $\text{KNO}_3$ Solution	0.0048
Aq. Sat. $\text{KCl}$ Solution	0.0048

SiF

## SOLUBILITY OF POTASSIUM FLUOSILICATE IN AQUEOUS ETHANOL SOLUTIONS AT $14^\circ$ (Pierrat, 1921)

Wt. Percent $\text{C}_2\text{H}_5\text{OH}$ in Solvent	Gms. $\text{K}_2\text{SiF}_6$ per liter sat. sol.	Wt. Percent $\text{C}_2\text{H}_5\text{OH}$ in solvent	Gms. $\text{K}_2\text{SiF}_6$ per liter sat. sol.
0.0	0.9	27.3	0.09
8.7	0.46	42.4	0.05
15.9	0.21	50	0.039*
		93.7	0.0096

\*Wassilieff and Martinoff, 1935 at  $17^\circ$ .

Other Results of Wassilieff and Martinoff, 1935 at  $17^\circ$ :

Solvent	Gms. $\text{K}_2\text{SiF}_6$ per 100 cc. sat. sol.
2.0 gm. $\text{KCl}$ per 100 cc. aq. 50% $\text{C}_2\text{H}_5\text{OH}$	0.0022
The above + 0.5 cc. 0.1 n $\text{HCl}$	0.0020

A discussion of the solid state reactions in systems such as  $\text{K}_2\text{SiF}_6$  +  $\text{MgO}$ , +  $\text{Al}_2\text{O}_3$ , +  $\text{SiO}_2$  etc., is given by Eitel, 1952.

## THE SYSTEM POTASSIUM BROMIDE - POTASSIUM FLUOSILICATE - WATER AT $25^\circ$ (Ricci and Skarulis, 1951)

Sat. Sol. Wt. %		Phase	Sat. Sol. Wt. %		Solid Phase
$\text{K}_2\text{SiF}_6$	$\text{KBr}$		$\text{K}_2\text{SiF}_6$	$\text{KBr}$	
0.15	0.0	$\text{K}_2\text{SiF}_6$	0.19	26.30	$\text{K}_2\text{SiF}_6$
.02	6.58	"	.09	28.61	"
.02	7.92	"	.05	33.26	"
.01	11.05	"	.07	36.42	"
.09	17.14	"	.09	40.05	"
.07	22.56	"	.14	40.47	$\text{K}_2\text{SiF}_6$ + $\text{KBr}$
			0.0	40.51	$\text{KBr}$

POTASSIUM SILICATE  $K_2SiO_3$ 

SiO

Data for equilibrium in the systems  $K_2SiO_3 + H_2O$ ,  $K_2Si_2O_5 + H_2O$ ,  $K_2SiO_3 + SiO_2$ ,  $SiO_2 + H_2O$  and  $K_2SiO_3 + SiO_2 + H_2O$ , at temperatures between  $200^\circ$  and  $1000^\circ$  +, determined by the "hydrothermal quenching method," are given by Morey (1917).

POTASSIUM STANNATE  $K_2SnO_3 \cdot 3H_2O$ 

SnO

 $[K_2Sn(OH)_6 \text{ and } K_2Sn(OH)_6 \cdot 2H_2O]$ 

t °	Gms. $K_2Sn(OH)_6$ per 100 gms. sat. sol.	Density sat. sol.	Solid Phase	Author
10	51.6	1.618	$K_2Sn(OH)_6$	Ordway, 1865
20	52.5	1.627	"	" "
28	50.7	--	"	Zocher, 1920
28	52.4	--	$K_2Sn(OH)_6 \cdot 2H_2O$	" "

POTASSIUM TANTALATE  $KTaO_3$ 

TaO

## SOLUBILITY IN WATER

(Lapitskii, Stepanov and Pehelkina, 1955)

Determined by radioactive tracer measurements.

	0	25	50	75	100
Moles $KTaO_3$ per liter	$4.34 \times 10^{-5}$	$4.87 \times 10^{-5}$	$1.22 \times 10^{-4}$	$2.88 \times 10^{-4}$	$4.89 \times 10^{-4}$
Mg. $KTaO_3$ per 100 ml.	1.17	1.31	3.29	7.74	13.10

POTASSIUM TELLURATE  $K_2TeO_4$ 

TeO

100 gms.  $H_2O$  dissolve 8.82 gms.  $K_2TeO_4$  at  $0^\circ$ , 27.53 gms. at  $20^\circ$  and 50.42 gms. at  $30^\circ$ .  
(Rosenheim and Weinheber, 1910-11)

POTASSIUM TITANATE  $K_2TiO_3$ 

TiO

Melting point data are given for:

$K_2TiO_3 + KF$	(Ono, Hata, and Kuriyama, 1954; Sholokovich, 1955)
$K_2TiO_3 + 2NaF \rightleftharpoons 2KF + Na_2TiO_3$	(Sholokovich, 1955)
$K_2TiO_3 + KCl$	(Sholokovich and Barkova, 1956)
$K_2TiO_3 + K_2SO_4$	( " " " " )
$K_2TiO_3 + K_2CrO_4$	( " " " " )
$K_2TiO_3 + K_2MoO_4$	( " " " " )
$K_2TiO_3 + K_2WO_4$	( " " " " )
$K_2TiO_3 + KVO_3$	( " " " " )
$K_2TiO_3 + NaF$	(Ono, Hata, and Kuriyama, 1954)
$K_2TiO_3 + NaCl$ (also + $TiO_2$ )	( " " " " )
$K_2TiO_3 + KF + TiO_2$	( " " " " )

# K KALIUM

## VO POTASSIUM VANADATE $KVO_3$

THE SYSTEM POTASSIUM VANADATE - POTASSIUM CHLORIDE - WATER AT 25°  
(Trujillo and Machado, 1955)

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
KCl	$KVO_3$		KCl	$KVO_3$	
0.0	9.7	$KVO_3$	14.5	0.8	$KVO_3$
0.3	6.2	"	15.4	0.6	"
1.1	4.7	"	19.0	0.4	"
3.0	3.4	"	21.9	0.4	"
4.7	1.9	"	24.2	0.3	"
5.9	1.4	"	26.4	0.3 <sup>a</sup>	$KVO_3 + KCl$
14.4	0.9	"	26.2	0.06 <sup>b</sup>	"
			26.2	0.0	KCl

a = average of two determinations

b = average of four other determinations

Melting points in the system  $KVO_3 + V_2O_5$  are given by Illarionov, Ozerov and Kildisheva, 1956, 1957a)

## POTASSIUM PENTAVANADATE $K_3V_5O_{14} \cdot 5H_2O$

100 gms.  $H_2O$  dissolve 19.2 gms. at 17.5°.

(Radan, 1889)

## POTASSIUM ZINC VANADATE $KZnV_5O_{14} \cdot 8H_2O$

100 gms.  $H_2O$  dissolve 0.41 gm. of the salt.

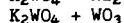
(Radan)

## WO POTASSIUM TUNGSTATE $K_2WO_4$

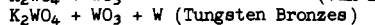
Fusion-point data are given for the following mixtures:



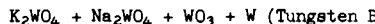
(Van Liempt, 1922)



(Van Liempt, 1922; Hoermann, 1929)



(Brimm, Brantly, Lorenz and Jellink, 1951)



(Brimm, Brantly, Lorenz and Jellink, 1951)

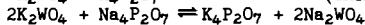


(Kislova, Posypaiko and Bergman, 1955;

Bergman, Kislova, and Posypaiko, 1955a)



(Sholokhovich and Bergman, 1954)



(Sholokhovich and Bergman, 1954)

## KRYPTON Kr

SOLUBILITY IN WATER  
(Morrison and Johnstone, 1954)

Two separate samples of purified gas were used and temperatures were chosen randomly. The precision of the results is excellent. The data are 5-10% lower than those of von Antropoff, 1919, which are given for comparison.

$\beta$  = cc. of krypton (at N.T.P.) dissolved by 1 gm.  $H_2O$  when the partial pressure of the gas is 1 atm.

$t^\circ$	$\beta$	$t^\circ$	$\beta$	Earlier results of von Antropoff	
				$t^\circ$	$\beta$
6.6	0.0820	46.0	0.0383	0	0.1105
8.0	0.0794	51.9	0.0359	10	0.0810
12.6	0.0695	57.9	0.0333	20	0.0626
15.5	0.0656	59.8	0.0328	30	0.0511
18.2	0.0617	64.7	0.0316	40	0.0433
21.2	0.0582	67.5	0.0307	50	0.0383
24.7	0.0535	71.5	0.0297	60	0.0357
30.2	0.0489	73.9	0.0295		
35.4	0.0443	74.9	0.0293		
41.4	0.0406				

SOLUBILITY OF KRYPTON IN VARIOUS ELECTROLYTE SOLUTIONS AT  $25^\circ$   
(Morrison and Johnstone, 1955)

Results expressed as Setschenow salting-out coefficients  $k$ , where  $k = \frac{\log S_0/S}{C}$ .  $C$  = concentration of salt in moles per 1000 gms.  $H_2O$ .

$S_0 (25^\circ) = 0.0515$  cc. (NTP) dissolved in 1 gm.  $H_2O$  when the partial pressure of the gas is 1 atm. (Value from Morrison and Johnstone, 1954.)

Electrolyte	$k$	Electrolyte	$k$	Electrolyte	$k$
NaCl	0.136	1/2BaCl <sub>2</sub>	0.151	KNO <sub>3</sub>	0.093
LiCl	0.116	1/2Na <sub>2</sub> SO <sub>4</sub>	0.203	HNO <sub>3</sub>	-0.003
HCl	0.028	KI	0.120	(CH <sub>3</sub> ) <sub>4</sub> N <sup>+</sup> I <sup>-</sup>	-0.016
KCl	0.124	KBr	0.120	(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> N <sup>+</sup> Br <sup>-</sup>	-0.032
NH <sub>4</sub> Cl	0.065				

## Kr KRYPTON

## SOLUBILITY OF KRYPTON IN ORGANIC LIQUIDS

(1) Clever, Saylor, and Gross, 1958; (2) Clever, Battino, Saylor, and Gross, 1957;  
(3) Clever, 1957; (4) Friedman, 1954.

Solubility					Solubility				
Solvent	t°	Ostwald Coefficient		Ref.	Solvent	t°	Ostwald Coefficient		Ref.
		Mole Fraction in Solution					Mole Fraction in Solution		
Methylcyclohexane	16.0	1.15	0.00614	(1)	2,4-dimethyl-				
"	30.0	1.078	0.00556	(1)	hexane	16.1	1.137	0.00772	(2)
Perfluoro-	43.1	0.999	0.00502	(1)	"	25.0	1.102	0.00733	(2)
methylcyclohexane	16.0	1.12	0.00906	(1)	"	40.6	1.052	0.00679	(2)
"	30.0	1.027	0.00808	(1)	2,2,4-trimethyl-				
"	43.1	1.01	0.00777	(1)	pentane	16.0	1.24	0.00849	(2)
Benzene	16.2	0.756	0.00281	(2)	"	25.1	1.171	0.00788	(2)
"	25.2	0.748	0.00273	(2)	"	40.45	1.091	0.00712	(2)
"	40.3	0.750	0.00264	(2)	n-nonane	16.35	1.017	0.00755	(2)
Cyclohexane	16.0	1.081	0.00488	(2)	"	24.8	0.971	0.00708	(2)
"	25.0	1.055	0.00467	(2)	"	40.35	0.923	0.00652	(2)
"	40.5	1.016	0.00436	(2)	n-decane	16.6	0.937	0.00759	(2)
n-hexane	16.15	1.38	0.00748	(2)	"	25.0	0.908	0.00722	(2)
"	25.1	1.27	0.00676	(2)	"	40.2	0.849	0.00653	(2)
"	40.6	1.23	0.00640	(2)	n-dodecane	16.1	0.834	0.00792	(2)
n-heptane	16.1	1.244	0.00759	(2)	"	25.2	0.824	0.00765	(2)
"	25.2	1.197	0.00716	(2)	"	40.5	0.772	0.00691	(2)
"	40.3	1.097	0.00638	(2)	n-tetradecane	16.0	0.791	0.00834	(2)
n-octane	16.2	1.11	0.00752	(2)	"	25.0	0.756	0.00781	(2)
"	25.2	1.064	0.00706	(2)	"	40.3	0.705	0.00703	(2)
"	40.3	0.996	0.00640	(2)	p-xylene	30	0.250	0.00125	(3)
3-methylheptane	16.0	1.099	0.00740	(2)	Mixtures of				
"	25.25	1.087	0.00718	(2)	p-xylene +				
"	40.6	1.024	0.00655	(2)	dichloro,	30	--	--	(3)
2,3-dimethylhexane	16.0	1.118	0.00746	(2)	dibromo,				
"	24.8	1.077	0.00704	(2)	diiodo-benzenes				
"	40.5	1.032	0.00654	(2)	nitromethane	24.85	0.380	--	(4)

## SOLUBILITY OF KRYPTON IN SEVERAL LIQUIDS, DETERMINED BY SIMPLE METHODS TO AN ACCURACY OF ABOUT 5 PERCENT

## Results of Korosy, 1937

## Results of Van Liempt and Van Wijk, 1937

S = cc. Kr (at 0 and 760 mm.) dissolved by 1.0 cc. solvent under 1 atmosphere pressure of Kr and vapor of solvent.

The Krypton used in both cases contained about 5 percent of xenon.

(Ostwald Exp.)(a)					
Solvent	t°		Solvent	t°	S
Ethyl Alcohol (95%)	21	0.62	Water	0.5	0.12
" " (97.5%)	21	0.67	"	20	0.06
Cyclohexanol	22	0.40	Gasoline (Benzene)	19	0.89
Acetone (technical)	19	0.83	Petroleum	20	1.00
" (dried)	20	1.05	Paraffine oil	18.5	0.60
Benzene	22	0.97	Benzene	19	0.67
Tetraline	24	0.49	Toluene	18	0.84
Butyl acetate (techn.)	20	0.85	Methyl alcohol	18	0.52
Butyl phthalate "	20	0.47	Ethyl " (96%)	19	0.51
Tricresyl phosphate "	22	0.23	Amyl "	23	0.66
Acetic acid (glacial)	22	0.47	Glycerol (100%)	22	0.01
Glycerol	20	0.06			
Chloroform	0	0.97			
"	21	1.01			
Bromoform	22	0.46			
Carbon tetrachloride	0	1.20			
" "	21	1.31			
Aq. 20% CaCl <sub>2</sub> Solution	22	0.04			
Olive Oil	22	0.44			
	37	0.43			

# LANTHANUM La

The solid-liquid equilibria of the systems krypton+argon and krypton + methane were determined by Veith (1937) from melting point curves.

The liquid-vapor data for the system krypton+oxygen were determined by Fastovskii and Gurvich, 1939. Other data are given by von Stackelberg, 1934.

## LANTHANUM La

### SOLUBILITY OF LANTHANUM IN MERCURY (Parks and Campanella, 1936)

Amalgams of lanthanum and mercury were prepared by heating the mixed constituents in fused quartz flasks to 200° or by electrolysis of Lanthanum Salts dissolved in absolute ethyl alcohol with Hg as the cathode. Such amalgams were kept in evacuated fused quartz flasks at the selected temperatures, approaching equilibrium from above and below. A filtered portion of the saturated solution was allowed to stand in contact with the air until the lanthanum had separated as the hydroxide and this was then determined by titration.

t°	Gms. La per 100 gms. La + Hg	t°	Gms. La per 100 gms. La + Hg
0	0.00552	37.5	0.0134
12.5	0.00907	50.0	0.0184
25.0	0.00960		

## LANTHANUM BROMATE $\text{La}(\text{BrO}_3)_3 \cdot 9\text{H}_2\text{O}$

BrO

### SOLUBILITY OF LANTHANUM BROMATE IN WATER (James, Fogg, McIntire, Evans and Donovan, 1927)

t°	Gms. per 100 gms. sat. sol.		t°	Gms. per 100 gms. sat. sol.	
	$\text{La}(\text{BrO}_3)_3$	$\text{La}(\text{BrO}_3)_3 \cdot 9\text{H}_2\text{O}$		$\text{La}(\text{BrO}_3)_3$	$\text{La}(\text{BrO}_3)_3 \cdot 9\text{H}_2\text{O}$
0	49.48	64.83	20	59.83	78.40
5	52.06	68.22	25	62.74	82.21
10	54.59	71.53	30	66.63	87.31
15	57.02	74.89	35	69.74	91.38

## LANTHANUM ACETATE $\text{La}(\text{CH}_3\text{COO})_3$

CH

Solvent	t°	Gms. $\text{La}(\text{CH}_3\text{COO})_3$ per 100 gms. solvent		Author
Water <sup>a</sup>	18	20.43		Vesterberg, 1916, 1917
	25	16.88		Meyer and Muller, 1920
Methanol	15	0.64		Henstock, 1934
	66(b.pt.)	0.77		"
Ethylenediamine	30	8.01		Muniyappan and Anjaneyalu, 1957
Ethylene glycol <sup>b</sup>	30	2.02		" " 1957a
Monoethanolamine	30	23.78		" " 1957a

<sup>a</sup>Forms  $\cdot 1.5 \text{ H}_2\text{O}$  solvate

<sup>b</sup>Forms  $\cdot 2 \text{ C}_2\text{H}_4(\text{OH})_2$  solvate

## La LANTHANUM

### LANTHANUM TRIFLUOROACETATE $\text{La}(\text{CF}_3\text{COO})_3$

At 29.8°, 0.142 gms.  $\text{La}(\text{CF}_3\text{COO})_3$  dissolve in 100 gms.  $\text{CF}_3\text{COOH}$ . The solid phase is  $\text{La}(\text{CF}_3\text{COO})_3 \cdot 3\text{CF}_3\text{COOH}$ . (Hara and Cady, 1954)

### CH LANTHANUM ETHYLENEDIAMINE TETRAACETATES (EDTA) (Sodium and Potassium Salts)

#### SOLUBILITIES IN WATER (Marsh, 1955)

$\text{LaNa}[\text{C}_2\text{H}_4\text{N}_2(\text{CH}_2\text{COO})_4]$		$\text{LaK}[\text{C}_2\text{H}_4\text{N}_2(\text{CH}_2\text{COO})_4]$	
t°	Gms. "hydrated salt" per liter	t°	Gms. "hydrated salt" per liter
2	120	2	58
25	139	25	182
		35	292

### LANTHANUM CITRATE $2(\text{LaC}_2\text{H}_5\text{O}_7) \cdot 7\text{H}_2\text{O}$

100 gms. aq. citric solution containing 10 gms. citric acid per 100 cc., dissolve 0.8 gm.  $\text{La}(\text{C}_6\text{H}_5\text{O}_7)$  at 20°. (Holmberg, 1907)

### LANTHANUM GLYCOLATE $\text{La}(\text{C}_2\text{H}_3\text{O}_3)_3$

One liter  $\text{H}_2\text{O}$  dissolves 3.328 gms.  $\text{La}(\text{C}_2\text{H}_3\text{O}_3)_3$  at 20°. (Jantsch and Grunkraut, 1912-13)

### CH LANTHANUM MALONATE $\text{La}_2(\text{C}_3\text{H}_2\text{O}_4)_3 \cdot 5\text{H}_2\text{O}$

100 gms. aq.  $\text{NH}_4$  malonate sol. (10 gms. per 100 cc.) dissolve 0.2 gm.  $\text{La}_2(\text{C}_3\text{H}_2\text{O}_4)_3$  at 20°. (Holmberg, 1907)

100 gms. aq. malonic acid sol. (20 gms. per 100 cc.) dissolve 0.6 gm.  $\text{La}_2(\text{C}_3\text{H}_2\text{O}_4)_3$  at 20°. (Holmberg, 1907)

### LANTHANUM LACTATE $\text{La}(\text{C}_3\text{H}_5\text{O}_3)_3 \cdot 3\text{H}_2\text{O}$

100 cc. sat. solution of lanthanum lactate in water contain 1.44 gms.  $\text{La}_2\text{O}_3 = 4.06$  gms.  $\text{La}(\text{C}_3\text{H}_5\text{O}_3)_3 \cdot 3\text{H}_2\text{O}$  at 20°. (Jantsch, 1926)

### LANTHANUM TARTRATE $\text{La}_2(\text{C}_4\text{H}_4\text{O}_6)_3 \cdot 9\text{H}_2\text{O}$

One liter  $\text{H}_2\text{O}$  dissolves 0.059 gm.  $\text{La}_2(\text{C}_4\text{O}_4\text{O}_6)_3$  at 25° (solid phase  $\text{La}_2(\text{C}_4\text{H}_4\text{O}_6)_3 \cdot 3\text{H}_2\text{O}$ ). Determined by electrolytic method. (Rimbach and Schubert, 1909)

SOLUBILITY OF LANTHANUM TARTRATE IN AQ. TARTARIC ACID AND  
AMMONIUM TARTRATE SOLUTIONS AT 20°  
(Holmberg, 1907)

In Aq. Tartaric Acid		In Aq. Ammonium Tartrate	
Gms. Tartaric Acid per 100 cc. Solvent	Gms. $\text{La}_2(\text{C}_4\text{O}_6)_3$ per 100 Gms. Sat. Sol.	Gms. Am. Tartrate per 100 cc. Solvent	Gms. $\text{La}_2(\text{C}_4\text{H}_4\text{O}_6)_3$ per 100 Gms. Sat. Sol.
20	0.6	10	0.2
40	1.2	20	0.6

LANTHANUM SULFONATES

CH

SOLUBILITY OF EACH IN WATER

Sulfonate	Formula	Gms. Anhydrous Sulfonate per 100 Gms. $\text{H}_2\text{O}$
Lanthanum Benzene Sulfonate	$\text{La}[\text{C}_6\text{H}_5\text{SO}_3]_3 \cdot 9\text{H}_2\text{O}$	63.1*
" m Nitrobenzene Sulfonate	$\text{La}[\text{C}_6\text{H}_4\text{NO}_2\text{SO}_3]_3 \cdot 6\text{H}_2\text{O}$	16 *
" m Chlorbenzene Sulfonate	$\text{La}[\text{C}_6\text{H}_4\text{Cl} \cdot \text{SO}_3]_3 \cdot 9\text{H}_2\text{O}$	13.1*
" m Bromobenzene "	$\text{La}[\text{C}_6\text{H}_4\text{Br} \cdot \text{SO}_3]_3 \cdot 9\text{H}_2\text{O}$	12.9*
" (6)Chloro(3)Nitrobenzene(1) { Sulfo-	$\text{La}[\text{C}_6\text{H}_3\text{Cl}(\text{NO}_2)\text{SO}_3]_3 \cdot 8\text{H}_2\text{O}$	24.5*
" (1)Bromo(4)Nitrobenzene(2) { nate	$\text{La}[\text{C}_6\text{H}_3\text{BrNO}_2\text{SO}_3]_3 \cdot 8\text{H}_2\text{O}$	5**
" $\alpha$ Naphthalene Sulfonate	$\text{La}[\text{C}_{10}\text{H}_7\text{SO}_3]_3 \cdot 6\text{H}_2\text{O}$	5.2*
" 1.5 Nitronaphthalene Sulfonate	$\text{La}[\text{C}_{10}\text{H}_6(\text{NO}_2)\text{SO}_3]_3 \cdot 6\text{H}_2\text{O}$	0.55*
" 1.6 " "	" $\cdot 9\text{H}_2\text{O}$	0.21*
" 1.7 " "	" $\cdot 9\text{H}_2\text{O}$	1.1*

\*Holmberg, 1907

\*\*Katz and James, 1913

LANTHANUM SORBATE ( $\text{CH}_3\text{CH} = \text{CHCH} = \text{CHCOO}$ )<sub>3</sub>La

The solubility in water at 20° is  $2.779 \times 10^{-3}$  gm. moles per liter.  
(Bergamini, 1949)

LANTHANUM SALICYLATE	(o-HOC <sub>6</sub> H <sub>4</sub> COO) <sub>3</sub> La
3,5-DINITROBENZOATE	(3,5(NO <sub>2</sub> ) <sub>2</sub> C <sub>6</sub> H <sub>3</sub> COO) <sub>3</sub> La
CINNAMATE	(C <sub>6</sub> H <sub>5</sub> CH = CHCOO) <sub>3</sub> La

Data for the extraction of  $\text{La}^{+++}$  from  $\text{H}_2\text{O}$  by methyl isobutyl ketone and by chloroform at 25° ( $\mu = 0.1\text{M NaClO}_4$ ) in the presence of salicylic, 3,5-dinitrobenzoic and cinnamic acids are reported by Hok-Bernstrom, 1956.



# La LANTHANUM

## CH LANTHANUM CUPFERRATE (C<sub>6</sub>H<sub>5</sub>N(NO)O)<sub>3</sub>La

### SOLUBILITIES AT 25° FROM PARTITION EXPERIMENTS

Solvent	Solubility	
Chloroform	5.6 x 10 <sup>-4</sup> molee/liter	
Hexone	4 x 10 <sup>-4</sup> "	(Dyrssen and Dahlberg, 1953)

## LANTHANUM CAMPHOR 10-SULFONATE (C<sub>10</sub>H<sub>15</sub>OSO<sub>3</sub>)<sub>3</sub>La

The solubility in water at room temperature is 17.30 wt. %.  
(Pirrone, 1942)

## CN LANTHANUM CobalticyANIDE La[Co(CN)<sub>6</sub>].4.5H<sub>2</sub>O

### SOLUBILITY IN VARIOUS AQUEOUS SOLUTIONS AT 20° (Gross and Kahn, 1955)

m = added substance, s = La[Co(CN)<sub>6</sub>].4.5H<sub>2</sub>O, both in moles per liter.

Ethanol		Acetone		Urea		Glycine	
m	s	m	s	m	s	m	s
0.0	0.03565	--	--	--	--	--	--
0.086	0.03396	0.277	0.03386	0.050	0.03798	0.0161	0.04060
0.173	0.03206	0.578	0.03246	0.100	0.04037	0.0322	0.04522
0.345	0.02891	1.115	0.02927	0.201	0.04489	0.0641	0.05409

100 gms. aq. 10% HCl (d<sub>15</sub> = 1.05) dissolve 10.41 gms. salt at 25°.  
(James and Willand, 1916)

## SCN LANTHANUM THIOCYANATE La(SCN)<sub>3</sub>

In a single experiment, Selwood and Appleton (1941) found that solutions of La(SCN)<sub>3</sub> and Nd(SCN)<sub>3</sub>, originally 38.1% each were partitioned between water and n-butanol in the ration 1.06 [38.7%/34.4% (H<sub>2</sub>O/alc.)].

## CO LANTHANUM OXALATE La<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub>

### SOLUBILITY OF LANTHANUM OXALATE IN WATER AT 25°

Solid Phase La<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub>.9H<sub>2</sub>O in all cases.

Gms. La<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub> per  
liter sat. solution—Determined by:

Conduc- tivity Method	Gravi- metric Method	Volu- metric Method	Colori- metric Method	Authority
0.00062	--	--	--	Rimback and Schubert, 1909
0.00070	0.00096	0.00121	--	Hauser and Herzfeld, 1912
0.00206	0.00214	--	--	Sarver and Brinton, 1927
0.00060	--	0.00208	0.00195	Kolthoff and Elmquist, 1931

SOLUBILITY OF LANTHANUM OXALATE IN AQ. SOLUTIONS OF OXALIC ACID AT 25°  
(Hauser and Wirth, 1908)

Normality of Aq. Oxalic Acid	Gms. per 100 Gms. Sat. Sol.		Solid Phase
	$\text{La}_2\text{O}_3$	$\text{La}_2(\text{C}_2\text{O}_4)_3$	
0.1	unweighable		$\text{La}_2(\text{C}_2\text{O}_4)_3 \cdot 9\text{H}_2\text{O}$
1.0	0.00032	0.00053	"
3.2 (sat.)	0.00045	0.00075	"

Results are also given for the solubility in mixtures of sulfuric and oxalic acids.

SOLUBILITY OF LANTHANUM OXALATE IN AQ. SOLUTIONS OF SULFURIC ACID AT 25°  
(Hauser and Wirth, 1908; Wirth, 1908; Wirth, 1912)  
(Sarver and Brinton, 1927 (\*))

CO

Normality of $\text{H}_2\text{SO}_4$	Gms. per 100 Gms. Sat. Sol.		Solid Phase
	$\text{La}_2\text{O}_3$	$\text{La}_2(\text{C}_2\text{O}_4)_3$	
*0.086	--	0.0222	$\text{La}_2(\text{C}_2\text{O}_4)_3 \cdot 9\text{H}_2\text{O}$
0.1	0.0208	0.0346	"
*0.419	--	0.1078	"
0.5	0.0979	0.1629	"
*0.958	--	0.2523	"
1.0	0.2383	0.3962	"
1.5	0.319	0.5304	"
*1.846	--	0.5128	"
2.0	0.4417	0.7344	"
*2.612	--	0.6840	"
3.09	0.680	1.1306	"
4.32	0.880	1.4630	"
5.6	1.092	1.8155	"

SOLUBILITY OF LANTHANUM OXALATE IN AQ. HYDROCHLORIC ACID SOLUTIONS AT 25°  
(Sarver and Brinton, 1927)

From 50 to 1000 gms. of the saturated solutions were evaporated to dryness in small porcelain dishes and the residue converted to oxide and weighed.

Normality of Acid in Aqueous Solvent	Gms. $\text{La}_2(\text{C}_2\text{O}_4)_3$ per 100 gms. sat. sol.	Mixtures of HCl + Oxalic Acid Normalities:	Gms. $\text{La}_2(\text{C}_2\text{O}_4)_3$ per 100 gms. sat. sol.
0.1008 HCl	0.0208	0.978 HCl + 0.1 $(\text{COOH})_2$	0.0532
0.2576 "	0.0567	2.000 " + 0.1 "	0.2998
0.5004 "	0.1384	2.865 " + 0.1 "	0.6330
0.978 "	0.3074	3.965 " + 0.1 "	1.026
1.484 "	0.4937	0.978 " + 0.5 "	0.0062
2.000 "	0.6770	2.865 " + 0.5 "	0.1098
2.865 "	1.082	3.965 " + 0.5 "	0.3127
4.000 "	1.327	1.484 " + sat. "	
5.200 "	1.285	4.00 " + sat. "	

In 0.02N HCl, Korenman, 1954 reports a  $K_{sp}$  of  $1.07 \times 10^{-28}$  at 20°.

# La LANTHANUM

## SOLUBILITY OF LANTHANUM OXALATE IN NITRIC AND NITRIC-OXALIC ACID MIXTURES

Results at 15°  
(von Scheele, 1899)

100 gms. aq. 10.2%  $\text{HNO}_3$  ( $\bar{d}$  = 1.063) dissolve 0.80 gm.  $\text{La}_2(\text{C}_2\text{O}_4)_3$ .  
100 gms. aq. 19.4%  $\text{HNO}_3$  ( $\bar{d}$  = 1.116) dissolve 2.69 gms.  $\text{La}_2(\text{C}_2\text{O}_4)_3$ .

Results at 25°  
(Sarver and Brinton, 1927)

	Normality of Acid in Aqueous Solvent	Gms. La <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> per 100 gms. sat. sol.	Normality of Acid in Aqueous Solvent	Gms. La <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> per 100 gms. sat. sol.
CO	0.2482 HNO <sub>3</sub>	0.0354	4.00 HNO <sub>3</sub> + 0.1 (COOH) <sub>2</sub>	1.568
	1.992 "	0.9256	2.00 " + 0.5 "	0.1292
	4.054 "	2.660	3.03 " + 0.5 "	0.3576
	2.00 " + 0.1 (COOH) <sub>2</sub>	0.3908	4.00 " + 0.5 "	0.7200
	3.03 " + 0.1 "	1.227	4.00 " + sat. "	0.7664
			6.00 " + sat. "	1.304

Results at 90°  
(Necker and Kremers, 1928)

The mixtures were frequently shaken during 36 hours. For analysis 50 cc. of the filtered saturated solutions were evaporated to dryness in porcelain dishes and the residues ignited and weighed as oxide.

Normality of Acid in Aqueous Solvent	Gms. $\text{La}_2\text{O}_3$ per 100 cc. sat. sol.	Normality of Acid in Aqueous 5% $(\text{COOH})_2$ Solution	Gms. $\text{La}_2\text{O}_3$ per 100 cc. sat. sol.
0.779 $\text{HNO}_3$	0.4421	0.779 $\text{HNO}_3$	0.0302
1.558 "	1.2377	1.558 "	0.3083
3.75 "	4.6670	2.337 "	0.7517
5.00 "	10.4160	3.75 "	3.5260
		5.00 "	9.3907

## THE SYSTEM LANTHANUM OXALATE - LANTHANUM NITRATE - WATER AT 25° (James and Whitmore, 1912)

Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
$\text{La}_2(\text{C}_2\text{O}_4)_3$	$\text{La}(\text{NO}_3)_3$		$\text{La}_2(\text{C}_2\text{O}_4)_3$	$\text{La}(\text{NO}_3)_3$	
0	60.17	$\text{La}(\text{NO}_3)_3$	not det.	not det.	$\text{La}_2(\text{C}_2\text{O}_4)_3 \cdot 5\text{H}_2\text{O}$
0.67	59.91	"	3.32	42.27	$\text{La}_2(\text{C}_2\text{O}_4)_3 \cdot 8\text{H}_2\text{O}$
2.10	59.03	"	2.80	38.50	"
2.23	59.03	" + $\text{La}_2(\text{C}_2\text{O}_4)_3 \cdot 3\text{H}_2\text{O}$	2.51	35.57	"
2.26	58.22	$\text{La}_2(\text{C}_2\text{O}_4)_3 \cdot 3\text{H}_2\text{O}$	2.21	31.53	"
2.34	55.20	"	2.01	28.63	"
2.47	52.74	"	1.46	22.15	"
2.59	49.84	"	1.18	17.99	"
2.68	45.26	"	0.50	9.89	"
not det.	not det.	$\text{La}_2(\text{C}_2\text{O}_4)_3 \cdot 5\text{H}_2\text{O}$	0.28	5.06	"

100 cc. aq. 20% triethylamineoxalate dissolve approx. 0.032 gm.  
 $\text{La}_2(\text{C}_2\text{O}_4)_3$ . (Grant and James, 1917)

LANTHANUM CHLORIDE  $\text{LaCl}_3$ 

Cl

SOLUBILITY OF LANTHANUM CHLORIDE IN WATER  
(Friend and Hale, 1940)

$t^\circ$	Gms. $\text{LaCl}_3$ per 100 gms. Sat. Sol.	$t^\circ$	Gms. $\text{LaCl}_3$ per 100 gms. sat. Sol.	$t^\circ$	Gms. $\text{LaCl}_3$ per 100 gms. Sat. Sol.
0	48.12	36.4	49.87	64.6	54.96
10.0	48.46	45.8	51.16	64.6	54.84
11.4	48.83	50.2	52.00	71.5	56.70
15.4	48.99	55.4	53.15	76.0	57.59
25.0	49.27	59	53.65	80.4	58.87
26.2	49.40	63.6	54.30	92.1	63.02
33.0	49.69				

The solid phase was  $\text{LaCl}_3 \cdot 7\text{H}_2\text{O}$  throughout.

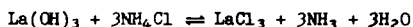
SOLUBILITY OF LANTHANUM CHLORIDE IN ACID SOLUTIONS  
(Friend and Hale, 1940)

The addition of "free acid" (hydrochloric?) decreased the solubility linearly at both temperatures.

Results at $25^\circ$		Results at $50^\circ$	
Normality of Acid	Gms. $\text{LaCl}_3$ per 100 gms. Sat. sol.	Normality of Acid	Gms. $\text{LaCl}_3$ per 100 gms. Sat. Sol.
0	49.27	0	52.00
0.174	48.79	0.171	51.46
0.817	45.87	0.400	50.88
1.471	43.55	0.597	50.28
1.644	42.78	1.568	47.66
2.611	39.47	1.831	46.95

SOLUBILITY OF LANTHANUM CHLORIDE AND OF LANTHANUM OXIDE IN AQUEOUS  
SOLUTIONS OF AMMONIUM CHLORIDE AT  $15^\circ$ ,  $30^\circ$ ,  $50^\circ$  and  $100^\circ$   
(Prandtl and Rauchenberger, 1920)

The results are given only in the form of small scale diagrams and it is stated that the numerical data will be published in full in the dissertation of Johanna Rauchenberger, University of Munchen, 1920. The equilibrium



was approached by the authors from both sides. The composition of the basic chlorides obtained by shaking the oxide with 1.0 N  $\text{NH}_4\text{Cl}$  at different temperatures, and drying over soda lime, was approximately as follows:

At  $15^\circ$ ,  $\text{La}_4\text{Cl}_2\text{O}_5 \cdot 9\text{H}_2\text{O}$ ; at  $30^\circ$ ,  $\text{La}_3\text{ClO}_4 \cdot 6\text{H}_2\text{O}$ ; at  $50^\circ$ ,  $\text{La}_8\text{Cl}_2\text{O}_{11} \cdot 16\text{H}_2\text{O}$ .

## La LANTHANUM

### ClO LANTHANUM Hexa Antipyrine PERCHLORATE $[\text{La}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6](\text{ClO}_4)_3$

100 cc. sat. solution of Lanthanum Hexa Antipyrine Perchlorate in Water contain 1.48 gm.  $[\text{La}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6](\text{ClO}_4)_3$  at 20°. (Wilke-Dorfurt and Schliephake, 1928)

### CrO LANTHANUM CHROMATE $\text{La}_2(\text{CrO}_4)_3 \cdot 8\text{H}_2\text{O}$

100 gms. sat. solution of Lanthanum Chromate in Water contain 0.020 gm.  $\text{La}_2(\text{Cr}_2\text{O}_4)_3$  at 25°. (Britton, 1924)

The system  $\text{La}_2(\text{CrO}_4)_3 + \text{K}_2\text{CrO}_4 + \text{H}_2\text{O}$  at 25° was studied by Carobbi, 1924, but the table of results does not show the quantity of  $\text{La}_2(\text{CrO}_4)_3$  present in the solutions. The results show the several double compounds formed.

### F LANTHANUM FLUORIDE $\text{LaF}_3$

3%  $\text{HNO}_3$  solution saturated with  $\text{LaF}_3$  at 100° contains 0.94 mg. La per ml. (Khlopin and Merkulova, 1950)

Melting points in the systems  $\text{LaF}_3 + \text{NaF}$ ,  $\text{LaF}_3 + \text{KF}$ ,  $\text{LaF}_3 + \text{RbF}$  and  $\text{LaF}_3 + \text{CsF}$  are given by Dergunov, 1948.

### I LANTHANUM Hexa Antipyrine IODIDE $[\text{La}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6]\text{I}_3$

100 cc. sat. solution of Lanthanum Hexa Antipyrine Iodide in Water contain 29.50 gm.  $\text{La}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6 \text{I}_3$  at 20°. (Wilke-Dorfurt and Schliephake, 1928)

### IO LANTHANUM IODATE $\text{La}(\text{IO}_3)_3$

#### SOLUBILITY IN WATER

The solubility apparently depends on the particle size of the samples.

t°	Solubility	Author
25	0.000893 moles = 0.593 gms./liter	(1)
25	0.000883 moles = 0.586 "	(2)
25	0.0006634 " = 0.441 gms./liter sat. sol. d = 0.99749	(3)
25	0.6842 gms./1000 gms. $\text{H}_2\text{O}$ , $d_{25}^4 = 0.99825$	(4)
25	0.591 - 0.623 gms./liter (different samples)	(5)

(1) Monk, 1951

(2) Monk, 1951b

(3) Pearce and Oelke, 1938

(4) Harkins and Pearce, 1916

(5) LaMer and Goldman, 1929; Friedman and LaMer, 1931

The earlier data of Rimbach and Schubert, 1909 are too high.

## SOLUBILITY OF LANTHANUM IODATE IN AQUEOUS SALT SOLUTIONS AT 25°

NOTE: Solubilities in certain solutions (e.g., KCl, K<sub>2</sub>SO<sub>4</sub>) are found in several tables:

Results of Pearce and Oelke, 1938

<u>With KCl Added</u>			<u>With MgCl<sub>2</sub> Added</u>		
Moles KCl per 1000 gms. H <sub>2</sub> O	Moles La(IO <sub>3</sub> ) <sub>3</sub> per Liter Sat. Sol.	Density	Moles MgCl <sub>2</sub> per 1000 gms. H <sub>2</sub> O	Moles La(IO <sub>3</sub> ) <sub>3</sub> per Liter Sat. Sol.	Density
0.0000	0.0006634	0.99749	0.0010	0.000702	0.99757
.0010	.000684	.99750	.005	.000817	.99798
.005	.000737	.99776	.010	.000908	.99841
.010	.001014	.99801	.050	.001306	1.00180
.050	.001195	1.00000	.100	.001601	1.00589
.100	.001919	1.00243	.500	.002782	1.03666
.500	.002452	1.02090	1.000	.003508	1.07255
1.000	.003167	1.04277	2.000	.004209	1.13805
2.000	.003898	1.08268	3.000	.004639	1.19716
3.500		1.13787			

10

<u>With K<sub>2</sub>SO<sub>4</sub> Added</u>			<u>With MgSO<sub>4</sub> Added</u>		
(Moles K <sub>2</sub> SO <sub>4</sub> )			(Moles MgSO <sub>4</sub> )		
0.0010	0.000824	0.99790	0.0010	0.000846	0.99766
.005	.001215	.99847	.005	.001209	.99839
.010	.001488	.99952	.010	.001448	.99921
.050	.002568	1.00554	.050	.002384	1.00496
			.100	.003021	1.01167
			.500	.005863	1.06116
			1.000	.008198	1.12180
			1.500	.009690	1.17865
			2.000	.010558	1.23098

Results of La Mer and Goldman, 1929; Friedman and La Mer, 1931

The solubility of Lanthanum iodate in water varied with different samples from 0.00089 to 0.00094 gm. mols. per liter (= 0.5907 to 0.6233 gms. La(IO<sub>3</sub>)<sub>3</sub> per liter).

Mols. salt per liter of Aq. Solvent	Mols. La(IO <sub>3</sub> ) <sub>3</sub> per liter sat. solution	Mols. salt per liter of Aq. Solvent	Mols. La(IO <sub>3</sub> ) <sub>3</sub> per liter sat. solution
0.0002 K <sub>2</sub> SO <sub>4</sub>	0.0009167	0.001 KCl	0.0009113
0.0005 "	0.0009746	0.005 "	0.0009749
0.0010 "	0.0010564	0.010 "	0.0010322
0.0020 "	0.0012153	0.05 "	0.0013331
0.0070 "	0.0016852	0.10 "	0.0015713
0.0125 "	0.0020272	0.10 "	0.0016480
0.02 "	0.0023675	0.20 "	0.0018776
0.05 "	0.0031871	0.50 "	0.0025641
0.05 "	0.003370	1.0027 "	0.0030547
0.10 KNO <sub>3</sub>	0.001679	2.00 "	0.0037828
0.10 NaNO <sub>3</sub>	0.001654	0.05 Na <sub>2</sub> SO <sub>4</sub>	0.003326
0.10 NaCl	0.001627	0.0333 La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	0.001830
0.033 LaCl <sub>3</sub>	0.0009233	0.0166 "	0.001532

(Cont.)

# La LANTHANUM

Results of La Mer and Goldman, 1929; Friedman and La Mer, 1931-Cont.

Mols. salt per liter of Aq. Solvent	Mols. $\text{La}(\text{IO}_3)_3$ per liter sat. solution
0.00166 $\text{La}(\text{NO}_3)_3$	0.0008347
0.00333 "	0.0008101
0.0166 "	0.0008696
0.0333 "	0.0009398
0.050 $\text{Mg}(\text{NO}_3)_2$	0.001766
0.05 $\text{MgCl}_2$	0.001768
0.05 "	0.001739
0.05 $\text{MgSO}_4$	0.003010
0.05 "	0.002997
0.05 $\text{CdCl}_2$	0.001689
0.05 $\text{CdSO}_4$	0.003205

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SOLUBILITY OF  $\text{La}(\text{IO}_3)_3$  IN WATER AND IN AQ. SALT SOLUTIONS AT 25°  
(Harkins and Pearce, 1916)

Salt	Conc. of Salt, Milli-Normal	Gms. $\text{Li}(\text{IO}_3)_3$ per Liter	$d_{25}^4$ of Sat. Sol.
$\text{La}(\text{NO}_3)_3$	0	0.6828	0.99825
"	2	0.5595	0.99732
"	5	0.5288	0.99807
"	10	0.5194	0.99859
"	50	0.5522	1.00212
"	100	0.6214	1.00661
"	200.52	0.7431	1.01533
$\text{KIO}_3$	0.0990	0.6290	1.00030
"	0.4957	0.5633	1.00027
"	0.9914	0.4970	1.00030
"	1.9828	0.3738	1.00031
$\text{NaIO}_3$	0.0913	0.63538	1.00060
"	0.4560	0.56466	1.00059
"	0.9130	0.50835	1.00065
"	1.8260	0.39938	1.00065
"	3.6530	0.19736	1.00069
"	4.5326	0.13393	1.00083
"	6.7989	0.09733	1.00130
$\text{NaNO}_3$	25	0.86901	1.00250
"	50	0.99040	1.00385
"	100	1.1603	1.00742
"	200	1.385	1.01290
"	400	1.636	1.02422
"	800	2.156	1.04677
"	1600	2.859	1.09005
"	3200	3.030	1.17243
$\text{La}(\text{NO}_3)_3 \cdot 2\text{NH}_4\text{NO}_3$	26.34	0.631	1.00112
"	52.68	0.674	1.00355
"	105.36	0.754	1.00971
"	158.04	0.816	1.01608
"	196.83	0.867	1.02183
"	393.67	1.063	1.04343
"	787.35	1.364	1.08286
"	1574.70	1.923	1.16652

SOLUBILITY OF LANTHANUM IODATE IN AQUEOUS  
SOLUTIONS OF ORGANIC COMPOUNDS AT 25°

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(Data of Monk, 1951b)

(Data of Monk, 1951)

Solvent	Wt. %	Moles $\text{La}(\text{IO}_3)_3$ per liter sat. sol.		Solvent	moles per liter	Moles $\text{La}(\text{IO}_3)_3$ moles per liter	
H <sub>2</sub> O	--	0.000883		H <sub>2</sub> O		0.000893	
Methanol	4.72	0.000578		Glycine	0.05610	0.001007	
"	9.53	0.000399		"	0.05610 + $\text{KIO}_3$	0.001024	0.000753
"	14.43	0.000270		"	0.05610 + "	0.001775	0.000589
Ethanol	3.82	0.000595		"	0.0966		0.001095
"	7.67	0.000420		"	0.0966 + "	0.000996	0.000848
"	11.59	0.000289		"	0.2133		0.001394
Acetone	4.09	0.000601		"	0.2133 + "	0.001574	0.001005
"	8.25	0.000428		"	0.2133 + "	0.001929	0.000926
"	12.46	0.000301		Alanine	0.06466		0.001010
n-Propanol	4.16	0.000592		"	0.1486		0.001183
"	8.40	0.000408		"	0.2116		0.001313
"	12.71	0.000284		Glycyl-			
Ethyl acetate	3.8	0.000655		glycine	0.04883		0.001063
"	6.1	0.000559			0.05804		0.001119
Dioxane	2.2	0.000769			0.06569		0.001144
"	4.7	0.000663			0.08884		0.001300
"	9.4	0.000488					
Glycol	5.62	0.000750					
"	11.24	0.000669					
"	16.85	0.000591					
Glycerol	6.31	0.000822					
"	12.44	0.000789					
"	18.43	0.000761					

LANTHANUM MOLYBDATE  $\text{La}_2(\text{MoO}_4)_3$ 

MoO

One liter H<sub>2</sub>O dissolves 0.0179 gm.  $\text{La}_2(\text{MoO}_4)_3$  at 25° and 0.0332 gm. at 85°. (Hitchcock, 1895)

EQUILIBRIUM IN THE SYSTEM LANTHANUM MOLYBDATE, SODIUM  
MOLYBDATE AND WATER AT 25°  
(Carobbi, 1928)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Na}_2\text{MoO}_4$	$\text{La}_2(\text{MoO}_4)_3$		$\text{Na}_2\text{MoO}_4$	$\text{La}_2(\text{MoO}_4)_3$	
0.77	0.01	$\text{La}_2(\text{MoO}_4)_3 \cdot$ aq. + 1.1.2	15.50	0.18	1.2.3
2.44	0.02	1.1.2	16.19	0.19	"
2.92	0.03	"	20.02	0.25	"
7.56	0.08	"	22.35	0.28	"
11.50	0.13	"	25.26	0.34	"
11.54	0.13	" + 1.2.3	25.27	0.34	" + $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$
11.52	0.13	1.2.3	25.30	0.34	" + "

1.1.2 =  $\text{La}_2(\text{MoO}_4)_3 \cdot \text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$ ; 1.2.3 =  $\text{La}_2(\text{MoO}_4)_3 \cdot 2\text{Na}_2\text{MoO}_4 \cdot 3\text{H}_2\text{O}$ .



La LANTHANUM

NO LANTHANUM NITRATE  $\alpha$  and  $\beta$   $\text{La}(\text{NO}_3)_3$

SOLUBILITY OF LANTHANUM NITRATES IN WATER  
(Friend, 1935)

t°	Gms. $\text{La}(\text{NO}_3)_3$ per 100 gms. sat. sol.	Solid Phase
0	50.03	$\alpha$ $\text{La}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$
18.4	54.16	"
21.2	55.03	"
35.4	59.12	"
42.4	63.84	"
44.2	65.13	"
43.0 tr. pt.	--	" + $\beta$ $\text{La}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$
14.4	56.27	$\beta$ $\text{La}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$
15.2	56.94	"
16.0	56.74	"
20	[60.13(a)?]	"
23.2	58.7	"
25	60.17(b)	"
29.6	60.08	"
32.2	61.34	"
40.0	62.71	"
46.4	65.55	"
49.4	65.17	"
56.0	68.30	"
65.4 m. pt.	75.04	"

(a) DiCapua, 1929.

(b) James and Whittemore, 1912.

SOLUBILITY OF LANTHANUM NITRATE IN AQUEOUS SOLUTIONS OF NITRIC ACID  
(Quill and Robey, 1937)

6 =  $\text{La}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$ ; 4 =  $\text{La}(\text{NO}_3)_3 \cdot 4\text{H}_2\text{O}$ ; 3 =  $\text{La}(\text{NO}_3)_3 \cdot 3\text{H}_2\text{O}$ ; 0 =  $\text{La}(\text{NO}_3)_3$

Results at 25°				Results at 50°			
d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{La}(\text{NO}_3)_3$	$\text{HNO}_3$			$\text{La}(\text{NO}_3)_3$	$\text{HNO}_3$	
--	59.0	0.0	6	1.929	66.65	0.0	6
1.771	56.42	3.06	6	1.912	61.21	2.59	6
--	46.42	11.95	6	1.892	61.85	5.29	6
--	29.10	34.69	6	1.852	56.70	12.05	6
--	29.62	40.17	4	1.880	56.34	14.93	6 + 4
--	28.73	41.14	4	1.755	44.23	27.73	4
--	25.18	54.41	4	1.645	30.31	44.48	4
--	21.61	58.36	4	--	29.58	50.53	4
1.489	2.79	70.70	3	--	5.48	78.31	0 (?)
--	0.56	87.85	0	--	1.38	85.51	0
1.483	0.0	90.0	NONE	1.419	0.41	91.15	0
				1.440	00.0	90.0	NONE

THE SYSTEM LANTHANUM NITRATE - MAGNESIUM NITRATE - WATER AT 20°  
(DiCapua, 1929)

The double salt (see below) was not found by this author.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{La}(\text{NO}_3)_3$	$\text{Mg}(\text{NO}_3)_2$	Solid Phase	$\text{La}(\text{NO}_3)_3$	$\text{Mg}(\text{NO}_3)_2$	Solid Phase
60.13	0	$\text{La}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$	26.0	24.0	$\text{La}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$
58.91	2.20	"	22.90	25.48	$\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$
55.06	6.21	"	15.35	30.93	"
50.11	9.83	"	6.89	36.30	"
42.98	17.40	"	3.20	39.25	"
37.02	19.25	"	0.0	43.68	"

THE SYSTEM LANTHANUM NITRATE - MANGANESE NITRATE - WATER AT 20°  
(DiCapua, 1929)

The double salt (see below) was not found by this author.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{La}(\text{NO}_3)_3$	$\text{Mn}(\text{NO}_3)_2$	Solid Phase	$\text{La}(\text{NO}_3)_3$	$\text{Mn}(\text{NO}_3)_2$	Solid Phase
60.13	0.0	$\text{La}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$	24.70	26.80	$\text{Mn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$
53.90	5.08	"	22.95	27.50	"
49.20	8.91	"	21.25	29.18	"
41.45	13.22	"	14.15	41.10	"
36.82	16.19	"	10.00	45.00	"
29.81	21.00	"	6.22	49.20	"
27.45	21.95	"	0.0	58.81	"

## LANTHANUM DOUBLE NITRATES

NO

Salt	Solvent	t°	Solubility (Gms. hydrated salt per 100 gms. sat. sol.)	Author
$2\text{La}(\text{NO}_3)_3 \cdot 3\text{Mg}(\text{NO}_3)_2 \cdot 24\text{H}_2\text{O}$	Water	18.6	62.19	
"	"	31.6	63.96	
"	"	46.8	68.57	(Friend
"	"	50.8	70.17	and
"	"	61.4	73.05	Wheat,
"	"	74.8	77.43	1935)
"	"	113.5*	100.00	
(Gms. hydrated salt per liter sat. sol.)				
"	Conc. $\text{HNO}_3$ ( $d_{16} = 1.325$ )	16	63.8	
$2\text{La}(\text{NO}_3)_3 \cdot 3\text{Mn}(\text{NO}_3)_2 \cdot 24\text{H}_2\text{O}$	"	16	193.1	(Jantsch,
$2\text{La}(\text{NO}_3)_3 \cdot 3\text{Ni}(\text{NO}_3)_2 \cdot 24\text{H}_2\text{O}$	"	16	80.3	1912)
$2\text{La}(\text{NO}_3)_3 \cdot 3\text{Co}(\text{NO}_3)_2 \cdot 24\text{H}_2\text{O}$	"	16	109.2	
$2\text{La}(\text{NO}_3)_3 \cdot 3\text{Zn}(\text{NO}_3)_2 \cdot 24\text{H}_2\text{O}$	"	16	124.1	
(Gms. per 100 gms. $\text{H}_2\text{O}$ )				
$\text{La}(\text{NO}_3)_3 \cdot 2\text{NH}_4\text{NO}_3$	$\text{H}_2\text{O}$	15	181.4	(Holmberg, 1907)

\*m. pt.

## La LANTHANUM

### DISTRIBUTION OF LANTHANUM NITRATE BETWEEN WATER AND n-HEXYL ALCOHOL AT 25°

(Templeton, 1949)

(Templeton and Daly, 1951)

Wt. % $\text{La}_2\text{O}_3$		Aqueous Phase		Alcohol Phase	
Aqueous Phase	Alcohol Phase	Wt. % $\text{La}(\text{NO}_3)_3$	Wt. % $\text{La}(\text{NO}_3)_3$	Wt. % $\text{H}_2\text{O}$	
28.6	2.36	60.6*	7.85	4.80	
27.4	1.575	60.1*	7.95	4.78	
26.15	1.05	57.8	4.79	4.36	
24.85	0.73	56.3	3.92	4.24	
23.5	0.52	54.3	2.74	4.10	
NO 22.1	0.35	51.0	1.64	4.08	
21.2	0.29				

\*Saturated with  $\text{La}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$

The distribution coefficient of a mixture of rare earth nitrates, containing 4% lanthanum nitrate, between methyl-n-hexyl ketone and water at room temperature was found to be less than 0.0012, with 33.0% of anhydrous salt in the aqueous phase. (Rothchild, Templeton, and Hall, 1948)

100 cc. of a saturated solution of  $\text{La}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$  in ethyl ether prepared by frequent agitation and allowing to stand overnight at about 20° contain 0.002 gm.  $\text{La}_2\text{O}_3$ . A saturated ethereal solution prepared as above but using Lanthanum nitrate dehydrated at 150° contain only 0.001 gm.  $\text{La}_2\text{O}_3$  per 100 cc. (Wells, 1930)

10 ml. of a saturated solution of lanthanum nitrate in ether at 20° contain 0.1 mg.  $\text{La}_2\text{O}_3$ . (Wells, 1930.) 1 liter of sat. sol. of  $\text{La}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$  in ether contains 1.04 gms.  $\text{La}(\text{NO}_3)_3$  at 17°. (Bachelet, Cheylan and LeBris, 1950.)

Data for the extraction of  $\text{La}(\text{NO}_3)_3$  by ether from aqueous solutions are given by Bock and Bock, 1950.

2.45 gm.  $\text{La}(\text{NO}_3)_3$  dissolve in 100 gm. ethylene diamine at 30°. (Moeller and Zimmermann, 1953.)

100 gm. of a saturated solution of  $\text{La}(\text{NO}_3)_3$  in tri-n-butyl phosphate at 25-27° contains 28.3 gms.  $\text{La}(\text{NO}_3)_3$ . The solid phase is the hexahydrate. (Wendlandt and Bryant, 1956.)

Fusion-point data for mixtures of  $\text{La}(\text{NO}_3)_3 + \text{Mg}(\text{NO}_3)_2$  are given by Quill and Robey, 1937.

## 0 LANTHANUM OXIDE $\text{La}_2\text{O}_3$

### SOLUBILITY OF LANTHANUM OXIDE IN WATER

t°	Milligrams $\text{La}_2\text{O}_3$ per liter sat. sol.	Method	Authority
18	0.405	Potentiometric	Sadolin, 1927
25	0.40	Volumetric	Rush, 1927
25	0.73	Volumetric	Kolthoff and Elmquist, 1931
25	0.3-0.67	Conductivity	" " " "
25	1.5	Potentiometric	Oka, 1948
25	1.3	"	Moeller and Kremers, 1944
25	1.4	"	Moeller and Fogel, 1951
25	0.59	"	Korenman, 1955

(See also Mironov and Odnosevtsev, 1957)

SOLUBILITY OF  $\text{La}_2\text{O}_3$  IN BASIC SOLUTIONS AT  $25^\circ$   
(Lewis, 1957)

0

Small amounts of NaOH or HCl were added to the solutions. No attempt to control the ionic strength is reported. Solubilities were measured by radiotracer techniques.

pH	Mg. $\text{La}_2\text{O}_3$ per liter	pH	Mg. $\text{La}_2\text{O}_3$ per liter	pH	Mg. $\text{La}_2\text{O}_3$ per liter
7.66	63.4	8.43	3.64	9.88	0.057
7.86	20.35	9.00	0.402	10.17	0.086
8.07	19.65	9.20	0.127	10.30	0.084
8.37	4.69	9.66	0.126	10.44	0.005

Deshmukh and Nayak give data for the relative solubility of lanthanum oxide in rochelle salt solutions. The amount of  $\text{La}_2\text{O}_3$  dissolved by boiling the solution for 1 minute were as follows:

(Read from curves drawn by the authors.)

Rochelle salt soln. wt. %	5	10	15	20	25	30
Gms. $\text{La}_2\text{O}_3$ per 100 ml. solution	0.3	.35	.45	.5	1.6	2.2

Data for the separation of  $\text{La}_2\text{O}_3$  from  $\text{Ac}_2\text{O}_3$  and other rare earth oxides by precipitation of the basic acetate are given by Perey, 1949. Graphs are given showing the percentage of La precipitated when  $\text{NH}_3$  is added to  $\text{La}_2\text{O}_3$  solutions in 30 vol. % acetic acid.

Data for the solubility of  $\text{La}(\text{OH})_3$  in fused  $\text{NH}_4\text{NO}_3$  at  $130^\circ$  are given by Vickery, 1949.

LANTHANUM Dimethyl PHOSPHATE  $\text{La}_2[(\text{CH}_3)_2\text{PO}_4]_6 \cdot 4\text{H}_2\text{O}$

PO

100 gms.  $\text{H}_2\text{O}$  dissolve 103.7 gms.  $\text{La}_2[(\text{CH}_3)_2\text{PO}_4]_6$  at  $25^\circ$ .  
(Morgan and James, 1914)

LANTHANUM SULFATE  $\text{La}_2(\text{SO}_4)_3$

SO

SOLUBILITY IN WATER

- (1) Muthmann and Rolig, 1898; (2) Barre, 1910, 1911; (3) Wirth, 1912;  
(4) Spedding and Jaffe, 1954; (5) Jones, Lietzke and Marshall, 1957;  
(6) Lietzke, 1957

[Solid Phase  $\text{La}_2(\text{SO}_4)_3 \cdot 9\text{H}_2\text{O}$ ]

Gms. $\text{La}_2(\text{SO}_4)_3$ per 100 gms.			Gms. $\text{La}_2(\text{SO}_4)_3$ per 100 gms.		
t°	Solution	H <sub>2</sub> O	t°	Solution	H <sub>2</sub> O
0	2.9	3.0 (1)	75	0.95	0.96 (1)
14	2.5	2.6 (1)	100	0.68	0.69 (1)
16.5	--	2.198 (2)	100	0.9	-- (6)
18	--	2.130 (2)	108	0.61	-- (5)
25	--	2.483 (3)	113	0.46	-- (5)
25	--	2.142 (4)	115	0.37	-- (5)
30	1.86	1.9 (1)	117	0.31	-- (5)
50	1.47	1.5 (1)	150	<0.1	(6)

# La LANTHANUM

## SOLUBILITY OF LANTHANUM SULFATE IN AQUEOUS SOLUTIONS OF SULFURIC ACID AT 25° (Wirth, 1912)

Normality of Aq. H <sub>2</sub> SO <sub>4</sub>	Gms. per 100 Gms. Sat. Sol.		Solid Phase
	La <sub>2</sub> O <sub>3</sub>	= La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	
Water	1.43	2.483	La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·9H <sub>2</sub> O
0.505	1.69	2.934	"
1.10	1.796	3.118	"
2.16	1.818	3.156	"
3.39	1.42	2.465	"
4.321	1.11	1.927	"
SO 6.685	0.531	0.9217	"
9.68	0.266	0.4617	"
12.60	0.214	0.371	"
15.15	0.177	0.307	"

Data for the solubility of lanthanum sulfate in aq. H<sub>2</sub>SO<sub>4</sub> in presence of solid oxalic acid at 25° are given by Wirth, 1908.

## THE SYSTEM LANTHANUM SULFATE - POTASSIUM SULFATE - WATER

### Results at 16.5° (Barre, 1910, 1911)

Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
K <sub>2</sub> SO <sub>4</sub>	La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>		K <sub>2</sub> SO <sub>4</sub>	La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	
0.0	2.198	1.0.9	0.846	0.185	1.1.2
0.247	0.727	1.1.2	1.029	0.054	1.5
0.496	0.269	"	1.156	0.022	"
1.0.9 = La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·9H <sub>2</sub> O			1.1.2 = La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·K <sub>2</sub> SO <sub>4</sub> ·2H <sub>2</sub> O		
			1.5 = La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·5K <sub>2</sub> SO <sub>4</sub>		

### Results at 25° (Zambonini and Carobbi, 1924)

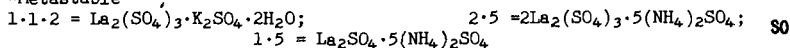
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>		La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>	
0.87	0.23	1.1.2	0.00	1.51	1.4.1
0.77	0.23	"	0.00	4.24	"
0.41	0.45	"	0.00	4.78	1.4½.2
0.28	0.79	2.3.8	0.00	10.16	"
0.26	0.74	" + 1.3	0.00	11.11	1.5.2
0.24	0.87	1.3	0.00	11.02	" + K <sub>2</sub> SO <sub>4</sub>
0.00	1.62	" + 1.4.1			
1.1.2 = La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·K <sub>2</sub> SO <sub>4</sub> ·2H <sub>2</sub> O;			1.4.1 = La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·4K <sub>2</sub> SO <sub>4</sub> ·H <sub>2</sub> O;		
2.3.8 = 2La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·3K <sub>2</sub> SO <sub>4</sub> ·8H <sub>2</sub> O;			1.4½.2 = La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·4½K <sub>2</sub> SO <sub>4</sub> ·2H <sub>2</sub> O;		
1.3 = La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·3K <sub>2</sub> SO <sub>4</sub> ;			1.5.2 = La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·5K <sub>2</sub> SO <sub>4</sub> ·2H <sub>2</sub> O		

## THE SYSTEM LANTHANUM SULFATE - AMMONIUM SULFATE - WATER

Results at 18°  
(Barre, 1910, 1911)

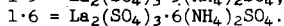
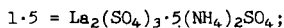
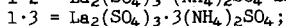
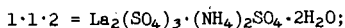
Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>		(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	
4.01	0.393	1.1.2	36.11	0.277*	1.1.2
8.73	0.279	"	47.49	0.137	2.5
18.24	0.253	"	53.82	0.067	1.5
27.89	0.476*	"	65.29	0.0117	"
			73.78	0.0033	"

\*Metastable



Results at 25°  
(Zambonini and Stolfi, 1926)

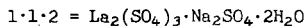
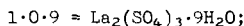
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>		La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	
0.88	6.24	La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·9H <sub>2</sub> O+1.1.2	0.22	29.37	1.3
0.88	6.26	1.1.2	0.19	30.40	1.5
0.75	7.19	"	0.05	33.6	"
0.73	11.11	"	0.05	36.85	"
0.34	14.48	"	0.02	39.24	" + 1.6
0.32	22.89	"	0.02	42.48	1.6
0.30	22.80	" + 1.3	0.02	43.24	"
0.28	25.12	1.3	0.00	44.64	1.6+(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
0.26	27.97	"			



## THE SYSTEM LANTHANUM SULFATE - SODIUM SULFATE - WATER

Results at 18°  
(Barre, 1910, 1911)

Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase
Na <sub>2</sub> SO <sub>4</sub>	La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>		Na <sub>2</sub> SO <sub>4</sub>	La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	
0.0	2.130	1.0.9	1.136	0.129	1.1.2
0.395	0.997	1.1.2	2.480	0.044	"
0.689	0.353	"	3.802	0.019	"
0.774	0.299	"	5.548	0.016	"



(Cont.)

# La LANTHANUM

## Results at 25° (Zambonini and Carobbi, 1925a)

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{La}_2(\text{SO}_4)_3$	$\text{Na}_2\text{SO}_4$	
0.19	0.54	$\text{La}_2(\text{SO}_4)_3 \cdot \text{Na}_2\text{SO}_4 \cdot 2\text{H}_2\text{O}$
0.09	0.75	"
trace	3.42	"
"	5.43	"
"	7.13	"
0.0	10.46	"
0.0	13.86	"
0.0	15.06	"
0.0	16.28	"
0.0	18.06	" + $\text{Na}_2\text{SO}_4$

## THE SYSTEM LANTHANUM SULFATE - THALLIUM SULFATE - WATER AT 25° (Zambonini and Carobbi, 1925)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{La}_2(\text{SO}_4)_3$	$\text{Tl}_2\text{SO}_4$		$\text{La}_2(\text{SO}_4)_3$	$\text{Tl}_2\text{SO}_4$	
1.84	0.19	$\text{La}_2(\text{SO}_4)_3 \cdot 9\text{H}_2\text{O} + 1 \cdot 1 \cdot 2$	0.15	1.89	1.3
1.19	0.14	1.1.2	0.16	2.01	" + $1 \cdot 4 \frac{1}{2}$
0.29	0.49	"	0.17	2.05	$1 \cdot 4 \frac{1}{2}$
0.19	0.84	"	0.12	2.37	"
0.15	1.27	"	--	3.19	"
0.11	1.75	" + 1.3	---	4.07	"
0.27	1.71	" + "	--	5.25	"
0.25	1.75	1.3	--	5.16	" + $\text{Tl}_2\text{SO}_4$
0.26	1.82	"	--	5.28	" + "

$$1 \cdot 1 \cdot 2 = \text{La}_2(\text{SO}_4)_3 \cdot \text{Tl}_2\text{SO}_4 \cdot 2\text{H}_2\text{O};$$

$$1 \cdot 4 \frac{1}{2} = \text{La}_2(\text{SO}_4)_3 \cdot \frac{1}{2} \text{Tl}_2\text{SO}_4$$

$$1 \cdot 3 = \text{La}_2(\text{SO}_4)_3 \cdot 3\text{Tl}_2\text{SO}_4$$

## SOLUBILITY OF LANTHANUM SULFATE IN URANYL SULFATE SOLUTIONS (Jones, Lietzke and Marshall, 1957)

In $\text{H}_2\text{O}$		In 0.1272 molal $\text{UO}_2\text{SO}_4$ soln.		In 1.348 molal $\text{UO}_2\text{SO}_4$ soln.	
t°	Wt. % $\text{La}_2(\text{SO}_4)_3$ in sat. sol.	t°	Wt. % $\text{La}_2(\text{SO}_4)_3$ in sat. sol.	t°	Wt. % $\text{La}_2(\text{SO}_4)_3$ in sat. sol.
108	0.61	97	2.04	78	4.39
113	0.46	105	1.74	91	3.97
115	0.37	120	0.87	148	3.80
117	0.31	145	0.29	150	3.75
		169	0.15	151	3.60
		199	0.083	152	3.46
		215	0.042	154	3.25
				160	2.69
				168	2.30
				178	1.85
				202	1.22
				222	0.88
				(two layers) 291	0.57

LANTHANUM SELENATE  $\text{La}_2(\text{SeO}_3)_2$ 

SeO

SOLUBILITY OF LANTHANUM SELENATE IN WATER  
(Friend, 1932)

t°	Gms. $\text{La}_2(\text{SeO}_4)_3$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{La}_2(\text{SeO}_4)_3$ per 100 gms. sat. sol.	Solid Phase
0.0	33.55	$\text{La}_2(\text{SeO}_4)_3 \cdot \text{Aq.}$	46.2	27.54	$\text{La}_2(\text{SeO}_4)_3 \cdot 12\text{H}_2\text{O}$
9.6	30.90	"	51.4	23.37	"
15.0	30.84	"	59.4	15.92	"
21.8	31.31	"	69.4	8.51	"
25.4	30.54	"	78.2	5.02	"
33.6	31.29	"	81.2	3.78	"
40.6	31.15	"	92.4	1.93	"
36.4	34.00*	$\text{La}_2(\text{SeO}_4)_3 \cdot 12\text{H}_2\text{O}$	93.4	1.97	"

\*Metastable

SOLUBILITY OF LANTHANUM SELENATE IN AQUEOUS SOLUTIONS OF SELENIC ACID  
(Friend, 1932)

At 35°			At 83.6°		
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{H}_2\text{SeO}_4$	$\text{La}_2(\text{SeO}_4)_3$		$\text{H}_2\text{SeO}_4$	$\text{La}_2(\text{SeO}_4)_3$	
0	31.2	$\text{La}_2(\text{SeO}_4)_3 \cdot \text{Aq.}$	0	3.25	$\text{La}_2(\text{SeO}_4)_3 \cdot 12\text{H}_2\text{O}$
2.08	28.96	"	1.68	4.81	"
7.80	24.07	"			

LANTHANUM TUNGSTATE  $\text{La}_2(\text{WO}_3)_2$ 

WO

## SOLUBILITY IN WATER

t°	Condition	Gms. $\text{La}_2(\text{WO}_4)_3$ per liter	Author
20	Unignited	0.14	Vickery, 1949
	Ignited	0.01	" "
27	--	0.0117	Hitchcock, 1895
65	--	0.0236	" "
100	Unignited	0.194	Vickery, 1949
	Ignited	0.01	" "



## Li LITHIUM

### LITHIUM Li

#### SOLUBILITY OF LITHIUM IN LIQUID AMMONIA, DETERMINED BY VAPOR PRESSURE MEASUREMENTS (Johnson and Piskur, 1933)

The vapor pressures of solutions of lithium in liquid ammonia at constant temperature give a curve which intersects the horizontal line representing the vapor pressure of the saturated solution. This point was determined at several temperatures with results showing that, contrary to the determinations of Ruff and Geisel, 1906, a slight increase in concentration of lithium in liquid ammonia occurs with increasing temperature.

t°	Vapor Pressure mm. Hg.	Mols. NH <sub>3</sub> per atom Li	Gms. Li per 100 gms. NH <sub>3</sub>
-63.5	1.1	3.81	10.698
-33.2	3.4	3.75	10.866
-32.7	3.4	3.74	10.895
0.0	34.0	3.60	11.319

The eutectic temperature in the system Li - NH<sub>3</sub> is about -185°.

(Birch and MacDonald, 1947)

The reaction  $\text{Li} + \text{NaCl} = \text{LiCl} + \text{Na}$  was studied at 900° by Jelinek, 1920. For data on the system  $\text{Li} + \text{LiH}$  see Messer, et al, 1958.

### AlO LITHIUM ALUMINATE $\text{LiH}(\text{AlO}_2)_2 \cdot 5\text{H}_2\text{O}$

One liter sat. solution of  $\text{LiH}(\text{AlO}_2)_2 \cdot 5\text{H}_2\text{O}$  in Water contains 0.00012 gm. equivalents at 25°, 0.00013 at 50° and 0.00033 at 80° as determined by electrical conductivity. (Prociv, 1929)

### AsO LITHIUM ARSENITE $\text{LiAsO}_2$

#### EQUILIBRIUM IN THE SYSTEM LITHIUM OXIDE, ARSENIC TRIOXIDE AND WATER AT 25°

(Schreinemakers and de Baat, 1920)

Four to six weeks constant agitation was required for saturation.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
Li <sub>2</sub> O	As <sub>2</sub> O <sub>3</sub>		Li <sub>2</sub> O	As <sub>2</sub> O <sub>3</sub>	
0.0	2.02	As <sub>2</sub> O <sub>3</sub>	5.36	6.32	LiAsO <sub>2</sub>
0.45	6.45	"	6.45	6.98	"
0.84	10.26	LiAsO <sub>2</sub>	7.35	7.47	"
0.89	3.74	"	7.64	7.50	" + LiOH·H <sub>2</sub> O
2.26	4.19	"	7.81	3.81	LiOH·H <sub>2</sub> O
4.24	5.65	"	7.15	0.0	"

LITHIUM URAHYL ARSENATE  $\text{Li}(\text{UO}_2)\text{AsO}_4$ 

AsO

The Ksp as determined in dilute  $\text{H}_2\text{SO}_4$  and  $\text{HNO}_3$  solutions at pH 2.05-5.30 is  $[\text{Li}^+][\text{UO}_2^{++}][\text{AsO}_4^{=}] = 1.52 \times 10^{-19}$ .  
(Chukhlantsev and Sharova, 1956)

LITHIUM BOROHYDRIDE  $\text{LiBH}_4$ 

BH

100 gms. ether dissolve 3 gms.  $\text{LiBH}_4$  at  $25^\circ$ .

100 gms. tetrahydrofuran dissolve 28 gms.  $\text{LiBH}_4$  at  $25^\circ$ .  
(Elliott, Roth, Roedel and Boldebuck, 1952)

LITHIUM FLUOBORATE  $\text{LiBF}_4$ 

BF

100 gms. ether dissolve 1.9 gms.  $\text{LiBF}_4$  at  $25^\circ$ .

100 gms. tetrahydrofuran dissolve 71 gms.  $\text{LiBF}_4$  at  $25^\circ$ .  
(Elliott, Roth, Roedel and Boldebuck, 1952)

## LITHIUM BORATE

BO

THE SYSTEM LITHIUM OXIDE - BORIC OXIDE - WATER  
(Dukelski, 1907; Reburn and Gale, 1955; Rollet and Bouaziz, 1955)

The results are in reasonably good agreement. A few of Dukelski's data have been shown to represent supersaturation. The transition temperature for the reaction  $\text{H}_3\text{BO}_3 + \text{Li}_2\text{B}_4\text{O}_7 \cdot 3\text{H}_2\text{O} = \text{Li}_2\text{B}_{10}\text{O}_{16} \cdot 10\text{H}_2\text{O}$  has not been firmly fixed ("between  $10^\circ$  and  $20^\circ$ ;" R. and G.), and there is some question as to the temperature at which the pentaborate ( $\text{Li}_2\text{B}_{10}\text{O}_{16} \cdot 10\text{H}_2\text{O}$ ) becomes congruently soluble. Reburn and Gale found it congruent only above  $40^\circ$ , and Dukelski found it incongruently soluble at  $30^\circ$ . However, Rollet and Bouaziz found congruent solubility in a reinvestigation of the  $30^\circ$  isotherm. All but the  $30^\circ$  data are from Reburn and Gale, 1955, except as noted.

A =  $\text{H}_3\text{BO}_3$       B =  $\text{Li}_2\text{B}_{10}\text{O}_{16} \cdot 10\text{H}_2\text{O}$       C =  $\text{Li}_2\text{B}_4\text{O}_7 \cdot 3\text{H}_2\text{O}$       D =  $\text{LiBO}_2 \cdot 2\text{H}_2\text{O}$   
E =  $\text{LiBO}_2 \cdot 8\text{H}_2\text{O}$       F =  $\text{LiOH} \cdot \text{H}_2\text{O}$       x =  $\text{Li}_2\text{B}_4\text{O}_7 \cdot x\text{H}_2\text{O}$  (Dukelski)

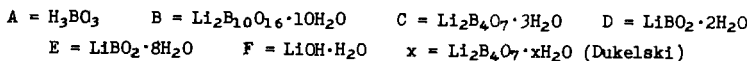
Sat. Sol. wt. %		Solid Phase	At $10^\circ$		Solid Phase
$\text{Li}_2\text{O}$	$\text{B}_2\text{O}_3$		$\text{Li}_2\text{O}$	$\text{B}_2\text{O}_3$	
0.0	2.03 <sup>a</sup>	A	0.48	1.46	E
0.78	8.24	A	0.42	1.00	E
1.00	9.79	A + C	1.88	0.46	E
0.92	8.65	C	4.91	0.41	E
0.45	2.10	C	6.69	0.50	E + F
0.53	1.89	C + E	6.74 <sup>a</sup>	0.0	F

<sup>a</sup>Values taken from other work; included for comparison.

(Cont.)

Li LITHIUM

THE SYSTEM LITHIUM OXIDE - BORIC OXIDE - WATER--Cont.



	Sat. Sol. wt. %		Solid Phase	Sat. Sol. wt. %		Solid Phase	Sat. Sol. wt. %		Solid Phase
	$Li_2O$	$B_2O_3$		$Li_2O$	$B_2O_3$		$Li_2O$	$B_2O_3$	
	At 20°			At 30°			At 40°		
BO	0.0	2.70 <sup>s</sup>	A	0.0	3.55 <sup>d</sup>	A	0.0	4.52 <sup>d</sup>	A
	1.04	11.11	A	0.60	8.67	A	1.24	15.08	A
	1.18	12.20	A + B	1.30	14.28	A + B	1.43	16.52	A + B
	1.21	12.27	B + C	1.30	14.14 <sup>d</sup>	A + B	1.57	17.04	B + C
	1.03	10.23	C	1.38	14.49	B	1.42	15.13	C
	0.50	3.00	C	1.39	14.60	B + C	0.79	7.19	C
	0.49	2.32	C	3.98	26.84	B	0.57	2.69	C
	0.61	2.06	C	5.06	30.81 <sup>d,n</sup>	B + x	1.32	3.43	C
	0.85	2.36	C + E	1.25	12.87	C	2.33	5.63	C + D
	0.74	1.77	E	0.68	5.63	C	3.74	3.52	D
	2.22	1.05	E	0.53	2.48	C	5.60	2.78	D
	4.94	1.00	E	0.53	2.47	x	7.56	2.33	D + F
	6.96	1.18	E + F	0.94	2.60	C	7.29 <sup>d</sup>	0.0	F
	6.86 <sup>a</sup>	0.0	F	0.95	2.61	x			
				1.46	3.70	C + E	At 60°		
				1.59	4.39	E	0.0	7.26 <sup>d</sup>	A
				3.41	13.74	E	1.46	20.31	A
				5.63	23.84 <sup>d,n</sup>	x + E	1.73	21.97	A + B
				1.38	3.25	E	1.93	22.41	B
				1.58	3.27 <sup>d</sup>	E	2.00	22.71	B + C
				1.73	2.80	E	1.82	20.51	C
				2.74	2.45	E	0.64	3.76	C
				2.94	2.51 <sup>d</sup>	E	0.66	3.10	C
				3.91	2.37	E	1.82	4.61	C
				5.49	2.47	D	2.64	6.47	C + D
				6.21	2.28	D	2.52	5.91	D
				6.81	2.13	D	3.83	4.34	D
				7.30	2.05 <sup>d</sup>	D + F	5.88	3.55	D
				5.92	2.66	Em	8.26	3.23	D + F
				6.71	2.87	Em	7.96 <sup>d</sup>	0.0	F
				7.45	3.00	Em + F	At 80°		
				7.71	3.38	E + F			
				7.05 <sup>d</sup>	0.0	F	0.0	10.76 <sup>d</sup>	A
							1.89	27.07	A
							2.08	28.70	A + B
							2.47	29.32	B
							2.50	29.44	B + C
							2.30	26.80	C
							0.85	6.98	C
							0.77	3.58	C
							2.30	5.81	C
							3.16	7.81	C + D
							3.15	7.41	D
							3.24	6.30	D
							7.08	4.74	D
							9.48	4.69	D + F
							8.87 <sup>d</sup>	0.0	F

<sup>a</sup>Values taken from other work; included for comparison.

<sup>b</sup>Read from the authors' curves.

<sup>m</sup>metastable.

<sup>n</sup>Shown to be supersaturated by later authors.

<sup>d</sup>Dukelski.

SOLUBILITY OF LITHIUM METABORATE ( $\text{LiBO}_2$ ) IN WATER

(1) Reburn and Gale, 1955; (2) Rosenheim and Reglin, 1921; Menzel, 1927;

(3) Rollet and Bouaziz, 1955.

t°	Gms. $\text{LiBO}_2$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{LiBO}_2$ per 100 gms. sat. sol.	Solid Phase
-0.515	0.78 (2)	Ice + $\text{LiBO}_2 \cdot 8\text{H}_2\text{O}$	38.8	9.42* (2)	$\text{LiBO}_2 \cdot 8\text{H}_2\text{O}$
0	0.88 (1)	$\text{LiBO}_2 \cdot 8\text{H}_2\text{O}$	44.8	14.7* (2)	"
	0.89 (2)	"	47.1	25.67* m.p. (2)	"
10	1.42 (1)	"	46	29.97* (2)	"
18	2.203 (2)	"	42	34.10* (2)	"
20	2.51 (1)	"	37	7.26 (1)	$\text{LiBO}_2 \cdot 2\text{H}_2\text{O}$ 80
25	3.344 (2)	"	38	7.33 (1)	"
30	4.63 (1)	"	39	7.34 (1)	"
	4.65 (2)	"	40	7.40 (1)	"
	5.0 (3)	"	50	7.48 (1)	"
34	5.97 (1)	"	60	8.43 (1)	"
35	6.41 (1)	"	70	9.48 (1)	"
36	6.84 (1)	"	80	10.58 (1)	"
36.9	7.2 (1)	" + $\text{LiBO}_2 \cdot 2\text{H}_2\text{O}$	101.2	13.4 (1)	"

\*metastable

SOLUBILITY OF LITHIUM TETRABORATE ( $\text{Li}_2\text{B}_4\text{O}_7$ ) IN WATER

(Reburn and Gale, 1955; Rollet and Bouaziz, 1955)

The trihydrate  $\text{Li}_2\text{B}_4\text{O}_7 \cdot 3\text{H}_2\text{O}$  is apparently the stable phase. It is conveniently prepared by boiling solutions containing equivalent proportions of the oxides. Rollet and Bouaziz report that a study of the system  $\text{Li}_2\text{B}_4\text{O}_7 - \text{LiCl} - \text{H}_2\text{O}$  at 30° showed the solid to be the tetrahydrate, but no supporting data are given. Gode, 1949a prepared and identified the trihydrate crystals. Rollet and Bouaziz data are given in parentheses. The earlier data of Dukelski on a "colloidal" tetraborate were obtained in supersaturated (non-equilibrium) solutions.

t°	Gms. $\text{Li}_2\text{B}_4\text{O}_7$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{Li}_2\text{B}_4\text{O}_7$ per 100 gms. sat. sol.	Solid Phase
0	2.20 (2.50)	$\text{Li}_2\text{B}_4\text{O}_7 \cdot 3\text{H}_2\text{O}$ " (?)	40	3.26 (3.68)	$\text{Li}_2\text{B}_4\text{O}_7 \cdot 3\text{H}_2\text{O}$ " (?)
10	2.55	"	60	3.76	"
20	2.81 (2.85) <sup>a</sup> (2.64) <sup>a</sup>	" " (?) "	80	4.35	"
30	3.01 (3.05) <sub>u</sub>	" " (?)	100	5.17	"

<sup>a</sup>Gode, 1949

## Li LITHIUM

### SOLUBILITY OF LITHIUM PENTABORATE ( $\text{Li}_2\text{B}_{10}\text{O}_{16}$ ) IN WATER (Reburn and Gale, 1955)

R. and G. claim that the salt is congruently soluble only above  $40^\circ$ .

t°	Gms. $\text{Li}_2\text{B}_{10}\text{O}_{16}$ per 100 gms. sat. sol.	Solid Phase
30	13.6	$\text{Li}_2\text{B}_{10}\text{O}_{16} \cdot 10\text{H}_2\text{O}$
45	19.27 <sup>a</sup>	"
50	20.88	"
60	24.34	"
70	27.98	"
80	31.79	"

<sup>a</sup>Rollet and Bouaziz, 1955.

## BO LITHIUM PERBORATE $\text{Li}_2\text{B}_2\text{O}_5 \cdot 2-1/2\text{H}_2\text{O}$

100 cc. water dissolve 10-13 gm. lithium perborate at ordinary temperature. (Bezner-Lowy, 1923)

Melting point data are given for:

$\text{LiBO}_2 + \text{LiF}$	(Kitaigorodski, Popova and Botwinkin, 1933)
$\text{LiBO}_2 + \text{Li}_2\text{SiO}_3$	(Klooster, 1910-11)
$\text{LiBO}_2 + \text{NaBO}_2$	(Klooster, 1910-11)
$\text{LiBO}_2 + \text{Li}_2\text{SO}_4$	(Kislova, Posypaiko and Bergman, 1955)
$\text{LiBO}_2 + \text{Li}_2\text{WO}_4$	(Kislova, Posypaiko and Bergman, 1955, 1955a)

Limited data for cryoscopy in fused  $\text{LiBO}_2$ :

With $\text{NaCl}$ , $\text{LiCl}$ , $\text{BaCl}_2$ , $\text{Na}_4\text{P}_2\text{O}_7$	(Zarzycki, 1952, 1953)
With $\text{NaCl}$ , $\text{LiCl}$ , $\text{BaCl}_2$ , $\text{TiO}_2$ , $\text{NiO}$	(Darmois and Zarzycki, 1951)
With many fluorides	(Zarzycki, 1953a)

## Br LITHIUM BROMIDE $\text{LiBr}$

### SOLUBILITY IN WATER

Earlier investigators failed to find the pentahydrate. Heiks and Garrett studied the system only below  $+5^\circ$ , and the bulk of their data are given only as graphs. It is not clear why the agreement on solutions saturated with dihydrate ( $5-35^\circ$ ) is so poor.

(Cont.)

## SOLUBILITY IN WATER--Cont.

(1) Huttig and Reuscher, 1924; Huttig and Steudmann, 1927; (2) Heiks and Garrett, 1954; (3) Kremers, 1958; (4) Bogórodsky, 1894; (5) Roger, 1944; (6) Scott and Durham, 1930; (7) Blidin, 1947a; (8) Simmons, Freimuth and Russell, 1936; (9) Garrett and Woodruff, 1951; also Jones, 1907.

t°	Gms. LiBr per 100 gms. sat. sol.	Ref.	Solid Phase	t°	Gms. LiBr per 100 gms. sat. sol.	Ref.	Solid Phase
-72	39.1	(1)	LiBr·5H <sub>2</sub> O	25	64.8	(3)	LiBr·2H <sub>2</sub> O
-67.5	39.3	(2)	+		63.0	(1)	"
-73	39.4	(9)	Ice		60.41	(6)	"
-53	47.9	(1)	LiBr·5H <sub>2</sub> O +		64.71	(7)	"
-49	48.9	(2)	LiBr·3H <sub>2</sub> O		61.61	(5)	"
-30	51.0	(1)	LiBr·3H <sub>2</sub> O		65.31	(8)	"
-10	55.0	(1)	"	30	65.7	(3)	"
0	58.8	(3)	"	32	65.4	(1)	LiBr·2H <sub>2</sub> O
	57.95	(6)	"	33	67.6	(1)	+
+ 4	59.2	(1)	LiBr·3H <sub>2</sub> O +	44	67.7	(4)	LiBr·H <sub>2</sub> O
5	59.0	(2)	LiBr·2H <sub>2</sub> O	40	67.2	(3)	LiBr·2H <sub>2</sub> O
10	62.4	(3)	LiBr·2H <sub>2</sub> O		67.8	(1)	LiBr·H <sub>2</sub> O
	59.5	(1)	"	50	67.9	(3)	"
20	63.9	(3)	"	60	69.1	(1)(3)	"
	61.6	(1)	"	80	71.0	(1)(3)	"
				100	72.7	(1)(3)	"
				159	--	(4)	LiBr·H <sub>2</sub> O + LiBr

SOLUBILITY OF LITHIUM BROMIDE IN AQUEOUS SOLUTIONS  
OF HYDROBROMIC ACID AT 25°  
(Scott and Durham, 1930)

Gms. per 100 gms. sat. solution		Solid Phase
HBr	LiBr	
0.0	60.41*	LiBr·2H <sub>2</sub> O
5.44	55.29	"
23.93	38.09	"
29.90	34.45	"

\*Compare with values in the preceding table.

## THE SYSTEM LITHIUM BROMIDE - MAGNESIUM BROMIDE - WATER

The data below are those of Blidin, 1947a at 25°. Heiks and Garrett, 1954 studied the system from room temperature to the eutectic, and are in general agreement. Most of their data is presented graphically.

Invariant points  
(Heiks and Garrett, 1954)

t°	Sat. Sol. wt. %		Solid Phase
	MgBr <sub>2</sub>	LiBr	
-27.0	12.0	38.5	MgBr <sub>2</sub> ·10H <sub>2</sub> O + MgBr <sub>2</sub> ·6H <sub>2</sub> O + LiBr·3H <sub>2</sub> O
-50.0	4.8	44.2	" + LiBr·5H <sub>2</sub> O + "
-78.0	11.3	29.5	" + " + Ice

(Cont.)

# Li LITHIUM

Results at 25°  
(Blidin, 1947a)

The data given below do not lie on a smooth curve, but the analyses of the wet residues indicate that the salts form solid solutions.

	Saturated Solution Wt. %		Wet Residue Wt. %		Solid Phase
	MgBr <sub>2</sub>	LiBr	MgBr <sub>2</sub>	LiBr	
	50.38	0.0	--	--	MgBr <sub>2</sub> ·6H <sub>2</sub> O
	44.0	8.12	58.30	2.6	Solid Solution
	36.52	16.69	58.7	3.8	"
	33.17	23.90	58.2	6.6	"
Br	25.30	34.40	53.1	11.9	"
	20.0	39.8	48.2	20.2	"
	15.50	44.9	43.1	23.2	"
	4.75	56.66	36.9	26.8	"
	0.0	64.71	--	--	LiBr·2H <sub>2</sub> O

## THE SYSTEM LITHIUM BROMIDE - LEAD BROMIDE - WATER (Roger, 1944)

Diagrams are presented for the 0° and 25° isotherms, but numerical data are given for 25° only. The refractive indices were determined at 25°. At 50° the solubility curves have the same form as at 0° and 25°, but the field of stability of the double salt is very small.

### Results at 0°

Gms. per 100 gms. sat. sol.		Solid Phase
PbBr <sub>2</sub>	LiBr	
0.46	0.0	PbBr <sub>2</sub>
0.037	1.4	"
*2	20	"
32.78	29.63	" + 1:1:4
*26.5	38.5	1:1:4
28.21	40.70	" + LiBr·3H <sub>2</sub> O
0.0	57.95	LiBr·3H <sub>2</sub> O

\*Estimated from graph

1:1:4 = LiBr·PbBr<sub>2</sub>·4H<sub>2</sub>O

(Cont.)

## Results at 25°

Gms. per 100 gms. sat. sol.		Density	Solid Phase	Gms. per 100 gms. sat. sol.		Density	Solid Phase
PbBr <sub>2</sub>	LiBr			PbBr <sub>2</sub>	LiBr		
0.975	0.0	1.0049	PbBr <sub>2</sub>	30.04	28.88	1.825	PbBr <sub>2</sub>
0.845	0.102	--	"	30.55	29.20	1.852	"
0.642	0.324	--	"	34.05	29.48	1.954	"
0.321	1.11	--	"	35.88	29.77	2.046	"
0.205	2.78	--	"	36.74	29.81	2.055	" + 1:1:4
0.225	4.67	--	"	35.08	31.57	2.045	1:1:4
0.302	6.63	--	"	33.88	33.39	2.066	"
0.530	10.80	--	"	33.49	34.26	2.087	"
0.805	14.45	--	"	33.21	35.75	2.134	"
1.56	18.44	--	"	34.23	37.42	2.222	"
6.30	23.02	1.271	"	36.48	37.89	2.305	" + LiBr·2H <sub>2</sub> O
18.66	27.45	1.512	"	31.23	41.18	2.213	LiBr·2H <sub>2</sub> O
23.11	28.26	1.638	"	27.72	43.28	2.146	"
23.41	28.30	1.654	"	22.08	47.40	2.092	"
25.52	28.38	1.703	"	14.85	51.83	1.972	"
27.13	28.62	1.738	"	0.0	61.61	1.7405	"

Br

## THE SYSTEM LITHIUM BROMIDE - METHANOL

(Oosaka and Sawaya, 1950; Pavlopouloa and Strehlow, 1954(\*))

The 1:4 alcoholate melts congruently at 31.1°. Results are in gms. LiBr per 100 gms. sat. sol.

t°	Solid Phase LiBr	Solid Phase LiBr·4CH <sub>3</sub> OH	
0	58.0	30.3	52.3
5	58.0	31.2	51.2
10	58.0	32.0	49.8
15	58.1(18°-53.9, d.=1.410)*	33.0	48.2
20	58.2	34.2	46.6
25	58.2(58.3, d.=1.486)*	35.9	44.8
30	58.2	38.8	42.8
31.1	--	40.40	40.40
35	58.3	--	--
40	58.3	--	--

SOLUBILITY OF LITHIUM BROMIDE IN AQUEOUS SOLUTIONS OF ETHYL ALCOHOL AT 25°  
(Simmons, Freimuth and Russell, 1936)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
C <sub>2</sub> H <sub>5</sub> OH	LiBr		C <sub>2</sub> H <sub>5</sub> OH	LiBr	
0.0	65.31	LiBr·2H <sub>2</sub> O	43.28	47.63	LiBr·H <sub>2</sub> O
4.88	62.08	"	47.57	46.70	"
10.23	59.06	"	46.53	46.63	" + LiBr
14.44	56.68	"	47.86	46.51	LiBr
20.09	55.24	"	51.66	44.13	"
26.59	52.98	"	55.24	42.45	"
33.05	52.07	" + LiBr·H <sub>2</sub> O	58.78	41.22	"
35.43	50.79	LiBr·H <sub>2</sub> O			



# Li LITHIUM

## SOLUBILITY OF LITHIUM BROMIDE IN ABSOLUTE ETHYL ALCOHOL (Bonnell and Jones, 1926)

The results in parentheses were obtained by thermal analysis. The eutectic point for LiBr + LiBr·4C<sub>2</sub>H<sub>5</sub>OH is at 13.2°. The congruent m. pt. of LiBr·4C<sub>2</sub>H<sub>5</sub>OH is 23.8°.

Between 13.2° and 23.8° lithium bromide alcoholate is formed and different values are obtained depending upon the solid phase present.

t°	Gms. LiBr per 100 gms. C <sub>2</sub> H <sub>5</sub> OH	Solid Phase	t°	Gms. LiBr per 100 gms. C <sub>2</sub> H <sub>5</sub> OH when the Solid Phase is	
				LiBr	LiBr·4C <sub>2</sub> H <sub>5</sub> OH
0	32.61	LiBr			
10	36.02	"			
25	72.10	"	13.2	70.0	70.0
30	72.51	"	15	70.2	38.1 (68.7)
40	73.03	"	16	70.4	39.0 (67.5)
50	77.52	"	20	70.8	42.0 (60.6)
60	82.84	"	23	71.2	46.0 (53.0)
70	89.13	"	23.8	71.3	47.2
75	91.12	"			
80	99.10	"			

## THE SYSTEM LITHIUM BROMIDE - n-PROPANOL (Oosaka and Sawaya, 1950)

The 1:4 alcoholate melts congruently at 36.5°. Results are in wt. % LiBr in the saturated solutions.

t°	Solid Phase LiBr	Solid Phase LiBr·4n-C <sub>3</sub> H <sub>7</sub> OH	
		LiBr	LiBr·4n-C <sub>3</sub> H <sub>7</sub> OH
0	--	17.2	--
5	--	18.0	--
6	41.4	--	41.4
10	41.4	18.8	40.5
15	41.4	19.5	39.1
20	41.4	20.2	37.6
25	41.4	21.1	35.8
30	41.4	22.5	33.2
35	41.4	24.4	29.6
36.5	--	26.56	26.56
40	41.4	--	--

## SOLUBILITY OF LITHIUM BROMIDE IN ABSOLUTE ACETONE (Bell, Rowlands, Bamford, Thomas and Jones, 1930)

t°	Gms. LiBr per 100 gms. (CH <sub>3</sub> ) <sub>2</sub> CO	Solid Phase	t°	Gms. LiBr per 100 gms. (CH <sub>3</sub> ) <sub>2</sub> CO	Solid Phase
10	13.4	LiBr·2(CH <sub>3</sub> ) <sub>2</sub> CO	35.5	22.6	LiBr·2(CH <sub>3</sub> ) <sub>2</sub> CO + LiBr
18	(11.24)*	"	37	23.7	LiBr
20	21.3	"		(19.8)*	"
25	(17.67)†	"	40	26.3	"
30	21.3	"	50	34.6	"
32	22.1	"	60	39.7	"
35	22.4	"			

\*Determinations made by means of specific conductivity measurements by Lannung, 1932.

†Mylius and Funk, 1897.

## SOLUBILITY OF LITHIUM BROMIDE IN VARIOUS OTHER SOLVENTS

Br

Solvent	t°	Solubility	Author
Ethylenediamine	25	2.41 Gms. LiBr/100 gms. solvent	(Isbin and Kobe, 1945)
Monoethanolamine	25	ca. 60	" (Isbin and Kobe, 1945)
Ethylene glycol	14.7	60.0 (?)	" (deConnick, 1905)
	25	39.4	" (Isbin and Kobe, 1945)
Benzaldehyde	25	13.03	" (Müller, Raschka and Wittemann, 1927)
Liquid SO <sub>2</sub>	25	0.067	"

Melting point data are given for:

LiBr + LiCl	(Botschmar, 1933)
LiBr + LiF	( " " )
LiBr + LiOH	(Scarpa, 1915)
LiBr + AgBr	(Sandonnini and Scarpa, 1913)
LiBr + KBr	(Kellner, 1917)
LiBr + RbBr <sub>2</sub>	(Kellner, 1917; Ferrari and Calla, 1931)
LiBr + NaBr	(Kellner, 1917)
LiBr + SrBr <sub>2</sub>	(Kellner, 1917)
LiBr + PbBr <sub>2</sub>	(Gromakov, 1950)
LiBr + NaF = LiF + NaBr	(Volkov and Zakhvalinskii, 1953a)

The reactions of LiBr with other alkali iodides, fluorides and chlorides below the melting points were studied by Link and Wood, 1940.

LITHIUM BROMATE LiBrO<sub>3</sub>

BrO

SOLUBILITY OF LITHIUM BROMATE IN WATER  
(Simmons and Waldeck, 1931; Averko-Antonovich, 1948)

t°	Gms. LiBrO <sub>3</sub> per 100 gms. Sat. Sol.	Solid Phase	t°	Gms. LiBrO <sub>3</sub> per 100 gms. Sat. Sol.	Solid Phase
- 1.05	10.3	Ice	35	67.5 (S.W.)	LiBrO <sub>3</sub> ·H <sub>2</sub> O
- 4.8	20.3	"	35.0	67.78	"
- 9.8	30.6	"	45.0	70.4	"
-20.0	40.0	"	50.0	71.8	"
-40.0	52.0	"	50	71.5 (S.W.)	"
-47	54.5	Ice+LiBrO <sub>3</sub> ·H <sub>2</sub> O	52	†72.4	LiBrO <sub>3</sub> ·H <sub>2</sub> O + LiBrO <sub>3</sub>
-45.0	54.9	LiBrO <sub>3</sub> ·H <sub>2</sub> O	* 4	66.8	LiBrO <sub>3</sub>
-40.0	55.4	"	*17.5	68.2	"
-36.7	56.2	"	*45	71.8	"
-31.5	56.8	"	53	72.4 (S.W.)	"
-26.5	57.3	"	55.0	72.72	"
-21.0	58.2	"	56	72.6 (S.W.)	"
-16.5	58.5	"	65.0	73.86	"
-10.8	59.4	"	70.5	74.3 (S.W.)	"
- 6.3	60.2	"	80.0	75.84	"
0	61.23	"	85	76.2 (S.W.)	"
5	61.6 (S.W.)	"	100	78.0 (S.W.)	"
115	63.3 (S.W.)	"	100.5	78.6	"
20.1	64.51	"	111	79.6	"
24.9	65.54	"	121	81.2	"
25	65.4 (S.W.)	"	143	84.6	"

\* = Metastable

† = Estimated from author's data.

# Li LITHIUM

## CH LITHIUM METHIONATE $\text{Li}_2[\text{CH}_2(\text{SO}_3)_2]$

100 gms.  $\text{H}_2\text{O}$  sat. with Lithium Methionate contain 72.8 gms.  $\text{Li}_2[\text{CH}_2(\text{SO}_3)_2]$  at 25°. (Baker and Terptr, 1929; Baker, 1930; Valeri and Baumrucker, 1949)

## LITHIUM FORMATE $\text{LiHCOO}$

### THE SYSTEM LITHIUM FORMATE - WATER (Groschuff, 1903)

t°	Gms. $\text{HCOOLi}$ per 100 gms. Solution	Mols. $\text{HCOOLi}$ per 100 mols. $\text{H}_2\text{O}$	Solid Phase
- 4.27	5.80	--	Ice
- 9.02	10.98	--	"
-16.42	17.84	--	"
-20	21.14	9.28	$\text{HCOOLi} \cdot \text{H}_2\text{O}$
0	24.42	11.18	"
18*	27.85	13.36	"
49.5	35.60	19.14	"
74	44.91	28.22	"
91	54.16	40.90	"
98	57.05	45.99	$\text{HCOOLi}$
104	57.64	47.11	"
120	59.63	51.13	"

\*Sp. gr. sat. sol. at 18° = 1.142.

### FREEZING-POINTS OF MIXTURES OF LITHIUM FORMATE AND FORMIC ACID (Kendall and Adler, 1921)

The previous results on this system by Groschuff, 1903 are considered to be largely in error.

t°	Gm. Mols. $\text{LiHCOO}$ per 100 gm. mols. mixture	Solid Phase	t°	Gm. Mols. $\text{LiHCOO}$ per 100 gm. mols. mixture	Solid Phase	t°	Gm. Mols. $\text{LiHCOO}$ per 100 gm. mols. mixture	Solid Phase
8.4	0.0	$\text{HCOOH}$	-14.6	18.19	$\text{HCOOH}$	90.5	25.91	$\text{LiHCOO}$
7.0	1.58	"	-17.1	19.56	"	97.9	26.38	"
5.2	3.47	"	-19.8	21.05	"	113.1	27.71	"
3.2	5.23	"	-21.7	22.24	"	131.2	29.87	"
1.1	7.09	"	-23.5	23.49	"	145.1	31.98	"
-1.3	8.93	"	-25.0	24.33	"	150.4	33.04	"
-3.5	10.75	"	+18.0	23.49	$\text{LiHCOO}$	159.1	35.01	"
-5.6	12.23	"	34.0	23.98	"	163.5	36.13	"
-8.2	13.99	"	80.0	25.31	"			

LITHIUM ACETATE  $\text{CH}_3\text{COOLi}$ SOLUBILITY OF LITHIUM ACETATE IN WATER  
(Sidgwick and Gentile, 1922)

$t^\circ$	Gms. $\text{CH}_3\text{COOLi}$ per 100 gms. sat. sol.	Solid Phase	$t^\circ$	Gms. $\text{CH}_3\text{COOLi}$ per 100 gms. sat. sol.	Solid Phase
- 1.54	2.63	Ice	53.3	52.23	$\text{CH}_3\text{COOLi} \cdot 2\text{H}_2\text{O}$
- 2.98	4.83	"	55.4	56.60	"
- 6.62	9.53	"	57.3	61.92	"
-16.12	18.33	"	57.8*	64.25	"
$\pm 0$	23.76	$\text{CH}_3\text{COOLi} \cdot 2\text{H}_2\text{O}$	57.0	64.88	$\text{CH}_3\text{COOLi}$
+25.8	31.28	"	102.8	66.73	"
36.7	38.25	"	157.5	71.33	"
50.5	49.55	"	286*	--	"

\*(m. pt.)

FREEZING-POINTS OF MIXTURES OF LITHIUM ACETATE AND ACETIC ACID  
(Davidson and McAllister, 1930)

Previous determinations upon this system are given by Vasilev, 1909.

$t^\circ$	Gm. Mols. $\text{LiC}_2\text{H}_3\text{O}_2$ per 100 gm. mols. mixture	Solid Phase	$t^\circ$	Gm. Mols. $\text{LiC}_2\text{H}_3\text{O}_2$ per 100 gm. mols. mixture	Solid Phase
16.50	0.0	$\text{HC}_2\text{H}_3\text{O}_2$	110.0	41.84*	1-1
14.85	3.56	"	112.0	45.74*	"
14.16	5.01	"	112.5	48.76*	"
13.15	6.86	"	112.5	50.06*	"
12.10	8.45	"	136.0	43.95	$\text{LiC}_2\text{H}_3\text{O}_2$
16.7	8.61	1-1	147.5	46.04	"
22.1	9.15	"	156.0	47.57	"
25.0	9.53	"	161.0	48.22	"
51.0	12.28	"	178.5	52.41	"
70.0	16.24	"	188.0	55.89	"
83.0	20.25	"	192.0	56.90	"
98.0	27.64	"	221.0	70.87	"
106.5	35.34	"	272	100.00	"
109.0	39.83	"			

\*Metastable; 1-1 =  $\text{LiC}_2\text{H}_3\text{O}_2 \cdot \text{HC}_2\text{H}_3\text{O}_2$ 

100 gms. methyl alcohol ( $\text{CH}_3\text{OH}$ ) sat. with dehydrated lithium acetate dissolve 30.37 gms.  $\text{LiC}_2\text{H}_3\text{O}_2$  at  $15^\circ$  and 32.47 gms. at  $67.2^\circ$  (b.pt.).  
(Henstock, 1934)

Melting points in the system  $\text{LiC}_2\text{H}_3\text{O}_2 + \text{KC}_2\text{H}_3\text{O}_2 + \text{NaC}_2\text{H}_3\text{O}_2$  are given by Diogenov, 1956. Data for the system  $\text{LiC}_2\text{H}_3\text{O}_2 + \text{NaNO}_3 \rightleftharpoons \text{LiNO}_3 + \text{NaC}_2\text{H}_3\text{O}_2$  are given by Diogenov, 1956a.

# Li LITHIUM

## LITHIUM PHENYL ACETATE $\text{LiC}_7\text{H}_7\text{CO}_2$

Fusion-point data for mixtures of Lithium phenyl acetate ( $\text{LiC}_7\text{H}_7\text{CO}_2$ ) and Phenyl acetic acid ( $\text{HC}_7\text{H}_7\text{CO}_2$ ) and for Lithium phenyl acetate and Phenyl acetic anhydride,  $(\text{C}_7\text{H}_7\text{CO}_2)_2\text{O}$ , are given by Bakunin and Vitale, 1935.

## CH LITHIUM CITRATE $\text{C}_3\text{H}_4(\text{OH})(\text{COOLi})_3 \cdot 4\text{H}_2\text{O}$

### SOLUBILITY IN WATER

100 gms.  $\text{H}_2\text{O}$  dissolve 61.2 gms. Li citrate at  $15^\circ$ .  $d_{15}$  sat. sol. = 1.187. (Greenish and Smith, 1902)

### SOLUBILITY IN AQUEOUS ALCOHOL AT $25^\circ$ (Seidell, 1910)

Wt. % $\text{C}_2\text{H}_5\text{OH}$ in Solvent	$d_{25}$ of sat. sol.	Gms. $\text{C}_3\text{H}_4\text{OH}(\text{COOLi})_3 \cdot 4\text{H}_2\text{O}$ per 100 Gms. Solvent
0	1.216	74.50
10	1.150	49.30
20	1.083	32.10
30	1.025	18.80
40	0.976	9.65
50	0.933	4.93
60	0.897	2.25
70	0.867	0.60
80	0.838	0.30
100	0.788	0.02

## LITHIUM TARTRATE $\text{Li}_2\text{C}_4\text{H}_4\text{O}_6$

### SOLUBILITY OF LITHIUM d-TARTRATE IN WATER (Campbell and Slotin, 1933)

$t^\circ$	Gms. $\text{Li}_2\text{C}_4\text{O}_4\text{O}_6$ per 100 gms. $\text{H}_2\text{O}$	Solid Phase	$t^\circ$	Gms. $\text{Li}_2\text{C}_4\text{O}_4\text{O}_6$ per 100 gms. $\text{H}_2\text{O}$	Solid Phase
0	42.106	$\text{Li}_2\text{C}_4\text{H}_4\text{O}_6 \cdot 2\text{H}_2\text{O}$	25	26.711	$\text{Li}_2\text{C}_4\text{H}_4\text{O}_6$
8.0	33.451	"	30	26.663	"
10.55	31.495	"	45	27.510	"
20.0	27.052	"	60	29.522	"
21.67tr.pt.	--	" + $\text{Li}_2\text{C}_4\text{H}_4\text{O}_6$			

## LITHIUM TARTRATE DERIVATIVES

CH

## SOLUBILITY IN WATER

Salt	Formula	t°	Gms. Salt per 100 Gms. sat. sol.	Author
Lithium Dihydroxytartrate	$\text{Li}_2\text{C}_4\text{H}_4\text{O}_6 \cdot 2\frac{1}{2}\text{H}_2\text{O}$	0	0.079	(1)
Lithium Sodium Racemic Tartrate	$\text{LiNaC}_4\text{H}_4\text{O}_6 \cdot 2\text{H}_2\text{O}$	20	19.97	(2)
" " Dextro "	" "	20	22.55	(2)
" Potassium Racemic "	$\text{LiKC}_4\text{H}_4\text{O}_6 \cdot \text{H}_2\text{O}$	20	35.19	(2)
" " Dextro "	" "	20	37.82	(2)

(1) Fenton, 1898;

(2) Schlossberg, 1900.

EQUILIBRIUM IN THE SYSTEM LITHIUM d-TARTRATE, AMMONIUM  
d-TARTRATE AND WATER  
(Campbell and Slotin, 1933)

Gms. per 100 gms. $\text{H}_2\text{O}$		
$(\text{NH}_4)_2\text{C}_4\text{H}_4\text{O}_6$	$\text{Li}_2\text{C}_4\text{H}_4\text{O}_6$	Solid Phase
Results at 0°		
0.0	42.106	$\text{Li}_2\text{C}_4\text{H}_4\text{O}_6 \cdot 2\text{H}_2\text{O}$
2.516	36.857	"
3.473	32.561	"
6.013	30.160	" + DS
8.022	22.125	DS
14.491	14.092	"
23.081	8.846	"
36.610	7.011	"
45.930	6.026	" + $(\text{NH}_4)_2\text{C}_4\text{H}_4\text{O}_6$
45.125	3.952	$(\text{NH}_4)_2\text{C}_4\text{H}_4\text{O}_6$
44.251	1.973	"
43.916	0.0	"
Results at 30°		
0.0	26.661	$\text{Li}_2\text{C}_4\text{H}_4\text{O}_6$
3.076	27.143	"
7.703	29.181	"
9.350	30.661	"
11.980	32.731	" + DS
14.672	26.071	DS
16.744	22.603	"
24.662	14.732	"
29.651	11.603	"
39.671	8.182	"
63.600	6.916	"
66.205	6.771	" + $(\text{NH}_4)_2\text{C}_4\text{H}_4\text{O}_6$
66.310	3.326	$(\text{NH}_4)_2\text{C}_4\text{H}_4\text{O}_6$
63.813	0.0	"

DS =  $\text{Li}_2\text{C}_4\text{H}_4\text{O}_6 \cdot (\text{NH}_4)_2\text{C}_4\text{H}_4\text{O}_6$

# Li LITHIUM

## EQUILIBRIUM IN THE SYSTEM LITHIUM d-TARTRATE, AMMONIUM d-TARTRATE AND WATER--Cont.

Gms. per 100 gms. H <sub>2</sub> O			Solid Phase
(NH <sub>4</sub> ) <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>6</sub>	Li <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>6</sub>		
Results at 60°			
0.0	29.552	Li <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>6</sub>	
5.807	30.051	"	
11.003	31.452	"	
16.349	34.242	"	
23.121	37.981	" + DS	
24.431	27.609	DS	
41.083	16.151	"	
63.011	13.103	"	
98.392	10.244	" + (NH <sub>4</sub> ) <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>6</sub>	
92.832	6.650	(NH <sub>4</sub> ) <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>6</sub>	
90.247	3.631	"	
87.171	0.0	"	

CH

DS = Li<sub>2</sub>C<sub>4</sub>H<sub>4</sub>O<sub>6</sub> · (NH<sub>4</sub>)<sub>2</sub>C<sub>4</sub>H<sub>4</sub>O<sub>6</sub>

DS = Li<sub>2</sub>C<sub>4</sub>H<sub>4</sub>O<sub>6</sub> · (NH<sub>4</sub>)<sub>2</sub>C<sub>4</sub>H<sub>4</sub>O<sub>6</sub>

## THE SYSTEM LITHIUM AMMONIUM d-TARTRATE, LITHIUM AMMONIUM l-TARTRATE AND WATER (Campbell and Slotin, 1933)

The saturated solutions and the solid phases were analyzed polarimetrically using as a scale the rotations of solutions of pure Lithium Ammonium d Tartrate of different concentrations, determined for the sodium D line at 30°. The isotherm at 0° was determined and the invariant points only at 30° and 60°.

Gms. per 100 gms. H <sub>2</sub> O			Solid Phase
t°	d-LiNH <sub>4</sub> C <sub>4</sub> H <sub>4</sub> O <sub>6</sub>	r-LiNH <sub>4</sub> C <sub>4</sub> H <sub>4</sub> O <sub>6</sub>	
0	0.0	2.806	Racemate form (= Li <sub>2</sub> (NH <sub>4</sub> ) <sub>2</sub> (C <sub>4</sub> H <sub>4</sub> O <sub>6</sub> ) <sub>2</sub> ·H <sub>2</sub> O)
"	6.531	2.363	"
"	12.241	1.860	"
"	17.690	1.64	"
"	23.251	1.462	" + <u>d</u> form
"	24.810	0.98	<u>d</u> form
"	28.519	0	"
30	0.0	6.542	Racemate form
"	32.917	--	" + <u>d</u> form
"	37.910	0.0	<u>d</u> form
60	0.0	11.480	Racemate form
"	44.103	--	" + <u>d</u> form
"	52.743	0.0	<u>d</u> form

LITHIUM BENZOATE  $C_6H_5COOLi$ 

CH

SOLUBILITY OF LITHIUM BENZOATE IN WATER  
(Sidgwick and Ewbank, 1922)

t°	Gms. $C_6H_5COOLi$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $C_6H_5COOLi$ per 100 gms. sat. sol.	Solid Phase
- 1.69	7.22	Ice	34.5	33.20	$C_6H_5COOLi \cdot H_2O$
- 3.94	13.69	"	84.5	34.61	$C_6H_5COOLi$
- 6.49	19.85	"	111.0	36.51	"
0	27.97	$C_6H_5COOLi \cdot H_2O$	162.4	45.14	"
+13.5	29.80	"	176.0	49.12	"
28.5	32.12	"			

100 gms. Methyl Alcohol ( $CH_3OH$ ) saturated with dehydrated lithium benzoate contain 20.52 gms.  $LiC_6H_5COO$  at 15° and 19.71 gms. at 67° (b.pt.).  
(Henstock, 1934)

SOLUBILITY IN AQUEOUS ETHANOL SOLUTIONS AT 25°  
(Seidell, 1910)

Percent C <sub>2</sub> H <sub>5</sub> OH in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. C <sub>6</sub> H <sub>5</sub> COOLi per 100 Gms. Sat. Sol.	Percent C <sub>2</sub> H <sub>5</sub> OH in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. C <sub>6</sub> H <sub>5</sub> COOLi per 100 Gms. Sat. Sol.
0	1.103	27.64	60	0.970	19.80
10	1.088	28.60	70	0.932	15.40
20	1.072	28.50	80	0.890	10.70
30	1.052	27.80	90	0.847	6.40
40	1.030	26.20	95	0.823	4.50
50	1.003	23.60	100	0.799	2.60

LITHIUM o-HYDROXYBENZOATE  $C_6H_4(OH)COOLi$   
(SALICYLATE)

CH

SOLUBILITY OF LITHIUM ORTHO HYDROXYBENZOATE IN WATER  
(Sidgwick and Ewbank, 1922)

t°	Gms. $oC_6H_4 \cdot OH \cdot COOLi$ per 100 gms. sat. sol.	Solid Phase
- 2.26	10.17	Ice
- 5.56	20.62	"
-12.82	35.83	"
- 8.5	45.20	$oC_6H_4 \cdot OH \cdot COOLi \cdot 6H_2O$
- 1.0	49.04	"
+ 9.0	52.45	$oC_6H_4 \cdot OH \cdot COOLi \cdot H_2O$
3.5	52.96	$oC_6H_4 \cdot OH \cdot COOLi \cdot 6H_2O$ (unstable)
10.0	59.96	$oC_6H_4 \cdot OH \cdot COOLi \cdot H_2O$
28.5	56.50	"
32.0	57.50	"
38.5	59.67	"
52.0	64.18	" (unstable)
60.0	66.56	"
73.0	66.56	$oC_6H_4 \cdot OH \cdot COOLi$
113.0	71.46	"
138.0	75.77	"



## Li LITHIUM

### SOLUBILITY OF LITHIUM SALICYLATE IN AQUEOUS ETHANOL SOLUTIONS AT 25° (Seidell, 1909, 1910)

Gms. C <sub>2</sub> H <sub>5</sub> OH per 100 Gms. Solvent	d <sub>25</sub> of Sat. Sol.	Gms. C <sub>6</sub> H <sub>4</sub> OHCOOH· $\frac{1}{2}$ H <sub>2</sub> O per 100 Gms. Sat. Sol.	Gms. C <sub>2</sub> H <sub>5</sub> OH per 100 Gms. Solvent	d <sub>25</sub> of Sat. Sol.	Gms. C <sub>6</sub> H <sub>4</sub> OHCOOH· $\frac{1}{2}$ H <sub>2</sub> O per 100 Gms. Sat. Sol.
0	1.209	56.0	60	1.104	51.1
10	1.195	55.9	70	1.083	49.5
20	1.180	55.4	80	1.056	47.5
30	1.163	54.7	90	1.026	45.8
40	1.144	53.7	92.3	1.020	45.6
50	1.124	52.5	100	1.027	48.2

100 gms. propyl alcohol dissolve 18.7 gms. Li salicylate (temp.?).  
(Schlamp, 1895)

## CH LITHIUM m, p HYDROXY BENZOATES

### SOLUBILITY OF LITHIUM META AND PARA HYDROXYBENZOATES IN WATER (Sidgwick and Ewbank, 1922)

Results for Meta Hydroxybenzoate			Results for Para Hydroxybenzoate		
t°	Gms. mC <sub>6</sub> H <sub>4</sub> ·OH·COOLi per 100 gms. sat. sol.	Solid Phase	t°	Gms. pC <sub>6</sub> H <sub>4</sub> ·OH·COOLi per 100 gms. sat. sol.	Solid Phase
- 4.41	16.02	Ice	- 0.98	5.04	Ice
-10.78	29.58	"	- 2.37	9.81	"
-17.67	39.97	"	- 5.23	17.88	"
+10.0	52.53	mC <sub>6</sub> H <sub>5</sub> ·OH·COOLi	- 9.28	25.96	"
74.5	55.04	"	-12.62	31.54	" (unstable)
104.0	58.47	"	-12.5	30.84	pC <sub>6</sub> H <sub>5</sub> ·OH·COOLi
122.0	61.86	"	0	30.92	"
			85.0	31.96	"
			113.0	35.00	"

### LITHIUM HIPPURATE C<sub>6</sub>H<sub>5</sub>CO·NHCH<sub>2</sub>COOLi

100 gms. H<sub>2</sub>O dissolve about 40 gms. of the salt at 15-20°.  
(Squire and Caines, 1905)

LITHIUM PHTHALATE  $\text{Li}_2\text{C}_8\text{H}_4\text{O}_4$ 

CH

EQUILIBRIUM IN THE SYSTEM LITHIUM PHTHALATE, PHTHALIC ACID AND WATER  
(Smith, Sturm and Ely, 1935)

Gms. per 100 gms. sat. sol.

$\text{H}_2\text{C}_8\text{H}_4\text{O}_4$	$\text{Li}_2\text{C}_8\text{H}_4\text{O}_4$	Solid Phase
Results at 0°		
0.0	45.37	$2\text{Li}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 3\text{H}_2\text{O}$
1.27	45.41	"
2.81	45.75	" + $\text{LiHC}_8\text{H}_4\text{O}_4 \cdot 2\text{H}_2\text{O}$
2.84	40.55	$\text{LiHC}_8\text{H}_4\text{O}_4 \cdot 2\text{H}_2\text{O}$
3.46	36.25	"
4.15	32.40	"
7.15	26.09	"
9.61	22.45	" + $\text{H}_2\text{C}_8\text{H}_4\text{O}_4$
8.67	20.39	$\text{H}_2\text{C}_8\text{H}_4\text{O}_4$
7.45	16.55	"
5.58	11.06	"
3.92	5.83	"
1.97	2.28	"
0.30	0.0	"
Results at 25°		
0.0	45.20	$2\text{Li}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 3\text{H}_2\text{O}$
2.38	45.17	"
3.60	45.15	"
5.20	45.19	" + $\text{LiHC}_8\text{H}_4\text{O}_4 \cdot 2\text{H}_2\text{O}$
6.51	38.13	$\text{LiHC}_8\text{H}_4\text{O}_4 \cdot 2\text{H}_2\text{O}$
7.79	34.07	"
9.08	32.36	"
11.39	28.23	"
14.01	25.56	"
16.34	24.25	" + $\text{H}_2\text{C}_8\text{H}_4\text{O}_4$
13.32	19.39	$\text{H}_2\text{C}_8\text{H}_4\text{O}_4$
10.56	14.56	"
6.97	8.87	"
3.34	3.22	"
0.68	0.0	"
Results at 50°		
0.0	46.08	$2\text{Li}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 3\text{H}_2\text{O}$
3.72	46.01	"
6.40	46.00	"
9.97	46.01	" + $\text{LiHC}_8\text{H}_4\text{O}_4 \cdot 2\text{H}_2\text{O}$
12.42	39.32	$\text{LiHC}_8\text{H}_4\text{O}_4 \cdot 2\text{H}_2\text{O}$
15.07	34.77	"
18.92	30.05	"
21.78	28.29	"
24.00	26.69	" + $\text{H}_2\text{C}_8\text{H}_4\text{O}_4$
20.21	21.36	$\text{H}_2\text{C}_8\text{H}_4\text{O}_4$
15.29	15.28	"
11.48	10.80	"
6.81	5.30	"
4.75	3.28	"
1.75	0.0	"

# Li LITHIUM

## EQUILIBRIUM IN THE SYSTEM LITHIUM PHTHALATE, MAGNESIUM PHTHALATE AND WATER (Smith and Ely, 1938)

Gms. per 100 gms. sat. sol.		Solid Phase
MgC <sub>8</sub> H <sub>4</sub> O <sub>4</sub>	Li <sub>2</sub> C <sub>8</sub> H <sub>4</sub> O <sub>4</sub>	
Results at 25°		
0.0	45.24	2Li <sub>2</sub> C <sub>8</sub> H <sub>4</sub> O <sub>4</sub> ·3H <sub>2</sub> O
7.52	41.12	"
12.98	36.72	"
16.39	34.50	"
19.27	33.05	"
19.97	32.50	" + 2MgC <sub>8</sub> H <sub>4</sub> O <sub>4</sub> ·11H <sub>2</sub> O
20.43	29.53	2MgC <sub>8</sub> H <sub>4</sub> O <sub>4</sub> ·11H <sub>2</sub> O
20.96	26.88	"
22.40	21.78	"
23.06	19.63	"
25.31	14.86	"
31.09	4.55	"
34.14	0.0	"

Results at 50°		
0.0	46.01	2LiC <sub>8</sub> H <sub>4</sub> O <sub>4</sub> ·3H <sub>2</sub> O
6.97	41.76	"
18.32	35.22	"
26.06	31.05	"
34.75	17.49	2MgC <sub>8</sub> H <sub>4</sub> O <sub>4</sub> ·11H <sub>2</sub> O
36.10	11.74	"
40.31	3.18	"
42.28	0.0	"

## CH LITHIUM Racemic and Laevo MANDELATES LiC<sub>8</sub>H<sub>7</sub>O<sub>3</sub>

### EQUILIBRIUM IN THE SYSTEM LITHIUM (r) RACEMIC MANDELATE, RACEMIC MANDELIC ACID AND WATER AT 25° (Ross and Morrison, 1933)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
HC <sub>8</sub> H <sub>7</sub> O <sub>3</sub>	LiC <sub>8</sub> H <sub>7</sub> O <sub>3</sub>		HC <sub>8</sub> H <sub>7</sub> O <sub>3</sub>	LiC <sub>8</sub> H <sub>7</sub> O <sub>3</sub>	
0.0	4.9	LiC <sub>8</sub> H <sub>7</sub> O <sub>3</sub>	13.7	3.3	1·1
0.9	4.7	"	14.6	3.2	"
4.0	4.7	"	15.3	3.2	"
4.7	5.0	" + 1·1	16.2	3.1	"
6.6	4.2	1·1	18.2	3.1	"
8.3	3.9	"	19.0	3.0	"
9.9	3.6	"	20.1	3.0	" + HC <sub>8</sub> H <sub>7</sub> O <sub>3</sub>
11.1	3.6	"	18.8	1.6	HC <sub>8</sub> H <sub>7</sub> O <sub>3</sub>
13.0	3.3	"	16.9	0.0	"

1·1 = LiC<sub>8</sub>H<sub>7</sub>O<sub>3</sub>·HC<sub>8</sub>H<sub>7</sub>O<sub>3</sub>

EQUILIBRIUM IN THE SYSTEM LITHIUM (-) LEVO MANDELATE, LEVO  
MANDELIC ACID AND WATER AT 25°  
(Ross, Morrison and Johnstone, 1937)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
(-) $\text{HC}_8\text{H}_7\text{O}_3$	(-) $\text{LiC}_8\text{H}_7\text{O}_3$		(-) $\text{HC}_8\text{H}_7\text{O}_3$	(-) $\text{LiC}_8\text{H}_7\text{O}_3$	
0.0	8.6	(-) $\text{LiC}_8\text{H}_7\text{O}_3$	10.6	3.5	1:1
1.0	8.5	"	11.9	3.4	"
1.3	8.6	"	10.3	3.4	(-) $\text{HC}_8\text{H}_7\text{O}_3$
2.6	5.6	1:1	10.2	2.6	"
5.6	4.0	"	10.0	1.7	"
6.9	4.0	"	9.9	0.8	"
9.2	3.7	"	10.1	0.0	"

1:1 = (-) $\text{LiC}_8\text{H}_7\text{O}_3 \cdot \text{HC}_8\text{H}_7\text{O}_3$

LITHIUM  $\alpha$ -CAMPHORATE  $\text{C}_{10}\text{H}_{14}\text{O}_4\text{Li}_2$

CH

SOLUBILITY IN AQUEOUS SOLUTIONS OF CAMPHORIC ACID AT 13.5°-16°  
AND VICE VERSA  
(Jungfleisch and Landrieu, 1914)

The mixtures were kept in a cellar at nearly constant temperature and shaken from time to time until equilibrium was reached. Additional results at 17°-23° are also given.

Gms. per 100 Gms. Sat. Sol.

$\text{C}_6\text{H}_{14}(\text{COOH})_2$ $\text{C}_{10}\text{H}_{14}\text{O}_4\text{Li}_2$		Solid Phase	
0.621	0	Camphoric Acid	$\text{C}_6\text{H}_{14}(\text{COOH})_2$
2.02	3.77	" "	" "
3.25	10.63	Monolithium Tetracamphorate	$\text{C}_{10}\text{H}_{15}\text{O}_4\text{Li} \cdot 3\text{C}_{10}\text{H}_{16}\text{O}_4$
3.51	12.61	" "	" "
3.99	20.56	" Dicumphorate	$\text{C}_{10}\text{H}_{15}\text{O}_4 \cdot \text{Li} \cdot \text{C}_{10}\text{H}_{15}\text{O}_4$
3.43	24.69	" "	" "
2.87	37.16	" Camphorate	$\text{C}_{10}\text{H}_{15}\text{O}_4\text{Li}$
0	40.80	Dilithium Camphorate	$\text{C}_{10}\text{H}_{14}\text{O}_4\text{Li}_2$

LITHIUM DIPICRYLAMIDE  $\text{Li}(\text{NO}_2)_3\text{C}_6\text{H}_2\text{NHC}_6\text{H}_2(\text{NO}_2)_3$

SOLUBILITY IN WATER  
(Treadwell and Hepenstrick, 1949)

t°	Moles Salt per Liter
20	0.169
25	0.181

LITHIUM nitrile  $\alpha$ ,  $\alpha$ -diphenyl  $\alpha'$  ethyl SUCCINATE  $(\text{C}_6\text{H}_5)_2\text{C}(\text{CN})\text{CH}(\text{C}_2\text{H}_5)\text{COOLi}$

5 gms. dissolve in 100 cc. of water at 5°. (Salmon-Legagneur, 1956)

# Li LITHIUM

## LITHIUM LAURATE, MYRISTATE, PALMITATE, STEARATE and OLEATE

SOLUBILITY OF EACH OF THESE SALTS, DETERMINED SEPARATELY, IN SEVERAL SOLVENTS

(Jacobson and Holmes, 1916; Partheil and Ferie, 1903 in parentheses)

Li laurate =  $C_{11}H_{23}COOLi$ , Li myristate =  $C_{13}H_{27}COOLi$ , Li palmitate =  $C_{15}H_{31}COOLi$ , Li stearate =  $C_{17}H_{35}COOLi$  and Li oleate =  $C_{17}H_{33}COOLi$

The lithium salts were prepared by adding the calculated amount of lithium acetate to the alcoholic solutions of the respective fatty acids. The resulting precipitates were dissolved in boiling alcohol and the solutions allowed to stand overnight in a cool place. The salts so obtained were washed and dried. Excess of salt shaken with solvent for 2 hrs. in all cases. The sat. sol. was analyzed by evaporating to dryness and weighing residue.

CH	Gms. of Each Salt (determined separately) per 100 Gms. Solvent Results in paren: are gms. per 100 cc. sat. sol.						
	Solvent	t°	Li	Li	Li	Li	Li
			Laurate	Myristate	Palmitate	Stearate	Oleate
Water	16.3	0.154	0.027	0.010	0.009	--	
	18	(0.158)	(0.0232)	(0.011)	(0.010)	(0.0674)	
	25	0.187	0.036	0.015	0.010	--	
		(0.176)	(0.0234)	(0.018)	(0.011)	(0.1320)	
	35	0.207	0.042	0.015	0.010	--	
	50	0.280	0.062	--	--	--	
Abs. Ethyl Alcohol	18	(0.418)	(0.184)	(0.0796)	(0.041)	(0.9084)	
	20	0.403	0.194	0.096	0.072	--	
	25	(0.4424)	(0.2100)	(0.0956)	(0.0532)	(1.010)	
	25.4	0.447	0.224	0.118	0.089	--	
	35	0.546	0.278	0.142	0.106	--	
	50	0.782	0.435	0.248	0.200	--	
	65	1.149	0.669	0.391	0.333	--	
	Methyl Alcohol	15.2	3.159	1.346	0.616	0.349	--
25		3.773	1.680	0.771	0.439	--	
34.6		4.597	2.193	1.086	0.658	--	
50		6.088	3.281	1.652	1.057	--	
Ether	15.8	0.011	0.013	0.007	0.011	--	
	25	0.006	0.004	0.007	0.011	--	
Amyl Alcohol	16	0.073	0.029	0.010	0.011	--	
	25.7	0.111	0.046	0.032	0.028	--	
	35	0.126	0.062	0.033	0.031	--	
	49.2	0.203	0.109	0.069	0.060	--	
Chloroform	15.2	0.006	0.004	0.004	0.004	--	
Amyl Acetate	14.5	0.068	0.037	0.038	0.034	--	
	25	0.064	0.034	0.024	0.029	--	
	35	0.061	0.044	0.037	0.031	--	
	50	0.061	0.045	0.036	0.044	--	
Methyl Acetate	24.5	0.026	0.013	0.015	0.012	--	
Acetone	15	0.300	0.413	0.434	0.571	--	
	25	0.376	0.447	0.508	0.706	--	
	35	0.430	0.502	0.537	0.663	--	

The phase diagram of the system lithium palmitate - water was determined by Vold, 1943, and it resembles that of sodium palmitate. The effect of adding small amounts of lithium chloride to the solutions is discussed. Only the compositions of the invariant solutions are given in tabular form.

Phase diagrams for the systems lithium stearate - decalin and lithium stearate - cetane are reported by Vold and Vold, 1950.

LITHIUM PLATINO CYANIDE  $\text{Li}_2\text{Pt}(\text{CN})_4 \cdot ?\text{H}_2\text{O}$ 

CN

SOLUBILITY OF LITHIUM PLATINOCYANIDE IN WATER  
(Terry and Jolly, 1923)

Gms. $\text{Li}_2\text{Pt}(\text{CN})_4$ per 100 gms. $\text{H}_2\text{O}$		Gms. $\text{Li}_2\text{Pt}(\text{CN})_4$ per 100 gms. $\text{H}_2\text{O}$		Gms. $\text{Li}_2\text{Pt}(\text{CN})_4$ per 100 gms. $\text{H}_2\text{O}$		Gms. $\text{Li}_2\text{Pt}(\text{CN})_4$ per 100 gms. $\text{H}_2\text{O}$	
t°		t°		t°		t°	
0.0	105.0	30.1	152.3	40.0	160.3	50.1	175.0
16.3	139.5	30.5	156.1	42.5	160.5	53.0	182.0
22.2	141.5	31.5	152.0	42.7	181.2	55.2	173.8
23.0	153.5	32.2	152.4	43.1	188.2	60.7	178.0
24.1	144.8	34.9	166.6	43.2	162.3	64.8	185.7
25.0	144.7	35.0	154.6	45.0	196.0	66.0	205.2
25.7	153.0	35.8	155.6	45.7	165.0	71.0	204.0
25.8	146.3	37.3	173.0	46.6	176.1	72 (tr. pt.)	
26.5	147.5	38.0	155.3	47.2	186.0	78.2	213.7
26.8	151.2	38.8	158.2	48.0	173.0	88.2	229.0
28.5	148.5	39.2	154.4	49.0 (tr. pt.)		89.8	238.7
29.5 (tr. pt.)		39.5 (tr. pt.)		49.2	173.1		

EQUILIBRIUM IN THE SYSTEM LITHIUM PLATINOCYANIDE,  
POTASSIUM PLATINOCYANIDE AND WATER AT 24.1°  
(Terry and Jolly, 1923)

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Li}_2\text{Pt}(\text{CN})_4$	$\text{K}_2\text{Pt}(\text{CN})_4$	
59.2	0.0	$\text{Li}_2\text{Pt}(\text{CN})_4 \cdot ?\text{H}_2\text{O}$
54.2	1.7	$\text{LiKPt}(\text{CN})_4 \cdot 2\text{H}_2\text{O}$
54.1	2.2	"
52.1	2.7	"
45.9	4.4	"
38.9	9.2	"
36.5	11.2	"
34.0	12.3	"
30.5	13.9	"
28.5	16.1	"
29.3	18.7	"
28.7	18.2	$\text{K}_2\text{Pt}(\text{CN})_4 \cdot 3\text{H}_2\text{O}$
27.3	16.1	"
23.0	19.8	"
22.0	19.4	"
19.3	20.2	"
10.2	23.6	"
6.1	26.5	"
4.6	26.9	"
0.0	28.6	"

# LI LITHIUM

## SCH LITHIUM THIOCYANATE LISCN

### SOLUBILITY OF LITHIUM THIOCYANATE IN WATER (Iwase, 1930)

t°	Gms. LISCN per 100 gms. sat. sol.	Solid Phase	t°	Gms. LISCN per 100 gms. sat. sol.	Solid Phase
20	53.2	LISCN·2H <sub>2</sub> O	34	--	LISCN·2H <sub>2</sub> O + LISCN
25	54.5	"	35	58.8	LISCN
30	56.7	"	40	60.4	"

## CO LITHIUM CARBONATE Li<sub>2</sub>CO<sub>3</sub>

### SOLUBILITY IN WATER (Bevade, 1885; Fluckiger, 1887; Draper, 1887)

An average curve was constructed from the available results and the following table read from it.

More recent results at 0° agreeing with the above are given by Rosenheim and Reglin, 1921; and at 0° and 100°, by Kraus and Burgess, 1927; and at 25° by Ageno and Valla, 1911; also Weber, 1929.

t°	Gms. Li <sub>2</sub> CO <sub>3</sub> per 100 Gms.		t°	Gms. Li <sub>2</sub> CO <sub>3</sub> per 100 Gms.	
	Water	Solution		Water	Solution
0	1.54	1.52	40	1.17	1.16
10	1.43	1.41	50	1.08	1.07
20	1.33	1.31	60	1.01	1.00
25	1.29	1.28	80	0.85	0.84
30	1.25	1.24	100	0.72	0.71

Density of saturated solution at 0° = 1.017; at 15° = 1.014.

Determinations of the equilibrium in aqueous solutions of lithium carbonate and bicarbonate in relation to the partial pressure of the carbon dioxide in the gas phase in contact with the solution are given by Walker, Bray and Johnston, 1927.

### SOLUBILITY OF LITHIUM CARBONATE IN WATER UNDER HIGH PRESSURES OF CARBON DIOXIDE (Haehnel, 1937)

A platinum lined autoclave was used and the mixtures shaken 1 hour and allowed to stand 1/2 hour before removing a sample for analysis. Lithium carbonate goes into solution in water in presence of CO<sub>2</sub> as bicarbonate. Such aqueous bicarbonate solutions are stable above -12° only under a CO<sub>2</sub> pressure of more than 1 atmosphere. The results are presented both in terms of gms. of Li<sub>2</sub>CO<sub>3</sub> (shown in parentheses in the following table) and of LiHCO<sub>3</sub> per 100 gms. sat. solution.

Pressure of CO <sub>2</sub> in Atmospheres	Gms. LiHCO <sub>3</sub> per 100 gms. saturated solution at:		
	-12°	-10°	-5°
1	22.71 (12.36)	21.25 (11.36)	16.12 ( 8.77)
3	22.71 (12.36)	22.43 (12.20)	— —
5	—	22.43 (12.20)	21.36 (11.62)
8	—	—	21.36 (11.62)
10	—	—	—
13	—	—	—
16	—	—	—
20	—	—	—
30	—	—	—
34	—	—	—
50	—	—	—

CO

Pressure of CO <sub>2</sub> in Atmospheres	Gms. LiHCO <sub>3</sub> per 100 gms. saturated solution at:			
	0°	+18°	+40°	+60°
1	14.13 ( 7.69)	10.56 (5.75)	8.55 (4.65)	7.33 (3.99)
3	—	—	—	—
5	16.96 ( 9.23)	12.52 (6.82)	8.62 (4.69)	— —
8	19.91 (10.83)	—	—	—
10	19.91 (10.83)	14.90 (8.11)	8.68 (4.72)	—
13	—	16.19 (8.81)	—	—
16	—	17.29 (9.41)	—	—
20	—	17.29 (9.41)	11.48 (6.25)	7.53 (4.10)
30	—	—	12.23 (6.66)	—
34	—	—	12.23 (6.65)	—
50	—	—	—	9.61 (5.23)

100 gms. H<sub>2</sub>O dissolve 5.501 gms. LiHCO<sub>3</sub> at 13°. (Bevade, 1884)

THE SYSTEM LITHIUM CARBONATE - LITHIUM HYDROXIDE - WATER  
(Hostalek, 1956a)

Solid Phase Li<sub>2</sub>CO<sub>3</sub>, except as noted.

Sat. Sol. wt. %		Sat. Sol. wt. %		Sat. Sol. wt. %	
Li <sub>2</sub> CO <sub>3</sub>	LiOH	Li <sub>2</sub> CO <sub>3</sub>	LiOH	Li <sub>2</sub> CO <sub>3</sub>	LiOH
At 20°		At 40°		At 80°	
1.10	0.22	0.87	0.30	0.58	0.31
1.05	0.27	0.59	0.79	0.49	0.41
0.80	0.58	0.36	1.70	0.34	0.87
0.67	0.88	0.27	2.23	0.29	1.10
0.45	1.71	0.16	3.34	0.20	1.72
0.39	2.06	0.10	5.11	0.09	2.99
0.35	2.34	0.08	7.01	0.07	5.52
0.23	3.21	0.10	9.56	0.08	9.94
0.12	5.06	0.09	11.25*	0.10	12.72*
0.10	7.52	At 60°		At 100°	
0.10	8.54				
0.07	9.48	0.73	0.27	0.50	0.21
0.08	10.45	0.66	0.33	0.29	0.65
0.08	10.98*	0.39	1.04	0.19	1.15
		0.26	1.71	0.09	2.00
		0.18	2.31	0.07	2.55
		0.11	3.30	0.07	3.09
		0.08	5.86	0.06	3.92
		0.09	8.65	0.07	6.08
		0.11	10.20	0.08	9.21
		0.11	11.65*		

\*Solid phase Li<sub>2</sub>CO<sub>3</sub> +  
LiOH·H<sub>2</sub>O



# Li LITHIUM

## THE SYSTEM LITHIUM CARBONATE - LITHIUM SULFATE - WATER (Plyushchev and Tulinova, 1957, 1957a)

Solid phase  $\text{Li}_2\text{CO}_3$ , except as noted

	Results at 0°				Results at 50°			
	Sat.	Sol.	wt. %		Sat.	Sol.	wt. %	
	$\text{Li}_2\text{CO}_3$	$\text{Li}_2\text{SO}_4$			$\text{Li}_2\text{CO}_3$	$\text{Li}_2\text{SO}_4$		
	1.50	0.000	0.142	18.98	0.999	0.000	0.109	12.16
	1.29	0.725	0.092	21.60	0.892	0.323	0.078	16.09
	1.00	1.72	0.072	22.56	0.676	0.800	0.083	16.29
	0.641	3.29	0.057	23.84	0.489	1.70	0.052	20.79
	0.403	6.42	0.052	24.99 <sup>a</sup>	0.289	4.14	0.052	21.70
	0.339	7.78	0.050	26.41 <sup>a</sup>	0.207	6.12	0.041	23.99 <sup>a</sup>
	0.181	13.98	0.022	26.48 <sup>b</sup>	0.180	7.80	0.041	24.75 <sup>a</sup>
	0.161	17.26	0.000	26.40 <sup>b</sup>	0.141	9.34	0.019	24.71 <sup>b</sup>
					0.114	10.87	0.000	25.18 <sup>b</sup>

<sup>a</sup>Solid phase  $\text{Li}_2\text{CO}_3 + \text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{O}$

<sup>b</sup>Solid phase  $\text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{O}$

## SOLUBILITY OF LITHIUM CARBONATE IN POTASSIUM SULFATE SOLUTIONS (Jager, 1958)

Moles per 1000 gms.  $\text{H}_2\text{O}$

At 25°		At 50°		At 75°		At 100°	
$\text{Li}_2\text{CO}_3$	$\text{K}_2\text{SO}_4$	$\text{Li}_2\text{CO}_3$	$\text{K}_2\text{SO}_4$	$\text{Li}_2\text{CO}_3$	$\text{K}_2\text{SO}_4$	$\text{Li}_2\text{CO}_3$	$\text{K}_2\text{SO}_4$
0.160	0.0	0.128	0.0	0.102	0.0	0.0788	0.0
0.170	0.0862	0.155	0.155	0.137	0.202	0.117	0.276
0.191	0.146	0.177	0.315	0.159	0.431	0.152	0.740
0.209	0.275	0.206	0.559	0.184	0.769	0.165	1.014
0.241	0.562	0.232	0.983	0.202	1.077	0.177	1.374
0.254	0.774			0.209	1.246	0.184	1.455

## THE SYSTEM LITHIUM CARBONATE - SODIUM CARBONATE - WATER AT 25°

(Urazov and Lifatova, 1944)

(Saegusa, 1948)

Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
$\text{Li}_2\text{CO}_3$	$\text{Na}_2\text{CO}_3$		$\text{Li}_2\text{CO}_3$	$\text{Na}_2\text{CO}_3$	
1.237	0.0	$\text{Li}_2\text{CO}_3$	1.232	0.0	$\text{Li}_2\text{CO}_3$
1.18	2.07	"	1.169	0.290	"
1.15	5.12	"	1.152	0.616	"
1.14	7.31	"	1.144	0.916	"
1.14	9.39	"	1.123	1.994	"
1.11	16.89	"	1.054	4.254	"
1.16	17.94	"	0.899	9.130	"
0.98	18.66	"	0.819	13.659	"
0.97	18.94	"	0.647	18.740	"
1.00	19.71	"	0.628	19.990	"
0.99	20.57	"	0.589	21.340	" + $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$
0.96	21.25	"	0.326	21.716	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$
0.93	23.40	" +	0.0	22.5	"
0.917	23.51	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$			
0.807	23.85	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$			
0.61	23.39	"			
0.40	23.24	"			
0.20	23.19	"			
0.08	23.02	"			
0.0	23.27	"			

(Cont.)

Data of Lagarde, 1943 at 0°, 25°

Gms. Na <sub>2</sub> CO <sub>3</sub> per liter Sat. Sol.	Gms. Li <sub>2</sub> CO <sub>3</sub> per liter Sat. Sol.	
	0°	25°
0.0	15.2	12.6
10.6	14.6	12.0
21.2	14.5	11.8
31.8	14.5	11.7
42.4	14.4	11.6

LITHIUM OXALATE Li<sub>2</sub>C<sub>2</sub>O<sub>4</sub>

CO

## SOLUBILITY IN WATER

t°	Gms. Li <sub>2</sub> C <sub>2</sub> O <sub>4</sub> per 100 gms. sat. sol.	Author
19	6.06	Boulanger, 1936a
25	5.87	Foote and Andrew, 1905

THE SYSTEM LITHIUM OXALATE - OXALIC ACID - WATER AT 25°  
(Foote and Andrew, 1905)

Mixtures of the two substances were dissolved in water, and the solutions cooled in a thermostat to 25°.

Gms. per 100 gms. Solution		Mols. per 100 Mols. H <sub>2</sub> O		Solid Phase
H <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	Li <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	H <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	Li <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	
10.20	--	2.274	--	H <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·2H <sub>2</sub> O
10.66	2.96	2.457	0.622	H <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O and HLiC <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O
10.55	3.11			
8.08	3.18	1.823	0.633	Double Salt HLiC <sub>2</sub> O <sub>4</sub> ·4H <sub>2</sub> O = 39.2H <sub>2</sub> C <sub>2</sub> O <sub>4</sub> and 44.7Li <sub>2</sub> C <sub>2</sub> O <sub>4</sub>
2.60	5.03	0.563	0.962	
2.16	6.54	0.469	1.273	HLiC <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O and Li <sub>2</sub> C <sub>2</sub> O <sub>4</sub>
2.12	1.61			
	5.87	--	1.901	Li <sub>2</sub> C <sub>2</sub> O <sub>4</sub>

100 gms. aqueous solution, simultaneously saturated with lithium oxalate and ammonium oxalate at 25°, contain 5.75 gms. Li<sub>2</sub>C<sub>2</sub>O<sub>4</sub> + 4.8 gms. (NH<sub>4</sub>)<sub>2</sub>C<sub>2</sub>O<sub>4</sub>.

(Foote and Andrew, 1905)

# LI LITHIUM

## THE SYSTEM LITHIUM OXALATE - ZIRCONIUM OXALATE - WATER AT 19° (Boulanger, 1936a)

The solid phases were of uncertain composition since the zirconyl oxalate apparently hydrolyzed, yielding mixtures composed of the oxalates, oxalic acid and water.

	Gms. per 100 gms. sat. solution		Gms. per 100 gms. sat. solution		Gms. per 100 gms. sat. solution	
	$\text{Li}_2(\text{COO})_2$	$\text{ZrO}(\text{COO})_2$	$\text{Li}_2(\text{COO})_2$	$\text{ZrO}(\text{COO})_2$	$\text{Li}_2(\text{COO})_2$	$\text{ZrO}(\text{COO})_2$
	6.06	0.0	6.89	3.41	7.10	5.35
	6.37	0.81	7.15	3.70	6.20	6.00
	6.66	1.56	7.42	3.82	5.63	6.91
CO	6.50	1.82	7.52	4.93	4.20	7.72
	6.56	2.05	7.70	5.01	3.53	8.24

## SOLUBILITY OF LITHIUM CARBONATE IN LITHIUM CHLORIDE SOLUTIONS (Lagarde, 1943)

Gms. LiCl per liter Sat. Sol.	Gms. $\text{Li}_2\text{CO}_3$ per liter Sat. Sol.	
	0°	25°
0.0	15.2	12.6
8.48	10.1	7.95
16.96	6.85	5.35
25.4	4.82	3.33
33.9	3.70	2.40
42.4	2.67	2.03

## SOLUBILITY OF LITHIUM CARBONATE IN AQUEOUS SOLUTIONS OF ALKALI SALTS AT 25° (Geffcken, 1905)

The original results were calculated to gram quantities and plotted on cross-section paper. The figures in the following table were read from the curves.

Gms. Salt per Liter	Grams $\text{Li}_2\text{CO}_3$ per Liter in Aqueous Solutions of:							
	$\text{KClO}_3$	$\text{KNO}_3$	$\text{KCl}$	$\text{NaCl}$	$\text{K}_2\text{SO}_4$	$\text{Na}_2\text{SO}_4$	$\text{NH}_4\text{Cl}$	$(\text{NH}_4)_2\text{SO}_4$
0	12.63	12.63	12.63	12.63	12.63	12.63	12.63	12.63
10	12.95	13.05	13.10	13.4	13.9	14.0	16.0	20.7
20	13.10	13.3	13.5	13.9	14.7	15.0	19.2	25.0
30	13.25	13.6	13.8	14.3	15.4	16.0	21.5	28.2
40	13.40	13.8	14.0	14.6	16.0	16.6	23.3	30.8
60	—	13.8	14.2	14.5	16.9	17.8	26.0	35.2
80	—	13.6	14.0	14.4	17.7	18.6	27.6	38.5
100	—	13.5	13.9	14.2	18.2	19.4	28.4	41.0
120	—	13.3	13.7	14.0	—	19.9	28.7	42.6
140	—	13.0	13.3	—	—	20.4	28.8	43.5
170	—	12.6	—	—	—	—	28.9	—
200	—	12.2	—	—	—	—	29.0	—

SOLUBILITY OF LITHIUM CARBONATE IN AQUEOUS SOLUTIONS OF  
ORGANIC COMPOUNDS AT 25°

(Rothmund, 1908, 1910; see also Traube, 1909 and tables following)

The solubility in  $H_2O = 0.1687$  mols.  $Li_2CO_3$  per liter = 12.47 gms. at 25°.

Aqueous Solution of:	Gm. Mols. $Li_2CO_3$ per Liter in Aq. Solution of:			
	0.125 Normality	0.25 Normality	0.5 Normality	1 Normality
Methyl Alcohol	—	0.1604	0.1529	0.1394
*Ethyl Alcohol	0.1614	0.1555	0.1417	0.1203
Propyl Alcohol	0.1604	0.1524	0.1380	0.1097
Amyl Alcohol (tertiary)	0.1564	0.1442	0.1224	0.0899
*Acetone	0.1600	0.1515	0.1366	0.1104
Ether	0.1580	0.1476	0.1300	—
Formaldehyde	0.1668	0.1653	0.1606	0.1531
Glycol	0.1660	0.1629	0.1565	0.1472
Glycerol	0.1670	0.1647	0.1613	0.1532
Mannite	0.1705	0.1737	0.1778	—
Grape Sugar	0.1702	0.1728	0.1752	0.1778
Cane Sugar	0.1693	0.1689	0.1661	0.1557
Urea	0.1686	0.1673	0.1643	0.1605
Thiourea	0.1667	0.1643	0.1600	0.1523
Dimethylpyrone	0.1562	0.1460	0.1280	0.0992
Amazonia	0.1653	0.1630	0.1577	0.1466
Diethylamine	0.1589	0.1481	0.1283	0.0937
Pyridine	0.1592	0.1503	0.1347	0.1091
Urethan	0.1604	0.1525	0.1377	0.1113
Acetamide	—	0.1614	0.1520	0.1358
Acetonitrile	0.1618	0.1556	0.1429	0.1178
Mercuricyanide	0.1697	0.1704	—	—

CO

\*See also below, and p. 390

SOLUBILITY OF LITHIUM CARBONATE IN AQUEOUS SOLUTIONS OF ACETONE AT 17.6°  
(Hartley, 1931)

Mols. $(CH_3)_2CO$ per 1.0 Mol. $(CH_3)_2CO + H_2O$	Mols. $Li_2CO_3$ per 1.0 Mol. $Li_2CO_3 + (CH_3)_2CO + H_2O$
0.0	0.00331
0.0326	0.00211
0.0668	0.00105

SOLUBILITY OF LITHIUM CARBONATE IN AQUEOUS SOLUTIONS  
OF SEVERAL ORGANIC COMPOUNDS  
(Weber, 1929)

Aqueous Solution of:	Gm. Mols. $Li_2CO_3$ per liter in Aq. Solution of:					
	0.005 Nor- mality	0.0208 Nor- mality	0.0417 Nor- mality	0.0625 Nor- mality	0.125 Nor- mality	0.25 Nor- mality
Paraldehyde	—	—	—	0.1629	0.1573	0.1467
Iso amyl alcohol	—	—	—	0.1621	0.1559	—
Hexyl alcohol	—	0.1666	0.1640	—	—	—
Octyl alcohol	0.1683	—	—	—	—	—

## LI LITHIUM

100 gms. aq. alcohol of 0.941 Sp. Gr. dissolve 0.056 gm.  $\text{Li}_2\text{CO}_3$  at 15.5°. (Geffcken, 1905)

Melting point data are given for:

$\text{Li}_2\text{CO}_3 + \text{Na}_2\text{CO}_3$	Skaliks, 1928
$\text{Li}_2\text{CO}_3 + \text{Li}_2\text{SO}_4$	Amadori, 1912
$\text{Li}_2\text{CO}_3 + \text{K}_2\text{CO}_3$	LeChatelier, 1894
$\text{Li}_2\text{CO}_3 + \text{LiCl} + \text{Li}_2\text{SO}_4$	Reshetnikov and Diogenov, 1953
$\text{Li}_2\text{CO}_3 + \text{Na}_2\text{SO}_4 = \text{Li}_2\text{SO}_4 + \text{Na}_2\text{CO}_3$	Volkov and Volkova, 1953
$\text{Li}_2\text{CO}_3 + 2\text{NaF} = 2\text{LiF} + \text{Na}_2\text{CO}_3$	Volkov and Shvab, 1953a
$\text{Li}_2\text{CO}_3 + 2\text{RbF} = 2\text{LiF} + \text{Rb}_2\text{CO}_3$	Volkov and Shvab, 1953b

## Cl LITHIUM CHLORIDE LiCl

### SOLUBILITY OF LITHIUM CHLORIDE IN WATER

The results of Huttig and Rensher, 1924; Benrath, 1927, 1932a; Deacon, 1927; Friend and Culley, 1931; Bassett and Sanderson, 1932; Appleby and Crawford, 1934; and Friend, Hale and Ryder, 1937 were plotted and from the average curve, the values above 0° were taken. The data below 0° are those of Woskressenskaya and Janatieva, 1937. The system has also been studied by Moran, Jr., 1956 and Garrett and Woodruff, 1951 at low temperatures. For other freezing points of dilute solutions see Klein and Svanberg, 1920 and Rodebush, 1918.

t°	Gms. LiCl per 100 gms. sat. sol.	Solid Phase
- 2.4	4.0	Ice
- 9.0	8.0	"
-23.0	14.0	"
-36.0	18.0	"
-50.0	21.0	"
-62.0	24.0	"
-66.0	24.4	Ice + $\text{LiCl} \cdot 5\text{H}_2\text{O}$
-73 <sup>c</sup>	24.85	" + "
-75.9 <sup>a</sup>	25.0	" + "
-80 <sup>b</sup>	25.3	" + "
-63.0	26.4	$\text{LiCl} \cdot 5\text{H}_2\text{O}$
-60.4	28.2	"
-58.0	29.6	"
-57.0	30.4	$\text{LiCl} \cdot 5\text{H}_2\text{O} + \text{LiCl} \cdot 3\text{H}_2\text{O}$
-65.6 <sup>a</sup>	--	" + "
-68 <sup>b</sup>	28.7	" + "
-54.0	30.5	$\text{LiCl} \cdot 3\text{H}_2\text{O}$
-48.0	30.8	"
-31.0	33.4	"
-19.2	36.4	"
-15.6	37.2	$\text{LiCl} \cdot 3\text{H}_2\text{O} + \text{LiCl} \cdot 2\text{H}_2\text{O}$
-20.5 <sup>a</sup>	--	" + "
-20	36.9	" + "

a = Moran, Jr., 1956

b = Huttig and Stevdmann, 1927

c = Appleby and Crawford, 1934

## SOLUBILITY OF LITHIUM CHLORIDE IN WATER—Cont.

t°	d. of sat. sol.	Gms. LiCl per 100 gms. sat. sol.	Solid Phase
0	1.268	40.9	LiCl·2H <sub>2</sub> O
5	—	42.0	"
10	1.279	42.7	"
15	—	43.8	"
18.5	1.293	45.35	" + LiCl·H <sub>2</sub> O
12.5 <sup>b</sup>	—	40.5	" + "
19.0 <sup>a</sup>	—	—	" + "
19.1 <sup>c</sup>	—	—	" + "
25	1.296	45.85	LiCl·H <sub>2</sub> O
30	—	46.3	"
40	1.303	47.3	"
50	1.308	48.3	"
60	—	49.6	"
70	—	51.1	"
80	1.331	52.8	"
90	1.342	54.8	"
96	1.347	56.1	" + LiCl
93 <sup>c</sup>	—	—	" + "
100.5 <sup>b</sup>	—	56.5	" + "
94 <sup>a</sup>	—	—	" + "
97	—	56.8*	LiCl·H <sub>2</sub> O
98	—	57.4*	"
100	1.347	56.2	LiCl
110	—	56.7	"
120	1.344	57.2	"
130	—	57.6	"
140	1.339	58.0	"
160	—	59.2	"

Cl

\*metastable

a = Moran, Jr., 1956

b = Huttig and Steudemann, 1927

c = Appleby and Crawford, 1934

SOLUBILITY OF LITHIUM CHLORIDE IN AQUEOUS SOLUTIONS  
OF HYDROCHLORIC ACID

(Engel, 1888)

Results at 0°

Gms. per 100 cc. Sat. Sol.		d <sub>0</sub> of Sat. Sol.
LiCl	HCl	
51.0	0.0	1.255
41.4	8.2	1.243
28.5	24.1	1.249
24.6	29.5	1.251

(Herz, 1911-12)

Results at 25°

Gms. per 100 cc. Sat. Sol.	
LiCl	HCl
57.4	0.0
56.87	2.30
53.64	3.84
51.98	6.43

# Li LITHIUM

## THE SYSTEM LITHIUM CHLORIDE - AMMONIA - WATER AT 23-25° (Collins and Cameron, 1928)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
LiCl	NH <sub>3</sub>		LiCl	NH <sub>3</sub>		LiCl	NH <sub>3</sub>	
45.4	0.0	LiCl·H <sub>2</sub> O	51.9	16.70	LiCl·NH <sub>3</sub>	45.3	32.7	LiCl·3NH <sub>3</sub>
46.7	3.1	"	54.7	20.0	"	41.52	35.7	"
48.1	7.9	"	57.0	21.64	"	39.3	35.8	"
50.84	13.88	"	52.57	27.31	"	39.11	38.6	"
50.73	14.86	"	46.1	32.0	LiCl·3NH <sub>3</sub>	37.9	40.4	"
50.81	15.34	LiCl·NH <sub>3</sub>				45.9	33.2	"

C1 The authors also give vapor pressure measurements for the above system at 25° and for the system LiCl + NH<sub>3</sub> at the temperatures 0°, 33°, 45.2°, 54.5°, 58.3°, 66.4°, 74.6° and 86.9°.

## THE SYSTEM LITHIUM CHLORIDE - LITHIUM CHLORATE - WATER (Campbell and Griffiths, 1956)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
LiClO <sub>3</sub>	LiCl		LiClO <sub>3</sub>	LiCl	
Results at 3°			Results at 8.5°--Cont.		
56.7	0.0	LiClO <sub>3</sub> ·3H <sub>2</sub> O	22.5	32.2	LiCl·2H <sub>2</sub> O
55.8	1.3	"	10.4	37.3	"
62.2	4.3	"	5.6	39.7	"
66.0	2.8	"	0.0	42.7	"
68.7	1.5	"	Results at 6°		
70.8	0.0	"			
73.6	0.0	LiClO <sub>3</sub> ·H <sub>2</sub> O	58.7	0.0	LiClO <sub>3</sub> ·3H <sub>2</sub> O
65.6	7.1	"	58.3	2.5	"
62.4	9.4	"	62.7	1.8	"
58.5	13.1	"	68.1	0.0	"
57.5	13.7	" + LiCl·H <sub>2</sub> O	74.1	0.0	LiClO <sub>3</sub> ·H <sub>2</sub> O
44.7	19.9	LiCl·H <sub>2</sub> O	70.0	2.7	"
40.9	21.1	LiCl·H <sub>2</sub> O + LiCl·2H <sub>2</sub> O	69.7	3.4	"
37.4	23.5	LiCl·2H <sub>2</sub> O	65.8	7.1	"
23.9	29.1	"	64.9	7.5	"
0.0	41.1	"	62.6	9.6	"
Results at 8.5°			61.4	10.7	"
			60.4	12.3	" + LiCl·H <sub>2</sub> O
75.0	0.0	LiCl·H <sub>2</sub> O	57.5	13.7	LiCl·H <sub>2</sub> O
73.4	1.5	"	54.8	15.2	"
72.0	1.9	"	53.9	15.0	"
66.1	7.7	"	45.2	20.0	"
65.6	8.8	"	38.2	23.7	"
64.2	11.2	" + LiCl·H <sub>2</sub> O	37.2	24.0	"
63.5	11.2	" + "	36.2	24.6	" + LiCl·2H <sub>2</sub> O
62.7	11.6	" + "	35.7	24.9	LiCl·2H <sub>2</sub> O
60.5	12.3	LiCl·H <sub>2</sub> O	34.1	25.4	"
50.8	17.4	"	24.4	29.7	"
31.3	27.7	"	23.5	30.0	"
30.6	27.8	" + LiCl·2H <sub>2</sub> O	18.3	32.5	"
28.2	28.9	LiCl·2H <sub>2</sub> O	16.3	33.5	"
			0.0	41.1	"

## THE SYSTEM LITHIUM CHLORIDE - LITHIUM CHLORATE - WATER--Cont.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
LiClO <sub>3</sub>	LiCl		LiClO <sub>3</sub>	LiCl	
Results at 25°					
82.6	0.0	4LiClO <sub>3</sub> ·H <sub>2</sub> O	71.8	9.2	4LiClO <sub>3</sub> ·H <sub>2</sub> O + LiCl·H <sub>2</sub> O
78.7	3.3	"	71.6	9.2	" + "
76.4	5.0	"	67.7	10.7	LiCl·H <sub>2</sub> O
76.1	5.1	"	41.7	23.3	"
75.7	5.6	"	33.8	27.7	"
75.8	5.7	"	27.0	31.3	"
75.9	5.8	"	25.5	31.7	"
72.3	9.2	" + LiCl·H <sub>2</sub> O	0.0	45.5	"

LITHIUM Gold CHLORIDE LiAuCl<sub>4</sub>SOLUBILITY OF LITHIUM GOLD CHLORIDE IN WATER  
(Rosenbladt, 1886)

t°	Gms. LiAuCl <sub>4</sub> per 100 Gms. Solution	t°	Gms. LiAuCl <sub>4</sub> per 100 Gms. Solution	t°	Gms. LiAuCl <sub>4</sub> per 100 Gms. Solution
10	53.1	40	67.3	60	76.4
20	57.7	50	72	70	81
30	62.5			80	85.7

THE SYSTEM LITHIUM CHLORIDE - ALUMINUM CHLORIDE - WATER AT 25°  
(Blidin, 1956a)

Sat. Sol. wt. %		Solid Phase	Sat. Sol. wt. %		Solid Phase
LiCl	AlCl <sub>3</sub>		LiCl	AlCl <sub>3</sub>	
45.95	0.0	LiCl·H <sub>2</sub> O	21.60	15.10	AlCl <sub>3</sub> ·6H <sub>2</sub> O
42.16	3.20	" + AlCl <sub>3</sub> ·6H <sub>2</sub> O	15.73	18.68	"
37.61	5.17	AlCl <sub>3</sub> ·6H <sub>2</sub> O	14.12	20.06	"
23.10	7.64	"	10.50	23.48	"
27.54	10.12	"	5.92	27.61	"
			0.0	33.20	"



# Li LITHIUM

## THE SYSTEM LITHIUM CHLORIDE - COPPER CHLORIDE - WATER AT 25° (Blidin, 1956)

Sat. Sol. wt. %			Sat. Sol. wt. %		
LiCl	CuCl <sub>2</sub>	Solid Phase	LiCl	CuCl <sub>2</sub>	Solid Phase
45.95	0.0	LiCl·H <sub>2</sub> O	25.84	16.72	LiCl·CuCl <sub>2</sub> ·2H <sub>2</sub> O
45.20	1.50	"	23.17	19.35	" + CuCl <sub>2</sub> ·2H <sub>2</sub> O
44.12	2.85	"	20.60	19.63	CuCl <sub>2</sub> ·2H <sub>2</sub> O
43.00	4.50	" + LiCl·CuCl <sub>2</sub> ·2H <sub>2</sub> O	15.02	24.16	"
38.15	7.57	LiCl·CuCl <sub>2</sub> ·2H <sub>2</sub> O	5.70	32.55	"
31.86	12.14	"	3.68	36.70	"
			0.0	44.62	"

## C1 THE SYSTEM LITHIUM CHLORIDE - MAGNESIUM CHLORIDE - WATER (Woskresenskaja and Janatjeva, 1937)

The eutectic temperature is -78°, with the solution containing 23.6% LiCl, 3.6% MgCl<sub>2</sub>, and the saturating phases Ice + LiCl·5H<sub>2</sub>O + Double Salt (composition not determined). The results are also expressed in molar bases.

Gms. LiCl Gms. MgCl <sub>2</sub> per 100 per 100 gms. gms.			Gms. LiCl Gms. MgCl <sub>2</sub> per 100 per 100 gms. gms.		
Sat. Sol.	Sat. Sol.	Solid Phase	Sat. Sol.	Sat. Sol.	Solid Phase
Results at -50°			Results at -10°		
31.0	0.0	LiCl·3H <sub>2</sub> O	8.8	0.0	Ice
29.5	2.0	"	6.4	4.0	"
28.4	4.0	" + D.S.	4.0	7.0	"
25.4	6.6	D.S.	0.0	11.6	"
23.6	8.6	" + MgCl <sub>2</sub> ·12H <sub>2</sub> O			
22.6	8.4	MgCl <sub>2</sub> ·12H <sub>2</sub> O	Results at 0°		
15.6	7.8	" + Ice	38.8	0.0	LiCl·2H <sub>2</sub> O
17.6	6.6	Ice	38.2	2.6	"
18.6	4.8	"	38.0	4.8	" + 1:1:7
20.4	1.4	"	32.5	8.6	1:1:7
21.0	0.0	"	29.6	11.0	"
Results at -30°			28.0	12.4	" + MgCl <sub>2</sub> ·6H <sub>2</sub> O
34.4	0.0	LiCl·3H <sub>2</sub> O	23.0	14.2	MgCl <sub>2</sub> ·6H <sub>2</sub> O
33.0	2.2	"	18.6	17.0	"
32.0	4.0	" + D.S.	13.2	21.6	"
28.6	7.4	D.S.	5.4	28.6	"
27.0	10.4	" + MgCl <sub>2</sub> ·6H <sub>2</sub> O	0.0	35.0	"
21.0	12.8	MgCl <sub>2</sub> ·6H <sub>2</sub> O	Results at 25°		
16.4	15.4	" + MgCl <sub>2</sub> ·8H <sub>2</sub> O	45.65	0.0	LiCl·H <sub>2</sub> O
4.4	22.2	MgCl <sub>2</sub> ·8H <sub>2</sub> O	43.1	2.68	"
3.4	22.8	" + MgCl <sub>2</sub> ·12H <sub>2</sub> O	40.0	5.74	" + 1:1:7
0.0	21.6	MgCl <sub>2</sub> ·12H <sub>2</sub> O	40.2	5.68	"
0.0	19.4	Ice	38.0	6.99	1:1:7
7.0	11.6	"	37.1	7.42	"
11.0	6.8	"	35.4	8.32	"
16.0	0.0	"	33.9	9.34	"

(Cont.)

1:1:7 = LiCl·MgCl<sub>2</sub>·7H<sub>2</sub>O

D.S. = Double Salt of Undetermined Composition

## THE SYSTEM LITHIUM CHLORIDE - MAGNESIUM CHLORIDE - WATER--Cont.

Gms. LiCl per 100 gms. Sat. Sol.	Gms. MgCl <sub>2</sub> per 100 gms. Sat. Sol.	Solid Phase	Gms. LiCl per 100 gms. Sat. Sol.	Gms. MgCl <sub>2</sub> per 100 gms. Sat. Sol.	Solid Phase
Results at 25°--Cont.			Results at 70°		
29.3	13.7	1:1:7	51.2	0.0	LiCl·H <sub>2</sub> O
*28.8	14.2	" + MgCl <sub>2</sub> ·6H <sub>2</sub> O	46.5	4.58	"
28.0	14.3	MgCl <sub>2</sub> ·6H <sub>2</sub> O	39.4	11.2	"
22.0	18.0	"	38.2	12.3	LiCl·H <sub>2</sub> O + 1:1:7
18.9	20.0	"	37.3	13.9	1:1:7
8.4	28.3	"	36.1	14.5	"
0.0	35.4	"	26.4	20.4	"
			22.3	23.5	"
			21.6	24.1	"
			20.5	24.4	"
46.2	0.0	LiCl·H <sub>2</sub> O	*20.0	26.4	" + MgCl <sub>2</sub> ·6H <sub>2</sub> O
39.9	6.27	" + 1:1:7	19.0	26.1	MgCl <sub>2</sub> ·6H <sub>2</sub> O
39.0	6.81	1:1:7	18.8	26.3	"
35.4	8.84	"	15.3	27.9	"
35.3	9.14	"	10.2	31.2	"
34.1	9.93	"	0.0	38.7	"
33.2	10.6	"			
31.7	10.7	"	Results at 102°		
29.3	13.5	"	56.9	0.0	LiCl
26.6	15.7	"	30.4	23.4	"
*26.6	16.6	" + MgCl <sub>2</sub> ·6H <sub>2</sub> O	29.2	23.9	"
25.7	16.5	MgCl <sub>2</sub> ·6H <sub>2</sub> O	22.5	29.7	"
24.8	16.8	"	19.2	34.1	"
17.1	21.7	"	17.4	35.6	" + MgCl <sub>2</sub> ·6H <sub>2</sub> O
10.1	27.3	"	13	39	MgCl <sub>2</sub> ·6H <sub>2</sub> O
0.0	35.6	"	9	41	"

1:1:7 = LiCl·MgCl<sub>2</sub>·7H<sub>2</sub>O

D.S. = Double Salt of Undetermined Composition

\* = Extrapolated Value

THE SYSTEM LITHIUM CHLORIDE - MANGANESE CHLORIDE - WATER  
(Benrath, 1934b)

Incomplete data are also given for the isotherms at 14°, 17.5°, 22°, 27°, 43°, 45°, 65°, 70°, 75°, 90° and 95°.

t°	Gms. per 100 gms. sat. sol.		Solid Phase	t°	Gms. per 100 gms. sat. sol.		Solid Phase
	MnCl <sub>2</sub>	LiCl			MnCl <sub>2</sub>	LiCl	
0	0.0	40.51	LiCl·2H <sub>2</sub> O	0	11.54	30.24	4·1·10 + 1·1·5
"	0.54	40.33	" + 4·1·10	"	11.63	30.18	1·1·5
"	2.35	36.77	4·1·10	"	13.43	28.53	"
"	3.56	35.23	"	"	13.45	28.60	" + MnCl <sub>2</sub> ·4H <sub>2</sub> O
"	8.62	32.30	"	"	12.48	25.40	MnCl <sub>2</sub> ·4H <sub>2</sub> O
"	10.19	31.10	"	"	14.15	22.12	"

1·1·5 = LiCl·MnCl<sub>2</sub>·5H<sub>2</sub>O4·1·10 = 4LiCl·MnCl<sub>2</sub>·10H<sub>2</sub>O

(Cont.)

# LI LITHIUM

## THE SYSTEM LITHIUM CHLORIDE - MANGANESE CHLORIDE - WATER--Cont.

t°	Gms. per 100 gms. sat. sol.		Solid Phase	t°	Gms. per 100 gms. sat. sol.		Solid Phase
	MnCl <sub>2</sub>	LiCl			MnCl <sub>2</sub>	LiCl	
0	27.91	8.84	MnCl <sub>2</sub> ·4H <sub>2</sub> O	60	5.53	46.50	LiCl·H <sub>2</sub> O + 2·1·4
"	38.86	0.0	"	"	9.68	41.07	2·1·4
20	0.0	45.28	LiCl·2H <sub>2</sub> O+LiCl·H <sub>2</sub> O	"	13.61	37.74	"
"	0.81	44.67	LiCl·H <sub>2</sub> O + 4·1·10	"	17.93	33.89	"
"	0.86	44.53	4·1·10	"	19.15	33.13	1·1·2
"	3.73	39.26	"	"	23.71	29.09	MnCl <sub>2</sub> ·2H <sub>2</sub> O
"	9.09	34.82	"	"	33.00	15.62	"
"	14.39	31.45	"	"	41.58	8.14	"
CI	16.47	30.11	"	"	51.60	0.0	" + MnCl <sub>2</sub> ·4H <sub>2</sub> O
"	17.25	29.65	" + 1·1·5	80	0.0	52.88	LiCl·H <sub>2</sub> O
"	18.26	28.50	1·1·5	"	5.25	49.47	"
"	19.13	27.65	"	"	7.78	48.33	" + 2·1·2
"	19.91	26.74	MnCl <sub>2</sub> ·2H <sub>2</sub> O	"	8.94	47.10	2·1·2
"	22.25	23.82	" + MnCl <sub>2</sub> ·4H <sub>2</sub> O	"	9.44	46.37	"
"	21.28	22.47	MnCl <sub>2</sub> ·4H <sub>2</sub> O	"	12.16	43.72	" + 1·1·2
"	28.75	11.51	"	"	17.82	36.79	1·1·2
"	42.36	0.0	"	"	21.62	33.28	"
35	2.55	45.14	LiCl·H <sub>2</sub> O + 2·1·4	"	27.52	28.23	" + MnCl <sub>2</sub> ·2H <sub>2</sub> O
"	5.48	40.53	2·1·4	"	35.11	15.02	MnCl <sub>2</sub> ·2H <sub>2</sub> O
"	10.66	35.93	"	"	52.03	0.0	"
"	12.99	34.26	"	99	0.0	55.84	LiCl
"	18.86	30.08	"	"	6.27	51.96	"
"	20.29	29.11	" + MnCl <sub>2</sub> ·2H <sub>2</sub> O	"	7.28	50.75	" + 2·1·2
"	21.57	26.40	MnCl <sub>2</sub> ·2H <sub>2</sub> O	"	8.81	49.47	2·1·2
"	28.77	17.98	"	"	13.23	44.26	"
"	29.07	17.66	" + MnCl <sub>2</sub> ·4H <sub>2</sub> O	"	17.83	39.77	"
"	31.00	13.76	MnCl <sub>2</sub> ·4H <sub>2</sub> O	"	20.63	37.25	" + 1·1·2
"	33.71	10.72	"	"	27.62	30.22	1·1·2
"	45.46	0.0	"	"	31.77	26.82	" + MnCl <sub>2</sub> ·2H <sub>2</sub> O
60	0.0	49.61	LiCl·H <sub>2</sub> O	"	36.15	15.89	MnCl <sub>2</sub> ·2H <sub>2</sub> O
"	1.37	48.68	"	"	53.40	0.0	"
"	4.31	47.10	"				

1·1·5 = LiCl·MnCl<sub>2</sub>·5H<sub>2</sub>O;

2·1·2 = 2LiCl·MnCl<sub>2</sub>·2H<sub>2</sub>O;

1·1·2 = LiCl·MnCl<sub>2</sub>·2H<sub>2</sub>O.

4·1·10 = 4LiCl·MnCl<sub>2</sub>·10H<sub>2</sub>O;

2·1·4 = 2LiCl·MnCl<sub>2</sub>·4H<sub>2</sub>O;

## THE SYSTEM LITHIUM CHLORIDE - SODIUM CHLORIDE - WATER

### Results at 25°

(Smith, Elgersma and Hardenberg, 1924.)

The saturated solutions were analyzed by a viscometric method and also by a modified synthetic method.

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
LiCl	NaCl	LiCl	NaCl	LiCl	NaCl
45.8	0.0	35.7	0.3	17.4	7.3
45.5	0.5	33.5	0.4	16.9	8.4
41.3	0.4	33.5	0.3	6.5	19.0
40.1	0.2	31.6	0.8	0.0	26.4
36.8	0.3	24.9	2.3		

(Cont.)

## THE SYSTEM LITHIUM CHLORIDE - SODIUM CHLORIDE - WATER—Cont.

Results at 40° (Blidin, 1953c)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
LiCl	NaCl		LiCl	NaCl	
47.98	0.0	LiCl·H <sub>2</sub> O	25.48	5.26	NaCl + ~ 4% LiCl
46.51	0.68	" + NaCl	17.52	10.13	" + "
44.76	0.82	NaCl + ~ 4% LiCl	6.14	19.05	" + "
41.60	1.04	" + "	0.0	26.65	" + "
33.96	3.17	" + "			

Cl

THE SYSTEM LITHIUM CHLORIDE - NICKEL CHLORIDE - WATER  
(Benrath, 1932a)

Incomplete results are also given for the isotherms at 20°, 30°, 35°, 40.5°, 60° and 75°.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
NiCl <sub>2</sub>	LiCl	Solid Phase	NiCl <sub>2</sub>	LiCl	Solid Phase
Results at 0°			Results at 25°—Cont.		
0	40.51	LiCl·2H <sub>2</sub> O	10.12	26.90	NiCl <sub>2</sub> ·4H <sub>2</sub> O
0.38	40.42	" + 4.1.10	17.12	19.52	"
2.45	36.24	4.1.10 + NiCl <sub>2</sub> ·4H <sub>2</sub> O	27.55	16.43	"
3.14	33.58	NiCl <sub>2</sub> ·4H <sub>2</sub> O	26.79	10.58	NiCl <sub>2</sub> ·6H <sub>2</sub> O
4.83	30.57	"	33.56	4.94	"
9.08	22.64	NiCl <sub>2</sub> ·6H <sub>2</sub> O	39.58	0.0	"
34.08	0.0	"			
Results at 17.5°			Results at 50°		
0.0	44.61	LiCl·2H <sub>2</sub> O	0	48.18	LiCl·H <sub>2</sub> O
0.28	42.61	4.1.10	0.26	48.11	" + 2.1.4
0.40	43.97	"	1.11	43.36	2.1.4
2.33	38.78	"	3.59	39.17	"
3.84	36.83	NiCl <sub>2</sub> ·2H <sub>2</sub> O + NiCl <sub>2</sub> ·4H <sub>2</sub> O	2.84	40.24	NiCl <sub>2</sub> ·2H <sub>2</sub> O
9.32	26.65	NiCl <sub>2</sub> ·4H <sub>2</sub> O	3.87	37.72	"
13.64	22.04	"	10.97	28.39	"
18.49	17.65	"	15.12	24.60	"
15.99	19.73	NiCl <sub>2</sub> ·6H <sub>2</sub> O	29.44	12.78*	"
20.56	14.69	"	18.25	21.61	NiCl <sub>2</sub> ·4H <sub>2</sub> O
37.07	0.0	"	22.43	17.38	"
			27.69	12.70	"
			35.05	6.60	"
			40.20	2.38	"
			43.17	0.0	"
Results at 25°			Results at 99.5°		
0	45.90	LiCl·H <sub>2</sub> O	0.0	55.84	LiCl
0.21	45.17	" + 2.1.4	0.55	55.50	" + 1.1.2
0.50	42.92	2.1.4	0.72	54.66	1.1.2
2.46	38.93	"	1.42	48.66	"
3.11	38.17	" + NiCl <sub>2</sub> ·2H <sub>2</sub> O	5.25	40.58	" + NiCl <sub>2</sub> ·2H <sub>2</sub> O
3.18	37.85	NiCl <sub>2</sub> ·2H <sub>2</sub> O	8.49	34.24	NiCl <sub>2</sub> ·2H <sub>2</sub> O
3.46	37.56	"	14.86	26.71	"
4.43	35.95	"	28.85	14.49	"
6.98	30.96	NiCl <sub>2</sub> ·4H <sub>2</sub> O	36.30	8.97	"
			46.71	0.0	"

\*Metastable

4.1.10 = 4LiCl·NiCl<sub>2</sub>·10H<sub>2</sub>O; 2.1.4 = 2LiCl·NiCl<sub>2</sub>·4H<sub>2</sub>O; 1.1.2 = LiCl·NiCl<sub>2</sub>·2H<sub>2</sub>O

# LI LITHIUM

## THE SYSTEM LITHIUM CHLORIDE - LEAD CHLORIDE - WATER AT 25° (Deacon, 1927)

Gms. per 1000 gms. H <sub>2</sub> O		Solid Phase	Gms. per 1000 gms. H <sub>2</sub> O		Solid Phase
LiCl	PbCl <sub>2</sub>		LiCl	PbCl <sub>2</sub>	
830.5	0.0	LiCl·H <sub>2</sub> O	221.6	5.61	PbCl <sub>2</sub>
830.0	17.2	"	156.2	2.58	"
835.0	31.0	"	75.88	1.53	"
835.0	72.0	"	43.77	1.39	"
834.9	101.6	" + PbCl <sub>2</sub>	21.64	1.58	"
794.1	103.4	PbCl <sub>2</sub>	7.16	2.58	"
621.8	94.43	"	6.67	2.68	"
453.9	48.71	"	3.88	4.74	"
329.2	16.36	"	0.0	10.87	"

## THE SYSTEM LITHIUM CHLORIDE - RUBIDIUM CHLORIDE - WATER (Bliden, 1953)

Results at 25°		Solid Phase at both temperatures	Results at 40°	
Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.	
LiCl	RbCl		LiCl	RbCl
45.95	0.0	LiCl·H <sub>2</sub> O	47.98	0.0
43.50	6.47	"	46.68	3.47
41.17	11.63	"	45.74	7.26
40.52	15.86	" + RbCl·2LiCl·4H <sub>2</sub> O	45.13	9.51
39.05	16.92	RbCl·2LiCl·4H <sub>2</sub> O	44.05	10.48
33.60	21.86	"	38.02	18.24
30.44	24.17	"	32.51	24.60
29.08	25.21	" + 3RbCl·LiCl·2H <sub>2</sub> O	30.22	27.14
28.51	21.60	3RbCl·LiCl·2H <sub>2</sub> O	26.44	25.46
26.65	19.52	"	24.43	25.17
23.26	20.04	"	21.26	25.03
19.30	21.48	"	18.45	25.66
12.98	27.45	"	15.50	28.74
8.60	35.09	"	9.78	34.63
6.75	39.87	" + RbCl	7.34	40.12
5.34	41.55	RbCl	2.50	45.26
2.60	44.17	"	0.0	49.85
0.0	48.12	"		

THE SYSTEM LITHIUM CHLORIDE - STRONTIUM CHLORIDE - WATER  
(Blidin, 1954)

Results at 25°

Results at 40°

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
LiCl	SrCl <sub>2</sub>		LiCl	SrCl <sub>2</sub>	
45.95	0.0	LiCl·H <sub>2</sub> O	47.98	0.0	LiCl·H <sub>2</sub> O
44.85	1.48	SrCl <sub>2</sub> ·2H <sub>2</sub> O	47.01	0.98	" + SrCl <sub>2</sub> ·2H <sub>2</sub> O
41.54	2.36	"	46.22	1.65	SrCl <sub>2</sub> ·2H <sub>2</sub> O
37.12	3.07	"	38.67	3.26	"
29.48	4.95	"	31.73	5.84	"
25.49	8.51	SrCl <sub>2</sub> ·6H <sub>2</sub> O	25.14	9.98	"
22.51	10.62	"	17.80	19.25	" + SrCl <sub>2</sub> ·6H <sub>2</sub> O
14.72	17.53	"	11.66	25.73	SrCl <sub>2</sub> ·6H <sub>2</sub> O
11.89	21.14	"	6.05	32.12	"
5.48	28.03	"	2.40	36.37	"
0.0	36.79	"	0.0	40.12	"

Cl

THE SYSTEM LITHIUM CHLORIDE - ZINC CHLORIDE - WATER AT 25°  
(Blidin, 1954; Blidin and Gordienko, 1954)

Results at 25°

Results at 40°

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
LiCl	ZnCl <sub>2</sub>		LiCl	ZnCl <sub>2</sub>	
0.0	81.20	ZnCl <sub>2</sub> ·1.5 H <sub>2</sub> O	0.0	81.86	ZnCl <sub>2</sub>
3.65	76.18	"	4.21	77.13	"
6.25	72.46	"	10.46	69.50	"
9.10	68.23	"	15.48	64.31	"
11.28	65.30	" + ZnCl <sub>2</sub> ·2LiCl·2.5H <sub>2</sub> O	19.56	60.07	" + ZnCl <sub>2</sub> ·2LiCl·2.5H <sub>2</sub> O
14.71	60.62	ZnCl <sub>2</sub> ·2LiCl·2.5H <sub>2</sub> O	20.62	57.48	ZnCl <sub>2</sub> ·2LiCl·2.5H <sub>2</sub> O
17.36	58.42	"	29.60	43.45	" + LiCl·H <sub>2</sub> O
20.05	53.86	"	30.16	39.60	LiCl·H <sub>2</sub> O
23.46	49.61	"	30.68	25.16	"
25.27	46.48	"	41.65	12.90	"
29.12	41.40	"	47.98	0.0	"
30.51	38.87	" + LiCl·H <sub>2</sub> O			
32.47	33.48	LiCl·H <sub>2</sub> O			
34.60	27.20	"			
36.50	20.90	"			
39.19	15.18	"			
41.43	9.17	"			
43.20	5.64	"			
45.95	0.0	"			

# Li LITHIUM

## SOLUBILITY OF LITHIUM CHLORIDE IN AQUEOUS SOLUTIONS OF ETHYL ALCOHOL AT 25° (Simmons and Freimuth, 1936)

(For additional data see Pinar de Rubies, 1913-1914 and Sarkisov and Melamud, 1953)

	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	LiCl	C <sub>2</sub> H <sub>5</sub> OH		LiCl	C <sub>2</sub> H <sub>5</sub> OH	
Cl	45.94	0.0	LiCl·H <sub>2</sub> O	27.19	56.42	LiCl·H <sub>2</sub> O
	44.90	4.45	"	25.43	60.24	"
	41.88	12.92	"	23.09	66.77	"
	40.65	14.49	"	22.41	68.96	" + LiCl
	37.02	24.39	"	22.18	72.98	LiCl
	34.17	34.24	"	22.13	74.24	"
	30.02	47.43	"	20.18	79.82	"

## SOLUBILITY OF LITHIUM CHLORIDE IN n-PROPYL ALCOHOL SOLUTIONS (Slavjanski, 1944)

The author determined the freezing points of various solutions containing lithium chloride, n-propyl alcohol, and water, and also reports several refractive indices.

Freezing t°	LiCl		n-Propyl Alcohol	
	Wt. %	Mole %	Wt. %	Mole %
-13.6	5.51	2.70	14.46	5.0
-18.31	4.75	2.55	26.30	10.0
-19.30	4.11	2.41	36.18	15.0
-20.85	3.57	2.23	44.54	20.0
-19.55	3.31	2.13	51.30	25.0
-21.00	2.15	1.97	57.92	30.0
-28.78	10.10	5.26	18.02	5.0
-30.90	9.15	5.06	25.72	10.0
-50.78	7.96	4.76	35.32	15.0
-45.01	15.88	8.29	13.60	5.0
-51.2	13.79	8.15	24.96	10.0
-58.4	22.85	11.24	0.0	0.0
-70.9	20.97	10.81	8.22	3.0
-72.5	19.68	10.51	13.22	5.0

## DISTRIBUTION OF LITHIUM CHLORIDE BETWEEN WATER AND AMYL ALCOHOL

Results at 24.9°  
(Cavanagh, 1924)

The mixtures were shaken in sealed tubes of about 600 cc. capacity. One of these was charged 10 times, precisely similarly, and provided a total of 2.5 liters of the amyl alcohol layer. These 10 successive samples of non aqueous equilibrium phase were shaken in turn with one and the same small aqueous phase (100 cc.) in a second tube, and this latter analyzed for Cl by a silver titration method. The procedure consisted essentially in the piece-meal concentration of a large amount of the phase to be analyzed, and the concentration of the LiCl dissolved therein by a piece-meal extraction of it with water.

Approx. Normality of LiCl in aq. Phase	Gm. mols. LiCl per 1000 gms.		Partition coefficient
	Aq. phase	Amyl alcohol phase	
0.05	0.051	0.000152	0.0030
0.10	0.0996	0.0003115	0.00313
0.20	0.198	0.000662	0.00335

Results at 30°  
(Dhar and Datta, 1913; Dhar, 1926a)

Normality conc. of LiCl in			Normality conc. of LiCl in		
Aq. layer (C <sub>1</sub> )	Alcoholic layer (C <sub>2</sub> )	$\frac{C_1}{C_2}$	Aq. layer (C <sub>1</sub> )	Alcoholic layer (C <sub>2</sub> )	$\frac{C_1}{C_2}$
0.65	0.0030	216.7	2.76	0.0250	110.4
1.86	0.0125	147.2	2.82	0.0275	102.6
2.34	0.0220	117.0	2.93	0.0300	97.7
2.58	0.0225	113.4	3.06	0.0325	94.1
2.68	0.0240	111.7	3.24	0.0347	93.4

THE SYSTEM LITHIUM CHLORIDE - DIOXANE - WATER AT 25°  
(Lynch, 1942)

The refractive index was used to determine the % Dioxane in the solutions.

Gms. per 100 gms. Sat. Sol.			Region of two Immiscible Liquids			
			Lighter Layer Wt. %		Heavier Layer Wt. %	
LiCl	Dioxane	Solid Phase	LiCl	Dioxane	LiCl	Dioxane
45.2	1.4	LiCl·H <sub>2</sub> O	*0.00	99.9	19.9	46.1
44.5	3.9	"	.00	99.9	18.9	45.5
44.3	4.6	" + 1:1:1	.02	99.4	16.9	44.0
37.4	10.6	1:1:1	.06	99.3	12.1	46.6
34.3	13.9	"	.20	91.5	4.92	57.9
30.8	19.6	"	.42	88.6	2.77	67.3
24.1	35.3	"				
20.9	43.7					

1:1:1 = LiCl·H<sub>2</sub>O·(C<sub>2</sub>H<sub>4</sub>)<sub>2</sub>O<sub>2</sub>

\* = Two liquid layers in equilibrium with 1:1:1 solid compound.



# Li LITHIUM

## SOLUBILITY OF LITHIUM CHLORIDE IN AQUEOUS SOLUTIONS OF URETHAN AT 25° (Palitzsch, 1928, 1929)

Gm. Mols. per 1000 gms. H <sub>2</sub> O		Solid Phase	Gm. Mols. per 1000 gms. H <sub>2</sub> O		Solid Phase
LiCl	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>		LiCl	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>	
19.92	0.0	LiCl	22.40	9.2954	LiCl + NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>
19.93	0.2463	"	14.73	48.336	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>
20.03	1.1528	"			

Freezing point data are given for the systems:

- C) LiCl + methylammonium chloride + H<sub>2</sub>O.  
LiCl + ethanolamine hydrochloride + H<sub>2</sub>O. (Garrett and Woodruff, 1951)

## SOLUBILITY OF LITHIUM CHLORIDE IN METHYL ALCOHOL (Lloyd, Brown, Glynwyn, Bonnel and Jones, 1928; Osaka and Sawaya, 1950)

t°	Wt. % LiCl in sat. sol.		Solid Phase LiCl	
	Solid Phase LiCl·3CH <sub>3</sub> OH		Solid Phase LiCl	
	LBGBJ	O & S	LBGBJ	O & S
0	31.1	24.5	--	30.5*
5	--	25.4	--	30.5*
10	--	27.6	30.6	30.5*
12.8	--	30.5	--	30.5
15	--	--	30.6 (18°-30.8) <sup>b</sup>	30.5
20	--	--	30.5	30.5
25	--	--	-- (29.1) <sup>b</sup>	29.7 <sup>a</sup>
30	--	--	30.5	30.5
40	--	--	30.6	--
50	--	--	30.7	--
60	--	--	30.9	--

\*metastable <sup>a</sup>Turner and Bissett, 1913 <sup>b</sup>Pavlopoulos and Strehlow, 1954

## SOLUBILITY OF LITHIUM CHLORIDE IN ETHYL ALCOHOL (Turner and Bissett, 1913)

t°	Gms. LiCl per 100 Gms. C <sub>2</sub> H <sub>5</sub> OH	Solid Phase	t°	Gms. LiCl per 100 Gms. C <sub>2</sub> H <sub>5</sub> OH	Solid Phase
0	14.42	LiCl·4C <sub>2</sub> H <sub>5</sub> OH	20	24.28	LiCl
5	15.04	"	30	25.10	"
10	16.77	"	40	25.38	"
15	18.79	"	50	24.40	"
17	20.31	"	60	23.46	"

## SOLUBILITY OF LITHIUM CHLORIDE IN OTHER ALCOHOLS

Alcohol	t°	Solubility	Author*
Propyl	25	16.22 gms./100 gms. solvent	(1)
n-Butyl	16	8.91 gms./100 ml. solvent	(2)
	25	12.98 <sup>a</sup> gms./100 gms. solvent	(3)
Amyl	18	7.32 gms./100 ml. solvent	(2)
	25	9.03 gms./100 gms. solvent	(1)
iso amyl	25	7.3 gms./100 ml. solvent	(4)
n-hexyl	25	5.8 "	(4)
2-ethyl hexyl	25	3.0 "	(4)
ethylene glycol	15	12.3 "	(5)
	25	14.3 gms./100 gms. solvent	(6)

\*The results of Patten and Mott, 1904 may not be reliable.

Cl

<sup>a</sup>d<sub>25</sub> = 0.8713

- |                                    |                             |
|------------------------------------|-----------------------------|
| (1) Turner and Bissett, 1913       | (4) Caley and Axilrod, 1942 |
| (2) Kato and Hagiwara, 1950        | (5) deConinck, 1905         |
| (3) Willard and Smith, 1922, 1923a | (6) Isbin and Kobe, 1945    |

## SOLUBILITY OF LITHIUM CHLORIDE IN ACETONE

t°	Gms. LiCl per 100 Gms. sat. sol.		
	(Bell, Rowlands, Bamford, Thomas and Jones, 1930)	(Miravittles, 1945)	(Laszczynski, 1894)
0	1.70	10.11	4.40
5	--	9.79	--
10	1.46	9.57	--
12	--	--	4.22
15	--	8.82	--
18	0.94*	--	--
20	1.16	8.10	--
25	--	7.67	3.94
30	0.86	7.21	--
35	--	6.80	--
37	0.60*	--	--
40	0.68	6.30	--
45	--	5.93	3.63 (46°)
50	0.60	5.61	--
53	--	--	3.03
58	--	--	2.09

\*The values at 18° and at 37° were calculated from specific conductivity measurements by Lannung, 1932.

Data for the solubility of LiCl in mixtures of acetone - H<sub>2</sub>O, phenol - H<sub>2</sub>O, dioxane - H<sub>2</sub>O, dioxane - iso amyl alcohol, and for LiCl + LiNO<sub>3</sub> mixtures in dioxane - isoamyl alcohol are reported by Sarkisov and Melamid, 1953.

# Li LITHIUM

## SOLUBILITY OF LITHIUM CHLORIDE IN QUINOLINE (Walton and Wise, 1922)

t°	Gms. LiCl per 100 gms. Quinoline	Solid Phase	t°	Gms. LiCl per 100 gms. Quinoline	Solid Phase
0	0.1515	(C <sub>9</sub> H <sub>7</sub> N) <sub>2</sub> LiCl	56.4	1.1734	(C <sub>9</sub> H <sub>7</sub> N) <sub>2</sub> LiCl
25	0.3538	"	67	1.2353	"
40	0.6175	"	75	0.8180	"
45	1.0328	"	96	0.4588	"
50	1.1107	"			

# Cl

## SOLUBILITY OF LITHIUM CHLORIDE IN PYRIDINE (Kahlenberg and Krauskopf, 1908)

In 100% Pyridine				In 97% Pyridine + 3% H <sub>2</sub> O by Volume			
t°	Gms. LiCl per 100 Gms.		Solid Phase	t°	Gms. LiCl per 100 Gms.		Solvent
	Sat. Sol.	Solvent			Sat. Sol.	Solvent	
8	11.31	12.71	LiCl·2C <sub>5</sub> H <sub>5</sub> N	22	12.50	14.31	
15		( 7.78)*		32	13.79	15.98	
28 <sup>a</sup>	11.87	13.47	"	45	15.58	18.46	
40	11.60	13.10	LiCl·C <sub>5</sub> H <sub>5</sub> N	58	16.72	20.08	
60	11.38	12.84	"	72	17.12	20.66	
80	11.71	13.27	"	97	18.35	22.48	
100	13.01	14.98	"				
		(14.26)*					

<sup>a</sup>tr. temp. about 28°

\*Laszczynski, 1894

## SOLUBILITY OF LITHIUM CHLORIDE AT 25° IN MIXTURES OF

Acetone and Benzene (Marden and Dover, 1917)		Ethyl Acetate and Benzene (Marden and Dover, 1917)	
Gms. Acetone per 100 Gms. Solvent	Gms. LiCl per 100 Gms. Solvent	Gms. Ethyl Acetate per 100 gms. Solvent	Gms. LiCl per 100 Gms. Solvent
100	2.30	100	1.78
90	1.69	90	0.147
80	0.966	80	0.028
60	0.234	70	0.005
40	0.088		
20	0.019		
10	0.009		
0	0		

## SOLUBILITY OF LITHIUM CHLORIDE IN VARIOUS ORGANIC SOLVENTS

Solvent	t°	Solubility	Author
Ethylenediamine	25	1.39 gms./100 gms. solvent	Isbin and Kobe, 1945
Monoethanolamine	25	ca. 30 "	" " "
Methyl acetate	20	12.1 gms./100 ml. solvent	Kato and Hagiwara, 1950
Ethyl Acetate	19	0.003 "	" " "
Diethyl acetate	19	14.05 "	" " "
Butylic acid	20	6.28 "	" " "

## SOLUBILITY OF LITHIUM CHLORIDE IN VARIOUS INORGANIC SOLVENTS

Solvent	t°	Solubility	Author	Cl
liq. NH <sub>3</sub>	-33.9	0.538 gms./100 gms. NH <sub>3</sub>	(1)	
	-20	0.814 "	(2)	
	0	1.532 "	(2)	
		(1.41)*		
	5	1.799 "	(2)	
	10	2.106 "	(2)	
	15	2.498 "	(2)	
	20	2.807 "	(2)	
	30	3.630 "	(2)	
Hydrazine	Room.	16 gms./100 cc. H <sub>2</sub> NNH <sub>2</sub>	(3)	
liq. SO <sub>2</sub>	25	0.00062 gms./100 gms. sat. sol.	(3)	
SeOCl <sub>2</sub>	25	3.21 gms./100 gms. sat. sol.	(4)	
POCl <sub>3</sub>	20	0.05 gms./liter sat. sol.	(5)	

\*Linhard and Stephan, 1933, 1934

- (1) Johnson and Krumboltz, 1933 (4) Wise, 1923  
 (2) Kumao and Toriumi, 1951 (5) Gutmann, 1952  
 (3) Welsh and Broderson, 1915

Fusion-point data are given for the following systems:

LiCl + KCl	(Schaeffer, 1919)
LiCl + KCl + NaCl	(Schaeffer, 1919)
LiCl + NaCl	(Schaeffer; Zemcznyny and Rimbach, 1910)
LiCl + LiOH	(Scarpa, 1915; Unzhakov, 1952)
LiCl + LiF	(Botschwar, 1933; Bergman and Banashek, 1953)
LiCl + MgCl <sub>2</sub>	(Sandonnini, 1913, 1914; Markov and Panchenko, 1955)
LiCl + MnCl <sub>2</sub>	(Sandonnini and Scarpa, 1913)
LiCl + NH <sub>4</sub> NO <sub>3</sub>	(Perman and Harrison, 1924a)
LiCl + PbCl <sub>2</sub>	(Tries, 1914)
LiCl + RbCl	(Richards and Meldrum, 1917; Zemcznyny and Rimbach, 1910; Keitel, 1925)
LiCl + SrCl <sub>2</sub>	(Sandonnini, 1911, 1911a, 1914; Banashek and Bergman, 1954)
LiCl + SnCl	(Rack, 1914)
LiCl + TiCl	(Sandonnini, 1911, 1914)
LiCl + Li <sub>2</sub> SO <sub>4</sub>	(Lesnykh and Bergman, 1953; Dergunov, 1951; Golubeva and Bergman, 1954; Klochko, 1933; Bergman and Akopov, 1953; Evseeva and Bergman, 1951)
LiCl + Li <sub>2</sub> WO <sub>4</sub>	(Kislova, Fosypaiko and Bergman, 1955)
LiCl + FeCl <sub>2</sub>	(Beusman, 1957)

(Cont.)

## Li LITHIUM

### Fusion-point data--Cont.

$\text{LiCl} + \text{Li}_2\text{SO}_4 + \text{Li}_2\text{WO}_4$	(Bergman, Kislova and Posypaiko, 1954)
$\text{LiCl} + \text{NaCl} + \text{CaCl}_2$	(Plyushchev, Komissarova, Meshchanina, and Akulkina, 1956)
$\text{LiCl} + \text{ZnCl}_2$	(Evseeva and Bergman, 1951)
$2\text{LiCl} + \text{ZnSO}_4 \rightleftharpoons \text{Li}_2\text{SO}_4 + \text{ZnCl}_2$	(Evseeva and Bergman, 1951)
$\text{LiCl} + \text{RbF} \rightleftharpoons \text{LiF} + \text{RbCl}$	(Volkov and Tumash, 1953)
$2\text{LiCl} + \text{SrF}_2 \rightleftharpoons 2\text{LiF} + \text{SrCl}_2$	(Banashchik and Bergman, 1954)
$2\text{LiCl} + \text{Na}_2\text{SO}_4 \rightleftharpoons \text{Li}_2\text{SO}_4 + 2\text{NaCl}$	(Bergman and Akopov, 1953)
$\text{LiCl} + \text{LiNO}_3$	(Blidin, 1940; Sumarokova, 1957)
$\text{LiCl} + \text{NaNO}_3 \rightleftharpoons \text{LiNO}_3 + \text{NaCl}$	(Blidin, 1940)
$\text{LiCl} + \text{LiVO}_3$	(Schmitz-Dumont and Schmitz, 1944)
$\text{LiCl} + \text{AgCl}$	(Lesnykh and Bergman, 1953b)
$2\text{LiCl} + \text{Ag}_2\text{SO}_4 \rightleftharpoons \text{Li}_2\text{SO}_4 + 2\text{AgCl}$	(Lesnykh and Bergman, 1953b)
$6\text{LiCl} + \text{Pb}_3(\text{VO}_4)_2 \rightleftharpoons 2\text{Li}_3\text{VO}_4 + 3\text{PbCl}_2$	(Bukhalova and Aleshkina, 1953)

For a study of reactions of  $\text{LiCl}$  + other alkali halides below the melting points, see Link and Wood, 1940.

## . ClO LITHIUM CHLORATE $\text{LiClO}_3$

### SOLUBILITY OF LITHIUM CHLORATE IN WATER

(Kraus and Burgess, 1927; Berg, 1929; Campbell and Griffiths, 1956)

The results are in generally good agreement. The nature of the stable saturating phase between 20 and 40° has been disputed. Campbell and Griffiths report it to be  $\text{LiClO}_3 \cdot 1/4 \text{H}_2\text{O}$ , Berg  $\text{LiClO}_3 \cdot 1/3 \text{H}_2\text{O}$ , while Kraus and Burgess thought it to be merely an anhydrous  $\text{LiClO}_3$ . The data below are those of Kraus and Burgess which were made by observing the temperature at which the last crystal of solid phase disappeared in the melt. Careful control of the temperature and vigorous stirring were necessary. The mixtures were kept under a slight excess pressure of dry nitrogen. The temperatures were read by means of a copper-constantan thermocouple.

t°	Gms. $\text{LiClO}_3$ per 100 gms. sat. sol.	Solid Phase
-8.7	15.76	Ice
-13.2	20.73	"
-17.4	24.44	"
-23.3	28.68	"
-30.5	32.71	"
-36.6	35.38	"
-40.0	37.00	" + $\text{LiClO}_3 \cdot 3\text{H}_2\text{O}$
-43.3 <sup>a</sup>	37.3	" + "
-37.1	38.10	$\text{LiClO}_3 \cdot 3\text{H}_2\text{O}$
-33.9	39.05	"
-15.7	45.35	"
-8.8	47.94	"
-4.8	50.49	"
-1.8	51.95	"
+2.2	54.57	"
4.8	56.66	"
6.1	58.16	"
7.3	60.15	"

<sup>a</sup>Campbell and Griffiths, using solubility methods.

(Cont.)

## SOLUBILITY OF LITHIUM CHLORATE IN WATER--CONT.

t°	Gms. $\text{LiClO}_3$ per 100 gms. sat. sol.	Solid Phase
8.0 m. pt.	62.60	$\text{LiClO}_3 \cdot 3\text{H}_2\text{O}$
7.9	63.44	"
7.4	64.88	"
6.0	67.18	"
3.4	69.74	"
+1.5 Eutec.	71.1	" + $\text{LiClO}_3 \cdot \text{H}_2\text{O}$
-0.1 <sup>a</sup>	73.1	" + "
-1.7	72.59*	"
-3.6	73.74*	"
-7.6	75.15*	"
-9.0 Eutec.	75.7*	" + $\text{LiClO}_3 \cdot 1/4\text{H}_2\text{O}$ ClO
-10.5 <sup>a</sup>	78.7*	" + "
-13.6	72.25*	"
-25.0 Eutec.	81.0	" + $\beta\text{LiClO}_3$
-25.0 <sup>a</sup>	82.7	" + "
3.8	71.89	$\text{LiClO}_3 \cdot \text{H}_2\text{O}$
6.0	72.60	"
9.1	73.74	"
14.0	76.08	"
18.9	78.54	"
21.0 tr. pt.	81.2	" + $\text{LiClO}_3 \cdot 1/4\text{H}_2\text{O}$
20.5 <sup>a</sup>	81.9	" + "
-3.2	76.59*	$\text{LiClO}_3 \cdot 1/4\text{H}_2\text{O}$
+2.9	77.59*	"
8.4	78.33*	"
12.8	79.26*	"
16.4	79.68*	"
22.1	81.68	"
27.4	82.17	"
32.3	83.43	"
36.5	84.94	"
41.5 tr. pt.	86.6	" + $\beta\text{LiClO}_3$
42.0 <sup>a</sup>	--	" + "
36.9	86.27*	$\beta\text{LiClO}_3$
48.7	87.0	"
64.4	88.81	"
71.9	90.35	"
86.3	92.45	"
95.7	94.05	"
99.0 tr. pt.	94.9	" + $\alpha\text{LiClO}_3$
103.0	95.08	$\alpha\text{LiClO}_3$
107.5	96.01	"
115.2	97.43	"
123.0	98.86	"
127.3 m. pt.	100.00	"

<sup>a</sup>Campbell and Griffiths, using solubility methods.

\*metastable

# Li LITHIUM

## ClO LITHIUM PERCHLORATE $\text{LiClO}_4$

### SOLUBILITY OF LITHIUM PERCHLORATE IN WATER (Simmons and Ropp, 1928)

t°	d. of sat. sol.	Gms. $\text{LiClO}_4$ per 100 gms. sat. sol.	Solid Phase
- 2.05	--	9.8*	ICE
- 4.3	--	14.6*	"
- 9.3	--	19.8*	"
-16.0	--	24.8*	" + $\text{LiClO}_4 \cdot 3\text{H}_2\text{O}$
-18.0	--	-- *	$\text{LiClO}_4 \cdot 3\text{H}_2\text{O}$
- 2.5	--	28.9*	"
0	1.215	29.90	"
10	1.236	32.88	"
10.5	--	33.0*	"
20	1.258	35.95	"
25	1.269	37.48	"
	1.2683	37.385†	"
27.3	--	37.2*	"
30	1.277	38.87	"
40	1.300	41.97	"
41.4	--	40.5*	"
64.6	--	50.0	"
77.9	--	55.0	"
89.2	--	60.0	"
92.3	--	62.5	"
94.3	--	65.0	"
95.1 m. pt.	--	66.32	"
94.8	--	66.67	"
93.2	--	70.00	"
92.7	--	70.3	"
92.53	--	70.33	" + $\text{LiClO}_4 \cdot \text{H}_2\text{O}$
93.2	--	70.5	$\text{LiClO}_4 \cdot \text{H}_2\text{O}$
97.3	--	71.0	"
108.9	--	72.8	"
120.7	--	75.0	"
136.9	--	80.0	"
144.0	--	82.5	"
148.5	--	85.0	"
149.0 m. pt.	--	86.5	"
149.3	--	87.5	"
144.2	--	90.0	"
145.75 tr. pt.	--	--	" + $\text{LiClO}_4$
167.5	--	91.04	$\text{LiClO}_4$
172.0	--	91.11	"
236.0 m. pt.	--	100.00	"

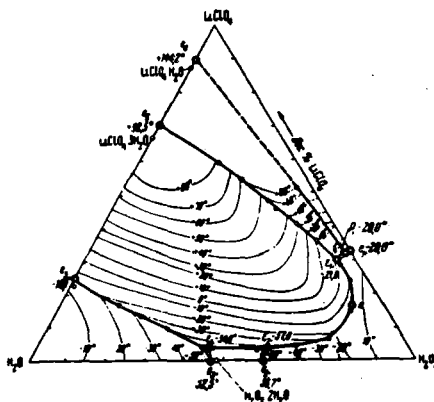
† Willard and Smith, 1923

\* Mironov, Pronina and Tokareva, 1958

THE SYSTEM LITHIUM PERCHLORATE - HYDROGEN PEROXIDE  
(Mironov, Pronina and Tokareva, 1958)

t°	Wt. % LiClO <sub>4</sub> in Sat. Sol.	Solid Phase	t°	Wt. % LiClO <sub>4</sub> in Sat. Sol.	Solid Phase
-0.4	0.0	H <sub>2</sub> O <sub>2</sub>	-9.2	25.0	H <sub>2</sub> O <sub>2</sub>
-0.5	5.0	"	-15.0	30.3	"
-1.8	9.7	"	-2.0	38.1	LiClO <sub>4</sub>
-6.0	16.6	"	+36	45.1	"

THE SYSTEM LITHIUM PERCHLORATE - HYDROGEN PEROXIDE - WATER  
(Mironov, Pronina and Tokareva, 1958)



Ternary Invariant Points:

	t°	Wt. % H <sub>2</sub> O <sub>2</sub>	Wt. % LiClO <sub>4</sub>	Solid Phases
P	-20	66	32	H <sub>2</sub> O <sub>2</sub> + LiClO <sub>4</sub> + LiClO <sub>4</sub> ·H <sub>2</sub> O
E <sub>1</sub>	-21	65	30	H <sub>2</sub> O <sub>2</sub> + LiClO <sub>4</sub> ·H <sub>2</sub> O + LiClO <sub>4</sub> ·3H <sub>2</sub> O
E <sub>2</sub>	-57	57	4	H <sub>2</sub> O <sub>2</sub> + LiClO <sub>4</sub> ·3H <sub>2</sub> O + H <sub>2</sub> O <sub>2</sub> ·2H <sub>2</sub> O
E <sub>3</sub>	-54	42	4	Ice + H <sub>2</sub> O <sub>2</sub> ·2H <sub>2</sub> O + LiClO <sub>4</sub> ·3H <sub>2</sub> O

SOLUBILITY OF LITHIUM PERCHLORATE IN ORGANIC SOLVENTS

Results with Anhydrous LiClO<sub>4</sub> at 25°  
(Willard and Smith, 1923)

Solvent	d. of solvent	d. of sat. sol.	Gms. LiClO <sub>4</sub> per 100 gms. sat. sol.
Water	--	1.2683	37.385
Methyl alcohol	0.78705	1.3849	64.57
Ethyl alcohol	0.78517	1.3173	60.28
n Propyl alcohol	0.7989	1.2006	51.22
n Butyl alcohol	0.8059	1.1326	44.23
iso Butyl alcohol	0.7981	1.0602	36.73
Acetone	0.7852	1.3233	57.72
	--	--	58.83 <sup>a</sup>
Ethyl acetate	0.89457	1.3005	48.75
Ethyl ether	0.70817	1.2116	53.21

<sup>a</sup>Miravittles, 1945



# Li LITHIUM

C10 Solubility of the Trihydrate  $\text{LiClO}_4 \cdot 3\text{H}_2\text{O}$  at  $25^\circ$   
(Willard and Smith, 1928)

Solvent	d. of sat. sol.	Gms. $\text{LiClO}_4$ per 100 gms. sat. sol.
Methyl alcohol	1.1420	60.95
Ethyl alcohol	1.0241	42.16
<u>n</u> Propyl alcohol	0.9349	26.82
<u>n</u> Butyl alcohol	0.9082	21.40
<u>iso</u> Butyl alcohol	0.8887	18.85
Acetone	1.0965	49.04
Ethyl acetate	1.0492	26.35
Ethyl ether	0.7091	0.196

SOLUBILITY OF LITHIUM PERCHLORATE TRIHYDRATE IN MIXTURES  
OF ETHYL ALCOHOL AND ETHYL ACETATE AT  $25^\circ$   
(Smith, 1925)

Vol. percent $\text{C}_2\text{H}_5\text{OH}$ in solvent	Gms. $\text{LiClO}_4$ per 100 gms. sat. sol.	Vol. percent $\text{C}_2\text{H}_5\text{OH}$ in solvent	Gms. $\text{LiClO}_4$ per 100 gms. sat. sol.
0.0 (= $\text{CH}_3\text{COOC}_2\text{H}_5$ )	26.35	60.0	38.58
10.0	31.05	70.0	39.79
20.0	33.59	80.0	40.84
30.0	35.10	90.0	41.77
40.0	36.51	100.0	42.16
50.0	37.96		

## CrO LITHIUM CHROMATE $\text{Li}_2\text{CrO}_4$

SOLUBILITY IN WATER  
(Hartford, Costa and Moore, 1952)

t°	Gms. $\text{Li}_2\text{CrO}_4$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{Li}_2\text{CrO}_4$ per 100 gms. sat. sol.	Solid Phase
0.7	47.27	$\text{Li}_2\text{CrO}_4 \cdot 2\text{H}_2\text{O}$	60.0	53.52	$\text{Li}_2\text{CrO}_4 \cdot 2\text{H}_2\text{O}$
7.2	47.74	"	70.0	55.27	"
10.4	47.89	"	74.6	56.12	" + $\text{Li}_2\text{CrO}_4$
20.0	48.60	"	75.1	56.17	$\text{Li}_2\text{CrO}_4$
29.8	49.62	"	80.0	56.34	"
30	49.94 <sup>a</sup>	"	90.0	56.57	"
40.2	50.66	"	100.0	56.82	"
50.1	52.10	"			

<sup>a</sup>Schreinemakers, 1906a

SOLUBILITY OF  $\text{Li}_2\text{CrO}_4$  IN ORGANIC SOLVENTS  
(Hartford, Costa and Moore, 1952)

Solvent	t°	Gms. $\text{Li}_2\text{CrO}_4$ /100 gms. sat. sol.
Methanol	0.5	13.4
	24.4	15.7
Ethanol	0.5	1.6
	24.4	1.8
Acetone	24.4	ca. 0.0025

Melting points have been determined for:

$\text{Li}_2\text{CrO}_4 + \text{LiOH}$	(Reshetnikov and Diogenov, 1952, 1953)
$\text{Li}_2\text{CrO}_4 + 2\text{NaOH} \rightleftharpoons 2\text{LiOH} + \text{Na}_2\text{CrO}_4$	(Reshetnikov and Diogenov, 1953)
$\text{Li}_2\text{CrO}_4 + \text{Na}_2\text{CrO}_4$	( " " " )
$\text{Li}_2\text{CrO}_4 + \text{Li}_2\text{WO}_4$	(Kislova, Posypaiko and Bergman, 1955)

LITHIUM DICHROMATE  $\text{Li}_2\text{Cr}_2\text{O}_7$

CrO

SOLUBILITY OF LITHIUM DICHROMATE IN WATER  
(Hartford and Lane, 1948)

t°	Gms. $\text{Li}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$ per 100 gms.	Solid Phase	t°	Gms. $\text{Li}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$ per 100 gms.	Solid Phase
	Sat. Sol.			Sat. Sol.	
-6.2	20.14	Ice	0.8	62.36	$\text{Li}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$
-12.0	29.97	"	*30.0	65.11	"
-17.2	34.82	"		65.4 <sup>a</sup>	"
-24.0	41.10	"	40.0	66.08	"
-35.4	47.39	"	50.0	67.28	"
-49.8	52.32	"	60.0	68.39	"
-70†	56.5	" + $\text{Li}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$	70.0	69.49	"
			80.0	70.76	"
			90.0	72.26	"
			100.0	73.55	"

†Approx.

The densities of the solutions at 30° were also determined.

\* Density = 1.567 (by extrapolation)

<sup>a</sup>Schreinemakers, 1906a.

# Li LITHIUM

CrO

THE SYSTEM LITHIUM OXIDE - CHROMIC OXIDE - WATER AT 30°  
(Schreinemakers, 1906a)

Composition in Weight percent:

Of Solution		Of Residue		Solid Phase
% CrO <sub>3</sub>	% Li <sub>2</sub> O	% CrO <sub>3</sub>	% Li <sub>2</sub> O	
0.0	7.09	--	--	LiOH·H <sub>2</sub> O
6.986	7.744	4.322	18.538	"
16.564	8.888	10.089	19.556	"
25.811	10.611	15.479	21.106	"
33.618	12.886	24.365	19.398	"
37.411	14.306	44.555	17.411	" + Li <sub>2</sub> CrO <sub>4</sub> ·2H <sub>2</sub> O
37.588	14.381	36.331	18.552	" + "
37.495	13.311	51.075	16.384	Li <sub>2</sub> CrO <sub>4</sub> ·2H <sub>2</sub> O
40.280	10.858	--	--	"
43.404	11.809	53.793	14.070	" + Li <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> ·2H <sub>2</sub> O
45.130	9.515	56.085	10.190	Li <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> ·2H <sub>2</sub> O
47.945	7.951	58.029	9.238	"
57.031	6.432	65.560	8.733	"
67.731	5.713	71.687	8.513	" + CrO <sub>3</sub>
67.814	5.689	80.452	3.780	" + "
65.200	4.661	--	--	CrO <sub>3</sub>
63.257	2.141	85.914	0.758	"
62.28	--	--	--	"

## F LITHIUM FLUORIDE LiF

SOLUBILITY OF LITHIUM FLUORIDE IN WATER

t°	d. of sat. sol.	Gms. LiF per 100 gms. H <sub>2</sub> O	Authority
0	--	0.120	(Payne, 1937)
18	1.003	0.27 (?)	(Mylius and Funk, 1897)
	--	0.125	(Carnot, 1890)
25	---	0.151	(Carter, 1928)
	--	0.132	(Meyer and Dunkel, 1931)
	0.9984	0.133	(Payne, 1937)
	--	0.13	(Tananaev, 1954)
	--	0.132	(Fatena and Karagunis, 1936)
	--	0.1234	(Talipov and Antipov, 1952)
35	0.9958	0.135	(Payne, 1937)

Selected results of Booth and Bidwell, 1950 at higher temperatures:

t°	Gms. LiF per 100 gms. H <sub>2</sub> O	t°	Gms. LiF per 100 gms. H <sub>2</sub> O
202	0.1118	300	0.0493
232	0.0718	350	0.0370
252	0.0582	375	0.0222

Results above the critical point are also given.

THE SYSTEM LITHIUM FLUORIDE - HYDROGEN FLUORIDE - WATER AT 25°  
(Tananaev, 1954)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
LiF	HF		LiF	HF	
0.13	0.0	LiF	0.41	28.85	LiF·HF
0.24	2.19	"	0.39	33.86	"
0.28	4.24	"	0.35	36.57	"
0.32	9.03	"	0.28	44.27	"
0.34	17.10	"	0.30	47.00	"
0.58	27.67	"	0.39	62.40	"
			1.27	71.40	"
			1.77	75.10	"

SOLUBILITY OF LITHIUM FLUORIDE IN OTHER SOLVENTS

Solvent	t°	Solubility	Author
Acetone	18	0.00000033 gm. LiF/100 gm. solvent	(1)
	37	0.0000004 "	(1)
Ethyl ether	25	0.05 "	(2)
Tetrahydrofuran	25	0.6 "	(2)
Bromine trifluoride	25	0.467 gm. LiF/100 gm. sat. sol.	(3)
	70	0.303 "	(3)
Hydrogen fluoride	-23.0 10.3	gm. LiF/100 gms. solvent	(4)
	-12.2 10.3	"	(4)
	- 3.3 10.3	"	(4)
	18 2.6	gms. LiF/100 cc. sat. sol.	(5)
	0-40 5.59*	gms. LiF/100 gms. solvent	(6)

\*Bond and Stowe, 1931, show that the reaction  $\text{LiF} + \text{HF} = \text{LiHF}_2$  occurs and the molecular ratio LiF : HF in the saturated solution at temperatures between 0° and 40°, is approximately 0.043.

- (1) Lannung, 1932
- (2) Elliott, Roth, Roedel and Boldebeck, 1952
- (3) Sheft, Hyman and Katz, 1953
- (4) Jache and Cady, 1952
- (5) Fredenhagen and Cadenbach, 1930, 1931, 1933
- (6) Bond and Stowe, 1931

LITHIUM Titanium FLUORIDE  $\text{Li}_2\text{TiF}_6 \cdot 2\text{H}_2\text{O}$

SOLUBILITY IN WATER AND IN ETHYL ALCOHOL AT 20-22°  
(Ginsberg, 1932)

Solvent	Gms. $\text{Li}_2\text{TiF}_6$ per 100 cc. Solvent	Solid Phase
Water	about 56	$\text{Li}_2\text{TiF}_6 \cdot 2\text{H}_2\text{O}$
"	48	$\text{Li}_2\text{TiF}_6$
98% $\text{C}_2\text{H}_5\text{OH}$	0.035	$\text{Li}_2\text{TiF}_6 \cdot 2\text{H}_2\text{O}$
"	0.030	$\text{Li}_2\text{TiF}_6$

## Li LITHIUM

F Melting point data are given for:

LiF + LiVO <sub>3</sub>	(Schmitz-Dumont and Schmitz, 1944)
LiF + YF <sub>3</sub>	(Dergunov, 1948)
LiF + NaF	(Bergman and Dergunov, 1941, 1941a)
LiF + MgF <sub>2</sub>	(Bergman and Dergunov, 1941; Tacchini, 1924; Counts, Roy and Osborn, 1953)
LiF + MgF <sub>2</sub> + NaF	(Bergman and Dergunov, 1941)
LiF + LiOH	(Scarpa, 1915)
LiF + Li <sub>2</sub> MoO <sub>4</sub>	(Schmitz-Dumont and Weeg, 1951)
LiF + Li <sub>2</sub> CrO <sub>4</sub>	( " " " " )
LiF + Li <sub>2</sub> WO <sub>4</sub>	( " " " " ; Kislova, Posypaiko and Bergman, 1955)
LiF + Li <sub>2</sub> SiO <sub>3</sub>	(Bergman, Nesterova and Bychkova, 1955; Bergman and Bychkova, 1955)
LiF + SrF <sub>2</sub>	(Banashchik and Bergman, 1954)
LiF + RbF	(Volkov and Tumash, 1953)
LiF + Li <sub>2</sub> CO <sub>3</sub>	(Schmitz-Dumont and Heckmann, 1949)
LiF + MoO <sub>3</sub>	(Schmitz-Dumont and Heckmann, 1952)
LiF + WO <sub>3</sub>	(Schmitz-Dumont, Bruns and Heckmann, 1953)
2LiF + Na <sub>2</sub> SO <sub>4</sub> = Li <sub>2</sub> SO <sub>4</sub> + 2NaF	(Speranskaya and Bergman, 1955)

The reactions of LiF with other alkali halides below the melting points were studied by Link and Wood, 1940.

## GeO LITHIUM GERMANATE 3LiGeO<sub>3</sub>·H<sub>2</sub>O

100 gms. sat. solution of Lithium Germanate in Water contain 0.84 gm. LiGeO<sub>3</sub> at 25°. (Pugh, 1926)

## I LITHIUM IODIDE LiI

### SOLUBILITY IN WATER

(Kremers, 1858, 1860; ice curve, Jones, 1907; above 70°, Huttig and Pohle, 1924)

t°	Gms. per 100 Gms.		Solid Phase	t°	Gms. per 100 Gms.		Solid Phase
	Water	Sat. Sol.			Water	Sat. Sol.	
- 0.296	1.08	1.06	Ice	30	171	63.1	LiI·3H <sub>2</sub> O
- 1.218	4.36	4.19	"	40	179	64.2	"
- 2.70	8.71	8.02	"	50	187	65.2	"
- 6.14	17.69	15.03	"	60	202	66.9	"
-16.2	38.31	27.70	"	70	230	69.7	"
-25	48.67	32.72	"	75	263	72.5	"
-59	85.13	46	"	75 m. pt.	--	--	"
-69*	93	48.2	" + LiI·3H <sub>2</sub> O	71.5	286	74.1	"
-91	107	51.7 <sup>c</sup>	" + "	70.5	297	74.8	" + LiI·2H <sub>2</sub> O
-60	100	50	LiI·3H <sub>2</sub> O	71.5	306	75.4	LiI·2H <sub>2</sub> O
-40	118	54.13	"	79	372	78.9	" + "
-20	134	57.27	"	77	437	81.4	" + LiI·H <sub>2</sub> O
0	151	60.2	"	80	433	81.3	LiI·H <sub>2</sub> O
	147	59.54 <sup>d</sup>	"	88	437	81.4	"
10	157	61.1	"	99	476	82.6	"
18	158	61.2 <sup>a</sup>	"	120	588	85.5	"
20	165	62.2	"	130	743	88.1	"
25	167	62.6	"	130	782	88.8	"
	160	61.6 <sup>b</sup>	"	130	826	89.2	" + LiI· $\frac{1}{2}$ H <sub>2</sub> O
	162	61.90 <sup>d</sup>	"	130	835	89.3	LiI· $\frac{1}{2}$ H <sub>2</sub> O

\*Eutec.

<sup>a</sup>Alanning, 1934;

<sup>b</sup>Robertson, 1933; <sup>c</sup>Huttig and Stevemann, 1927;

<sup>d</sup>Roger, 1944.

THE SYSTEM LITHIUM IODIDE - LEAD IODIDE - WATER  
(Demassieux and Roger, 1937; Roger, 1944)

The authors studied the system at 0°, 25°, 50°, and 60°, but present tables of data only for 25°. The 0° isotherm is discussed and a diagram drawn, but at 50° and 60° it is simply stated that "The curves have the same form as at 0° and 25°." The refractive indices were also determined.

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
PbI <sub>2</sub>	LiI	d <sub>25</sub> 4		PbI <sub>2</sub>	LiI	d <sub>25</sub> 4	
Results at 0°				Results at 25°--Cont.			
0.041	0.0	--	PbI <sub>2</sub>	18.17	35.68	1.695	PbI <sub>2</sub>
0	4	--	"	21.09	36.25	1.778	"
6	30	--	"	22.36	36.69	1.838	"
30.52	37.83	--	" + 1:1:4	26.01	38.08	1.986	"
20.24	48.41	--	1:1:4+LiI·3H <sub>2</sub> O	30.17	38.51	2.132	"
0.0	59.54	--	LiI·3H <sub>2</sub> O	31.91	38.53	2.192	" + 1:1:4
Results at 25°				31.18	39.25	2.184	1:1:4
				28.71	40.53	2.159	"
				27.26	42.16	2.150	"
0.077	0.0	--	PbI <sub>2</sub>	26.67	42.44	2.147	"
.027	.110	--	"	25.41	43.90	2.145	"
.009	.313	--	"	24.09	44.91	2.137	"
.004	.427	--	"	23.69	45.33	2.136	"
.0019	.850	--	"	23.05	46.24	2.140	"
.0009	3.32	--	"	22.45	46.40	2.140	"
.0024	5.26	--	"	22.27	47.70	2.141	"
.0062	6.51	1.041	"	21.91	48.19	2.146	"
.067	10.62	1.074	"	21.18	49.79	2.165	" +LiI·3H <sub>2</sub> O
.53	20.95	1.182	"	20.88	49.84	2.158	LiI·3H <sub>2</sub> O
.80	24.11	1.220	"	20.58	49.96	2.152	"
.84	24.70	1.226	"	15.81	52.69	2.078	"
2.83	28.84	1.301	"	13.65	54.25	2.041	"
5.18	31.12	1.355	"	9.73	56.19	1.967	"
7.92	32.10	1.421	"	4.39	59.42	1.882	"
11.22	33.64	1.504	"	1.79	60.51	1.843	"
12.54	33.67	1.522	"	0.0	61.90	1.825	"
14.09	35.21	1.597	"	1:1:4 = LiI·PbI <sub>2</sub> ·4H <sub>2</sub> O			

THE SYSTEM LITHIUM IODIDE - ANTIMONY IODIDE - WATER  
(Francois and Delwaulle, 1936)

The results are given only in the form of a diagram from which the following approximate values were read.

Results at 13°		Results at 35°		Results at 60°		Solid Phase at each temp.
Gms. per 100 gms. H <sub>2</sub> O		Gms. per 100 gms. H <sub>2</sub> O		Gms. per 100 gms. H <sub>2</sub> O		
SbI <sub>3</sub>	LiI	SbI <sub>3</sub>	LiI	SbI <sub>3</sub>	LiI	
0	160	0	175	0	195	
50	162	50	176	50	196	LiI·3H <sub>2</sub> O
75	163	105	176	135	205	" + 1·1·6
65	130	95	150	125	185	1·1·6
55	110	85	120	115	155	"
70	80	95	100	125	135	"
85	50	80	130	150	115	"

1·1·6 = LiI·SbI<sub>3</sub>·6H<sub>2</sub>O

## LI LITHIUM

### DISTRIBUTION OF LITHIUM IODIDE BETWEEN WATER AND NITROBENZENE AT 25° (Robertson, 1933)

Gm. Mols. LiI per liter		W
H <sub>2</sub> O layer (W)	C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub> layer (Nb)	Nb
4.55	0.00140	3250
2.38	0.00222	1070
1.57	0.00363	430
1.11	0.00141	790
0.82	< 0.00012	> 6830

### DISTRIBUTION OF LITHIUM IODIDE BETWEEN ETHYLENE GLYCOL AND ETHYL ACETATE AT 30° (Dawson and Griffith, 1951)

Moles LiI per liter		K
in glycol	in ethyl acetate	
0.1336	0.000320	417
0.4759	0.000975	489

Other data, and results for LiI + NH<sub>4</sub>I mixtures are also given.

### SOLUBILITY OF LITHIUM IODIDE IN SEVERAL SOLVENTS

Solvent	t°	Gms. LiI per 100 Gms. Solvent	Solvent	t°	Gms. LiI per 100 Gms. Solvent
Methyl Alcohol	18	143(d.=1.617) <sup>a</sup>	Nitromethane	0	1.22 <sup>†d</sup>
"	25	171(d.=1.718) <sup>a</sup>	"	25	2.52 <sup>d</sup>
"	25	343.4 <sup>b</sup>	Acetone	18	42.56 <sup>e</sup>
Ethyl Alcohol	25	250.8 <sup>b</sup>	"	37	75.25 <sup>e</sup>
Propyl Alcohol	25	47.52 <sup>*b</sup>	Acetonitrile	18	147(d.=1.600) <sup>a</sup>
Amyl Alcohol	25	112.5 <sup>b</sup>	"	25	154(d.=1.627) <sup>a</sup>
Glycol	15.3	38.9 <sup>c</sup>	Formic Acid	18	139(d.=1.934) <sup>a</sup>
Furfural	25	45.9 <sup>d</sup>	"	25	146(d.=1.926) <sup>a</sup>

\*Solid phase = LiI·4C<sub>3</sub>H<sub>7</sub>OH.

† = gms. per 100 cc. sat. sol.

<sup>a</sup>Pavlopoulos and Strehlow, 1954

<sup>b</sup>Turner and Bissett, 1913

<sup>c</sup>de Coninck, 1905

<sup>d</sup>Walden, 1906

<sup>e</sup>Lannung, 1932

## I LITHIUM IODOMERCURATE 2LiI·HgI<sub>2</sub>·6H<sub>2</sub>O

100 gms. sat. solution of lithium iodomercurate in water prepared by cooling a hot solution and allowing to stand at 24.7° for 3 months, contained 1.30 gms. Li, 27.4 gms. Hg, 58 gms. I and 13.3 gms. H<sub>2</sub>O; Sp. Gr. of the sat. sol. = 3.28. (Duboin, 1905)

Freezing point data for LiI + AgI are given by Sandonnini and Scarpa, 1913.

The reactions below the melting points in each of the following systems were studied by Link and Wood (1940) by means of X-rays.

LiI + NaCl	LiI + NaBr	LiI + NaF
LiI + KCl	LiI + KBr	LiI + KF
LiI + RbCl	LiI + RbBr	LiI + CsF
LiI + CsCl	LiI + CsBr	LiI + RbF

LITHIUM IODATE  $\text{LiIO}_3$ 

10

SOLUBILITY IN WATER  
(Ricci and Amron, 1951)

There is apparently a phase transition at 50-60°, but the low temperature phase precipitated so slowly that reliable measurements were not obtained. The data below are for the "high temperature" octahedral crystals except as noted. The crystals are anhydrous.

t°	Gms. $\text{LiIO}_3$ per 100 gms. sat. sol.	t°	Gms. $\text{LiIO}_3$ per 100 gms. sat. sol.	t°	Gms. $\text{LiIO}_3$ per 100 gms. sat. sol.
9.93	47.19*	40.0	44.12*	65.3	43.00
20.24	45.86*	45.0	43.84*	75.5	42.82
24.95	45.33* <sup>a</sup>	50.1	43.51*	85.5	42.76
(25	43.86 HR) <sup>b</sup>	60.2	43.35*?	95.1	42.85
29.94	44.89*				
34.95	44.45*				

\*metastable  
density = 1.587

<sup>b</sup>density = 1.558  
(HR) = Hexagonal Rod form.

Earlier data:

t°	Solubility	Author
10	42.18 gms. $\text{LiIO}_3$ per 100 gms. sat. sol.	Luhdemann, 1935
18	23.5 " form A	Heydweiller, 1912
18	38.3 " form B	" "
18	38 " "	Gruneisen, 1905
18	44.6 " "	Mylius and Funk, 1897



# LITHIUM

## THE SYSTEM LITHIUM IODATE - IODIC ACID - WATER AT 25° (Ricci and Amron, 1951)

(A =  $\text{LiIO}_3$ ; B =  $\text{HIO}_3$ ; S.S. = solid solution)

Saturated solution			Solid Phase	% $\text{LiIO}_3$ in solid	Saturated solution			Solid Phase	% $\text{LiIO}_3$ in solid
% A	% B	Density			% A	% B	Density		
43.86	0.00	1.558	A		35.35	42.23	2.567	S.S.	71.5
43.96	1.03	1.579	A		34.70	43.54	2.602	S.S.	71.0
43.96	3.13	1.620	A		34.09	44.79	2.636	S.S.	70.5
43.83	6.67	1.697	A		33.62	45.60	--	S.S.	71
43.56	11.18	1.797	A		33.48	46.00	--	S.S.	69.8
43.08	16.65	1.923	A		32.89	47.02	2.695	S.S.	68.9
42.49	20.89	2.027	A		32.81	47.25	2.702	S.S.	69.0
41.48	26.56	--	A		29.86	52.74	2.848	S.S.	67.3
40.81	28.80	2.237	A		27.25	57.45	2.979	S.S.	65.2
40.42	30.78	2.300	A		(26.84	58.15	2.995)	S.S.+B	(65.0)*
(40.19	31.33	2.311)	A+S.S.	(78.7)*	25.91	58.56	2.961	B	
39.75	32.46	2.334	S.S.	78.2	21.08	61.25	2.827	B	
39.57	32.65	2.340	S.S.	77.8	16.48	63.91	--	B	
38.84	34.58	2.385	S.S.	76.0	10.20	68.09	2.609	B	
38.53	35.42	--	S.S.	76	7.23	70.19	--	B	
37.21	38.25	2.475	S.S.	74.0	3.50	72.92	2.514	B	
37.13	38.52	2.476	S.S.	74.0	1.24	74.62	2.487	B	
36.18	40.29	2.525	S.S.	74	0.0	75.40	--	B	
36.28	40.38	--	S.S.	72.9					

\*Figures in parentheses are averages of three determinations.

## LITHIUM PERIODATES $x\text{Li}_2\text{O} \cdot y\text{I}_2\text{O}_7 \cdot 3\text{H}_2\text{O}$

### THE SYSTEM $\text{Li}_2\text{O} - \text{I}_2\text{O}_7 - \text{H}_2\text{O}$ AT 15° (Hessaby and Souchay, 1953)

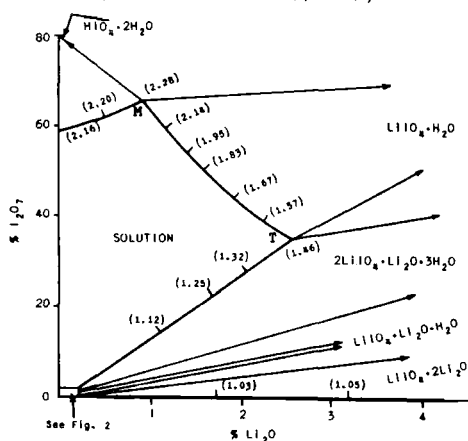


Fig. 1  
(Numbers in parentheses are densities)

M = 0.93 %  $\text{Li}_2\text{O}$ , 65%  $\text{I}_2\text{O}_7$

T = 2.53%  $\text{Li}_2\text{O}$ , 35.2%  $\text{I}_2\text{O}_7$

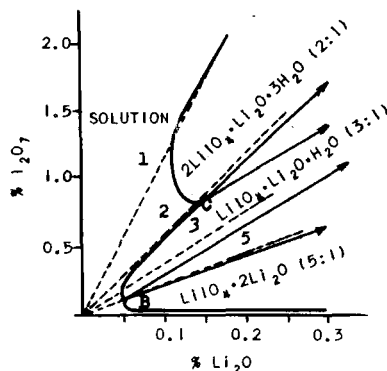
THE SYSTEM  $\text{Li}_2\text{O} - \text{I}_2\text{O}_7 - \text{H}_2\text{O}$  AT  $15^\circ$ —Cont.

Fig. 2

Enlargement of section of fig. 1. The dotted lines 1, 2, 3, and 5 indicate the mole ratios  $\text{Li}_2\text{O}/\text{I}_2\text{O}_7$ . Only  $2\text{LiIO}_4 \cdot \text{Li}_2\text{O} \cdot 3\text{H}_2\text{O}$  and  $\text{LiIO}_4 \cdot \text{Li}_2\text{O} \cdot \text{H}_2\text{O}$  are congruently soluble.

B = 0.05%  $\text{Li}_2\text{O}$ , 0.09%  $\text{I}_2\text{O}_7$

C = 0.130%  $\text{Li}_2\text{O}$ , 0.77%  $\text{I}_2\text{O}_7$

LITHIUM PERMANGANATE  $\text{LiMnO}_4 \cdot 3\text{H}_2\text{O}$ 

MnO

100 gms. water dissolve 71.4 gms. permanganate at  $16^\circ$ . (Ashoff)

LITHIUM MOLYBDATE  $\text{Li}_2\text{MoO}_4$ 

MoO

SOLUBILITY OF LITHIUM MOLYBDATE IN WATER  
(Rosenheim and Reglin, 1921)

$t^\circ$	Gms. $\text{Li}_2\text{MoO}_4$ per 100 gms. sat. sol.	Solid Phase	$t^\circ$	Gms. $\text{Li}_2\text{MoO}_4$ per 100 gms. sat. sol.	Solid Phase
0	45.24	$4\text{Li}_2\text{MoO}_4 \cdot 3\text{H}_2\text{O}$	30	44.26	$4\text{Li}_2\text{MoO}_4 \cdot 3\text{H}_2\text{O}$
20	44.30*	"	40	43.84	"
25	44.81	"	98	42.50	"

\*Wempe, 1912.

Fusion-point data for mixtures of  $\text{Li}_2\text{MoO}_4 + \text{MoO}_3$  and  $\text{LiMoO}_4 + \text{Na}_2\text{MoO}_4$  are given by Hoermann, 1929.

For the system  $\text{Li}_2\text{MoO}_4 + \text{Ag}_2\text{SO}_4 \rightleftharpoons \text{Li}_2\text{SO}_4 + \text{Ag}_2\text{MoO}_4$  see Belyaev and Doroshenko, 1956; for  $\text{Li}_2\text{MoO}_4 + \text{CdCl}_2 \rightleftharpoons 2\text{LiCl} + \text{CdMoO}_4$  see Lesnykh and Bergman, 1956.

# Li LITHIUM

## N LITHIUM NITRIDE $\text{LiN}_3$

### SOLUBILITY OF LITHIUM NITRIDE IN WATER (Rollet and Wohlgemuth, 1934)

The results in the table, except those for the eutectic and the tr. pts., were estimated approximately from the authors' diagram. The earlier results of Curtius and Rissom, 1898, are considered to be in error except the value for 16° which agrees fairly well with these.

t°	Gms. $\text{LiN}_3$ per 100 gms. sat. sol.	Solid Phase
-10	10.0	Ice
-30	20.0	"
-47.5 Eutec.	26.0	" + $\text{LiN}_3 \cdot 4\text{H}_2\text{O}$
-31 tr. pt.	33.5	$\text{LiN}_3 \cdot 4\text{H}_2\text{O}$ + $\text{LiN}_3 \cdot \text{H}_2\text{O}$
0	38.0	$\text{LiN}_3 \cdot \text{H}_2\text{O}$
+18	40.0	"
40	43.0	"
68.2 tr. pt.	48.0	" + $\text{LiN}_3$
100	50.0	$\text{LiN}_3$

## NO LITHIUM NITRITE $\text{LiNO}_2$

### SOLUBILITY IN WATER (Oswald, 1914)

t°	Gms. $\text{LiNO}_2$ per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. $\text{LiNO}_2$ per 100 Gms. Sat. Sol.	Solid Phase
- 7.5	11.1	Ice	38.5	55.5	$\text{LiNO}_2 \cdot \text{H}_2\text{O}$
-11.7	15	"	42	56.9	"
-21	21.2	"	49	60.6	"
-28.8	29	"	49.5	61.2	" + $\text{LiNO}_2 \cdot \frac{1}{2}\text{H}_2\text{O}$
-31.3	29.4	" + $\text{LiNO}_2 \cdot \text{H}_2\text{O}$	65	63.8	$\text{LiNO}_2 \cdot \frac{1}{2}\text{H}_2\text{O}$
-19.3	33.9	$\text{LiNO}_2 \cdot \text{H}_2\text{O}$	81.5	68.7	"
0	41.5	"	91	72.4	"
+19	48.9*	"	96	91.8	"
25	50.9	"	92.5	94.3	"

\*( $d_{19}$  = 1.3186)

(cont'd)

More recent determinations of the Solubility of Lithium Nitrite by Bureau, 1935, 1937, gave the following results, differing from the above.

Gms.			Gms.			
t°	LiNO <sub>2</sub> per 100 gms. sat. sol.	Solid Phase	t°	d. of sat. sol.	LiNO <sub>2</sub> per 100 gms. sat. sol.	Solid Phase
- 4.9	7.01	Ice	18.4	1.316	46.6	LiNO <sub>2</sub> ·H <sub>2</sub> O
-10.25	12.31	"	34.7	1.358	55.85	"
-24.25	21.08	"	50.9	--	63.0	" + LiNO <sub>2</sub> ·½H <sub>2</sub> O
-38.7*	26.58	" + LiNO <sub>2</sub> ·1½H <sub>2</sub> O	56.0	1.433	65.5	LiNO <sub>2</sub> ·½H <sub>2</sub> O
-22.7	32.9	LiNO <sub>2</sub> ·1½H <sub>2</sub> O	66.0	1.458	66.4	"
-10.95	40.5	"	79.5	1.495	70.2	"
- 7.95	43.5	" + LiNO <sub>2</sub> ·H <sub>2</sub> O	94.0	--	75.9	" + LiNO <sub>2</sub>
+ 1.0	44.0	LiNO <sub>2</sub> ·H <sub>2</sub> O	99.0	1.545	76.4	LiNO <sub>2</sub>

\*Eutec.

100 gms. H<sub>2</sub>O-dissolve 10.5 gms. AgNO<sub>2</sub> + 78.5 gms. LiNO<sub>2</sub> at 14°.  
(Oswald, 1914)

### LITHIUM NITRATE LiNO<sub>3</sub>

NO

#### SOLUBILITY IN WATER

(Donnan and Burt, 1903; Campbell and Bailey, 1958; Campbell, 1942; Massink, 1918; Malquori, 1928d)

The values were read from an average curve. Between 0-30° the data are scattered but in general agreement; above 30° (to 64°) Donnan and Burt report a stable hemihydrate LiNO<sub>3</sub>· $1\frac{1}{2}$ H<sub>2</sub>O; Campbell and Bailey found only the anhydrous salt above 30°. There is also disagreement on the eutectic composition.

Wt. % LiNO <sub>3</sub> in sat. sol.			Wt. % LiNO <sub>3</sub> in sat. sol.		
t°		Solid Phase	t°		Solid Phase
- 7.4	10.7 <sup>c</sup>	Ice			(Donnan and Burt, 1903)
-11.3	16.0 <sup>c</sup>	"	29.6	59	LiNO <sub>3</sub> ·3H <sub>2</sub> O+LiNO <sub>3</sub> · $\frac{1}{2}$ H <sub>2</sub> O
-17.7	22.3 <sup>c</sup>	"	35	59.5 <sup>a</sup>	LiNO <sub>3</sub> · $\frac{1}{2}$ H <sub>2</sub> O
-22.9	24.5(?) <sup>c</sup>	" + LiNO <sub>3</sub> ·3H <sub>2</sub> O	43.6	60.8	"
-17.8	33 (D.B.)	" + "	50.5	61.3	"
- 7.9	30.1(?)	LiNO <sub>3</sub> ·3H <sub>2</sub> O	55	63	"
0	34.6	"	60	63.6	"
5	36.2	"	64.2	64.9	"
10	37.8	"	70.9	66.1	"
15	39.8	"			
20	42.3	"			(Campbell and Bailey, 1958)
25	45.8	"	27.9	61.5	LiNO <sub>3</sub> ·3H <sub>2</sub> O+LiNO <sub>3</sub>
28	49.0	"	33.6	62.3	LiNO <sub>3</sub>
29.6mp	56.1	"	41.3	63.4	"
			47.1	63.6	"
			53.7	64.6	"
			70.0	66.4	"
			75.6	66.9	"
			90	68.0 <sup>b</sup>	"

<sup>a</sup>Massink, 1918

<sup>b</sup>Campbell, 1942

<sup>c</sup>Campbell and Bailey, 1958

# Li LITHIUM

## SOLUBILITY OF LITHIUM NITRATE IN HYDROGEN PEROXIDE - WATER MIXTURES (Floyd and Gross, 1955)

Read from curves drawn by the authors. A discontinuity occurs at 10-30 mole %  $\text{H}_2\text{O}_2$  in the solvent.

Mole fraction $\text{H}_2\text{O}_2$ in Solvent	Moles $\text{LiNO}_3$ per 1000 gms. solvent		
	0°	15°	25°
0.0	7.1	9.7	12.7
0.05	6.4	9.4	13.4
0.1	6.0	9.0	18.7
0.2	5.9	13.2	16.0
0.3	6.0	12.1	13.3
0.4	9.3	10.1	11.0
0.5	7.5	8.2	9.0
0.6	6.1	6.8	7.3
0.7	4.8	5.3	5.6
0.8	3.8	4.3	4.5
0.9	2.8	3.2	3.5
1.0	2.1	2.4	2.6

NO

## THE SYSTEM LITHIUM NITRATE - LITHIUM SULFATE - WATER

Massink (1918) reports two complex double salts at 35°. These data are questioned by Aravamudan (1957) on several grounds, and this author found the system to be simple. In addition, no evidence for the presence of anhydrous  $\text{Li}_2\text{SO}_4$  was obtained at 30 or 35°.

Additional data at 0°, 30° and 70° are given by Massink, 1916.

$\text{N} = \text{LiNO}_3$ ;  $\text{N} \cdot 3 = \text{LiNO}_3 \cdot 3\text{H}_2\text{O}$ ;  $\text{N}\frac{1}{2} = \text{LiNO}_3 \cdot \frac{1}{2}\text{H}_2\text{O}$ ;  $\text{S} = \text{Li}_2\text{SO}_4$ ;  $\text{S} \cdot 1 = \text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{O}$ ;  $\text{A} = 11:1:17 = 11\text{Li}_2\text{SO}_4 \cdot \text{LiNO}_3 \cdot 17\text{H}_2\text{O}$ ;  $\text{B} = 9:1:27 = 9\text{Li}_2\text{SO}_4 \cdot \text{LiNO}_3 \cdot 27\text{H}_2\text{O}$

Massink, 1918						Aravamudan, 1957					
Sat. Sol. wt. %			Sat. Sol. wt. %			Sat. Sol. wt. %			Solid		
$\text{LiNO}_3$	$\text{Li}_2\text{SO}_4$	Phase	$\text{LiNO}_3$	$\text{Li}_2\text{SO}_4$	Phase	$\text{LiNO}_3$	$\text{Li}_2\text{SO}_4$	Phase	$\text{LiNO}_3$	$\text{Li}_2\text{SO}_4$	Phase
at 25°			at 35°, cont'd.			at 35°					
47.58	0.0	N·3	50.55	~0.0	S·1+A	61.93	0.0	N			
47.60	~0	N·3, S·1	49.54	0.08	A	61.87	0.03	N+S·1			
43.45	0.19	S·1	41.83	0.17	"	60.98	0.03	S·1			
33.90	1.14	"	28.63	2.26	"	59.19	0.04	"			
18.64	8.41	"	22.18	5.16	"	55.04	0.05	"			
0.0	25.79	"	20.14	6.78	"	44.52	0.20	"			
at 35°			19.25	7.41	"	35.30	0.89	"			
			19.12	7.50	A, B	25.75	3.61	"			
59.49	~0.0	N· $\frac{1}{2}$	16.79	9.25	B	14.72	10.83	"			
61.93	~0.0	N	12.31	13.13	"	10.13	14.78	"			
61.97	~0.0	N, S	8.98	16.10	"	0.0	25.19	"			
62.14	~0.0	"	4.99	20.48	"						
59.65	~0.0	S	3.04	22.19	"						
57.91	~0.0	S, S·1	1.48	23.88	"						
52.03	~0.0	S·1	0.76	24.55	S·1						
			0.0	23.76	"						

THE SYSTEM LITHIUM NITRATE - AMMONIUM NITRATE - WATER  
(Campbell, 1942)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
NH <sub>4</sub> NO <sub>3</sub>	LiNO <sub>3</sub>		NH <sub>4</sub> NO <sub>3</sub>	LiNO <sub>3</sub>	
Results at 25°			Results at 31°		
69.2	0.0	NH <sub>4</sub> NO <sub>3</sub> IV	71.5	0.0	NH <sub>4</sub> NO <sub>3</sub> IV
55.8	9.9	"	70.0	0.6	"
49.1	17.4	"	68.2	1.6	"
43.6	25.7	"	66.2	2.9	"
40.2	31.5	"	60.5	7.7	"
38.5	35.0	"	56.5	11.4	"
37.6	39.0	" + LiNO <sub>3</sub>	47.3	22.9	"
36.9	39.5	LiNO <sub>3</sub>	43.8	32.9	"
33.8	41.0	"	42.3	34.5	"
32.2	41.8	"	42.0	38.6	" + LiNO <sub>3</sub>
29.0	43.3	"	39.9	39.3	LiNO <sub>3</sub>
20.8	47.3	"	39.3	39.9	"
19.6	48.0	"	38.4	40.5	"
14.3	50.5	"	37.7	41.1	"
14.0	51.0	" + LiNO <sub>3</sub> ·3H <sub>2</sub> O	32.2	43.0	"
12.5	49.0	LiNO <sub>3</sub> ·3H <sub>2</sub> O	31.5	43.5	"
11.5	47.5	"	24.0	47.0	"
7.0	45.0	"	14.8	51.8	"
3.8	45.0	"	9.1	53.9	"
2.8	45.3	"	5.1	56.0	"
1.0	45.6	"	3.1	56.7	"
0.0	46.0	"	1.5	57.7	"
			0.0	58.5	"
Results at 60°			Results at 90°		
81.0	0.0	NH <sub>4</sub> NO <sub>3</sub> III			
58.5	9.2	"	88.5	0.0	NH <sub>4</sub> NO <sub>3</sub> II
63.0	14.9	"	70.0	10.6	"
60.2	18.7	"	66.7	20.8	"
57.0	25.9	"	66.0	23.3	"
57.1	27.4	"	65.5	29.3	" + LiNO <sub>3</sub>
56.4	31.2	" + LiNO <sub>3</sub>	60.7	32.0	LiNO <sub>3</sub>
56.9	31.5	LiNO <sub>3</sub>	56.3	34.6	"
32.2	44.3	"	52.2	36.9	"
30.2	45.5	"	45.0	41.5	"
19.2	51.5	"	38.5	45.0	"
14.4	54.0	"	38.0	45.5	"
9.0	56.6	"	26.5	52.2	"
00.0	62.0	"	23.2	54.2	"
			17.6	57.8	"
			10.1	61.8	"
			0.0	68.0	"

# LI LITHIUM

## THE SYSTEM LITHIUM NITRATE - LEAD NITRATE - WATER AT 25° (Malquori, 1928d)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
LiNO <sub>3</sub>	Pb(NO <sub>3</sub> ) <sub>2</sub>		LiNO <sub>3</sub>	Pb(NO <sub>3</sub> ) <sub>2</sub>	
45.83	0.0	LiNO <sub>3</sub> ·3H <sub>2</sub> O	21.54	9.36	Pb(NO <sub>3</sub> ) <sub>2</sub>
44.75	2.47	"	10.88	15.50	"
40.45	2.65	" + Pb(NO <sub>3</sub> ) <sub>2</sub>	0.97	33.20	"
33.96	5.10	Pb(NO <sub>3</sub> ) <sub>2</sub>	0.57	33.12	"
29.15	6.30	"	0.0	37.07	"
28.36	8.65	"			

NO

## SOLUBILITIES IN THE SYSTEM LITHIUM NITRATE - ETHANOL - WATER (Campbell and Bailey, 1958; Campbell and Kartzmark, 1956a)

3 = LiNO<sub>3</sub>·3H<sub>2</sub>O

A = LiNO<sub>3</sub>

I = Ice

Solvent 27.2 Wt. % C <sub>2</sub> H <sub>5</sub> OH			Solvent 42.0 Wt. % C <sub>2</sub> H <sub>5</sub> OH			Solvent 49.7 Wt. % C <sub>2</sub> H <sub>5</sub> OH		
t°	Wt. % LiNO <sub>3</sub>	Solid	t°	Wt. % LiNO <sub>3</sub>	Solid	t°	Wt. % LiNO <sub>3</sub>	Solid
-17.8	0.0	I	-30.6	0.0	I	-36.0	0.0	I
-25.0	8.5	I	-38.8	5.6	I	-43.4	3.0	I
-27.1	10.2	I	-44.9	9.7	I	-48.7	8.0	I
-30.1	12.7	I	-51.0	--	I + 3	-54.2	10.4	I
-35.3	15.0	I	-41.8	12.5	3	-58.9	--	I + 3
-41.1	--	I + 3	-34.7	14.1	3	-33.7	14.1	3
-26.9	17.6	3	+15.5	33.8	3	-12.4	19.7	3
-16.6	20.3	3	21.3	39.6	3	+18.8	36.0	3
- 4.6	24.3	3	21	40.3	3m.p.	19.2	37.0	3
+13.0	35.4	3	22.4	42.8	3	20.1	38.5	3
25.0	48.6	3	22.1	47.0	3	21.8	43.7	3
25.3	52.2	3	21.6	48.7	3	21.3	45.7	3
22.2	--	3 + A	21.3	51.0	3 + A	19.5	--	3 + A
38.7	56.7	A	35.6	52.3	A	23.6	48.5	A
50.6	57.9	A	46.2	54.0	A	30.1	48.8	A

Solvent 66.4 Wt. % C <sub>2</sub> H <sub>5</sub> OH			Solvent 66.4 Wt. % C <sub>2</sub> H <sub>5</sub> OH		
t°	Wt. % LiNO <sub>3</sub>	Solid	t°	Wt. % LiNO <sub>3</sub>	Solid
-47.4	0.0	I	11.0	27.0	3
-57.9	4.9	I	13.8	29.6	3
-63.2	6.8	I	14.1	29.7	3
-73.0	9.0	I + 3	15.6	30.9	3
-62.0	10.2	3	17.5	35.6	3
-27.0	13.8	3	17.3	35.7	3
-18.2	15.5	3	16.6	40.0	3
- 7.8	18.3	3	14.8	--	3 + A
+ 4.4	23.2	3	31.1	43.0	A
10.3	26.6	3	43.1	43.9	A

(Cont.)

## SOLUBILITIES IN THE SYSTEM LITHIUM NITRATE - ETHANOL - WATER--Cont.

Solvent 78.2 Wt. % C <sub>2</sub> H <sub>5</sub> OH			Isothermal data at 25° (C. and K.)		
t°	Wt. % LiNO <sub>3</sub>	Solid	Wt. % C <sub>2</sub> H <sub>5</sub> OH	Wt. % LiNO <sub>3</sub>	Solid
-13.2	16.6	3	--	47.8	LiNO <sub>3</sub> ·3H <sub>2</sub> O
- 6.3	17.9	3	0.9	47.3	"
- 1.3	21.5	3	5.0	47.0	"
+ 0.8	24.4	3	11.6	47.8	"
1.6	26.2	3	13.5	49.2	"
2.5	27.4	3	14.1	51.9	"
5.4	30.6	3	11.2	53.5	"
5.6	31.4	3	6.9	58.0	" + LiNO <sub>3</sub> NO
~5.2	32.6	3 + A	6.6	58.4	LiNO <sub>3</sub>
11.3	32.8	A	10.3	55.7	"
24.0	34.5	A	16.9	53.2	"
28.8	35.1	A	35.8	44.5	"
31.9	35.2	A	60.0	32.8	"
43.5	36.2	A	72.9	26.3	"

THE SYSTEM LITHIUM NITRATE - TERTIARY BUTYL ALCOHOL - WATER AT 25°  
(Ginnings, Herring and Webb, 1933)

The composition of the homogeneous mixture (plait point) of the three compounds as determined by the synthetic method is 16.0 gms. LiNO<sub>3</sub> + 23.0 gms. tertiary Butyl Alcohol, (CH<sub>3</sub>)<sub>3</sub>COH, per 100 gms. sat. solution. The original results for the remaining points on the binodal curve are not given but only the values corresponding to derived empirical equations for the curve.

Results for the extraction of saturated LiNO<sub>3</sub> solutions by ether in the presence of 1M HNO<sub>3</sub> are given by Bock and Bock, 1950.

THE SYSTEM LITHIUM NITRATE - DIOXANE - WATER  
(Klochko and Grigor'ev, 1952)

The concentrations of LiNO<sub>3</sub> which cause layer separation of 1:1 (equimolar) dioxane - water mixtures were determined. Solutions containing <3.39 mole % LiNO<sub>3</sub> show no separation from 0-145°. Those >28.44 mole % LiNO<sub>3</sub> show none from 0-80°. The "layer-separation" zone is an inverted triangle with its apex at 8.8°, 11.4 mole % LiNO<sub>3</sub>.

At 15° the area extends from 11-13 mole % LiNO<sub>3</sub>.  
 At 50° " " 10-23.5 " " "  
 At 75° " " 7-28 " " "



# Li LITHIUM

## THE SYSTEM LITHIUM NITRATE - ACETIC ACID (Davidson and Geer, 1938)

t°	Mol. Percent LiNO <sub>3</sub>	Solid Phase	t°	Mol. Percent LiNO <sub>3</sub>	Solid Phase	t°	Mol. Percent LiNO <sub>3</sub>	Solid Phase
16.6	0.0	CH <sub>3</sub> COOH	12.80	7.693*	CH <sub>3</sub> COOH	66.7	12.64	LiNO <sub>3</sub>
16.3	0.156	"	11.80	9.384*	"	82.6	14.66	"
16.03	0.983	"	10.92	10.310*	"	91.6	15.66	"
15.71	2.013	"	39.0	9.38	LiNO <sub>3</sub>	101.0	17.08	"
15.0	4.115	"	46.3	10.31	"	118.3	19.84	"
14.46	5.305	"	54.2	11.26	"	132.2	22.34	"

\*Metastable

NO

## THE SYSTEM LITHIUM NITRATE - UREA (Howells, 1931)

t°	Gms. LiNO <sub>3</sub> per 100 gms. Mixture	Solid Phase	t°	Gms. LiNO <sub>3</sub> per 100 gms. Mixture	Solid Phase
132.0	0.0	CO(NH <sub>2</sub> ) <sub>2</sub>	113.5	27.89	1.2
126.7	2.78	"	117.5	29.56	"
122.3	4.67	"	122.5	32.6	"
113.9	7.93	"	125.9	35.92	"
105.0	10.79	"	123.7	39.39	"
102.9	11.31	"	122.0	42.25	"
90.1	14.53	"	113.2	46.36	"
74.0	19.52	"	104.1	48.63	"
71.0	18.8	" + 1.2	100.6	50.38	"
64.1	19.83*	"	98.5	50.00	" + LiNO <sub>3</sub>
44.7	22.98*	"	121.3	52.85	LiNO <sub>3</sub>
106.8	25.68	1.2	127.9	54.10	"
			146.4	57.07	"

\*Metastable

1.2 = LiNO<sub>3</sub>·2CO(NH<sub>2</sub>)<sub>2</sub>

## SOLUBILITY OF LITHIUM NITRATE IN VARIOUS SOLVENTS

Solvent	t°	Solubility	Author
Acetonitrile	23	2.99 gms. LiNO <sub>3</sub> per 100 cc. solvent	(1)
Isoamyl alcohol	0	6.41	(1)
	23	9.5	(1)
Pyridine	0	27.4	(1)
	23	37.15	(1)
Ethyl ether	10	0.06	(2)
		(Solid Phase Trihydrate)	
Acetone	20	2.37 gms. LiNO <sub>3</sub> per 100 cc. sat. sol.	(3)
Tri n-butyl phosphate	25	12.0 gms. LiNO <sub>3</sub> per 100 gms. sat. sol.	(4)
		(Solid Phase Trihydrate)	

(1) R. Muller, 1924

(2) Bachelet, Cheylan and LeBris, 1950

(3) Rosdestwensky and Lewis, 1911

(4) Wendlandt and Bryant, 1956

THE SYSTEM LITHIUM NITRATE - AMMONIA  
(Portnow and Dwilêwitch, 1937)

Li·8 =  $\text{LiNO}_3 \cdot 8\text{NH}_3$ ;      Li·4 =  $\text{LiNO}_3 \cdot 4\text{NH}_3$ ;      Li·2 =  $\text{LiNO}_3 \cdot 2\text{NH}_3$ .

The authors also give results for the densities of solutions of  $\text{LiNO}_3$  in  $\text{NH}_3$  at 20°. The result at 25° in parenthesis is by Hunt and Boneyk, 1933.

t°	Gms. $\text{LiNO}_3$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{LiNO}_3$ per 100 gms. sat. sol.	Solid Phase
-77.7	0.0	$\text{NH}_3$	- 3.0	56.96	Li·4 + Li·2
-77.8	3.03	"	+ 7.0	62.7	Li·2
-79.0	10.73	"	14.5	66.38	"
-80.5	21.74	"	12.5	69.24	" + $\text{LiNO}_3$ NO
-78.5	24.26	Li·8	25.0	70.0	$\text{LiNO}_3$
-62.0	30.62	"	25.0	(70.89)	"
-53.0	33.51	"	42.0	71.59	"
-54.0	35.66	Li·4	119.0	78.35	"
-28.5	40.51	"	160.0	82.60	"
-12.0	42.97	"	204.0	89.61	"
+ 5.5	49.28	"	264.	100.00	"
+ 3.0	52.82	"			

0.5 gms.  $\text{LiNO}_3$  dissolve in 100 gms. of anhydrous  $\text{HNO}_3$  (Temp. not given).  
(Jander and Wendt, 1948)

Melting point data are given for:

$\text{LiNO}_3 + \text{Li}_2\text{SO}_4$	(Amadori, 1913)
$\text{LiNO}_3 + \text{NaNO}_3$	(Craveth, 1898; Lehrman and Breslow, 1938; Protosenko, 1952; Blidin, 1940; Campbell and Campbell, 1947)
$\text{LiNO}_3 + \text{NH}_4\text{NO}_3$	(Holmes, O'Connell and Hankard, 1951; Campbell, 1940, 1942; Perman and Harrison, 1924)
$\text{LiNO}_3 + \text{RbNO}_3$	(Puschin and Radoicic, 1937)
$\text{LiNO}_3 + \text{TlNO}_3$	(Briscoe, Evans, and Robinson, 1932; Protosenko and Shelomov, 1953)
$\text{LiNO}_3 + \text{NaCl}$	(Blidin, 1940)
$\text{LiNO}_3 + \text{NaNO}_3 + \text{NH}_4\text{NO}_3$	(Campbell and Campbell, 1947)
$\text{LiNO}_3 + \text{N}_2\text{H}_4 \cdot \text{HNO}_3$	(Barlot and Marsaule, 1948)
$\text{LiNO}_3 + \text{LiOH}$	(Diogenov, 1951)
$\text{LiNO}_3 + \text{NaOH} \rightleftharpoons \text{LiOH} + \text{NaNO}_3$	(Diogenov, 1953)
$2\text{LiNO}_3 + \text{Na}_2\text{SO}_4 \rightleftharpoons \text{Li}_2\text{SO}_4 + 2\text{NaNO}_3$	(Volkov and Zakhvalinskii, 1953)
$\text{LiNO}_3 + \text{Guanidine Nitrate}$	(Clark and Esterbrook, 1949)
$\text{LiNO}_3 + \text{LiClO}_4$	(Markowitz, 1958)

LITHIUM NIOBATE  $\text{LiNbO}_3$

NbO

SOLUBILITY IN WATER

(Lapitskii, Shishkina, Pchelkina, and Stepanov, 1955)

t°	0	25	50	75	100
moles per liter	$2.3 \times 10^{-4}$	$2.8 \times 10^{-4}$	$4.3 \times 10^{-4}$	$6.0 \times 10^{-4}$	$7.4 \times 10^{-4}$
Mg. $\text{LiNbO}_3$ per 100 ml.	3.4	4.2	6.4	8.9	10.9

# LITHIUM

## LITHIUM HYDROXIDE $\text{LiOH} \cdot \text{H}_2\text{O}$

SOLUBILITY IN WATER  
(Dittmar, 1888; Pickering, 1893)

t°	Gms. per 100 gms. solution		Gms. LiOH per 100 gms. H <sub>2</sub> O	t°	Gms. per 100 gms. solution		Gms. LiOH per 100 gms. H <sub>2</sub> O
	Li <sub>2</sub> O = LiOH						
-10.5	--	7.23	--	30	7.05	11.27	12.9
-18 Eutec.	--	11.2	--			11.4 <sup>d</sup>	
0	6.67	10.64	12.7	40	7.29	11.68	13.0
		10.7 <sup>a</sup>		50	7.56	12.12	13.3
10	6.74	10.80	12.7	60	7.96	12.76	13.8
20	6.86	10.99	12.8	80	8.87	14.21	15.3
25	6.95	11.14	12.9	100	10.02	16.05	17.5
		11.35 <sup>b</sup>					
		11.0 <sup>c</sup>					

<sup>a</sup>Rollet and Lauffenburger, 1934

<sup>c</sup>Ueda, 1933

<sup>b</sup>Van Meurs, 1916

<sup>d</sup>Donk, 1908

## THE SYSTEM LITHIUM HYDROXIDE - HYDROGEN PEROXIDE - WATER (Makarov and Dobrynina, 1955)

In these tables  $\text{Li}_2\text{O} + \frac{1}{2} \text{O}_2 + \text{H}_2\text{O} = 100\%$ .  $\text{H}_2\text{O}_2 = \frac{1}{2} \text{O}_2 \times \text{H}_2\text{O}_2/\text{O}$ .

1:1:3 =  $\text{Li}_2\text{O}_2 \cdot \text{H}_2\text{O}_2 \cdot 3\text{H}_2\text{O}$ ; 1:1:2 =  $\text{Li}_2\text{O}_2 \cdot \text{H}_2\text{O}_2 \cdot 2\text{H}_2\text{O}$ ; 1:2 =  $\text{Li}_2\text{O}_2 \cdot 2\text{H}_2\text{O}_2$

L =  $\text{LiOH} \cdot \text{H}_2\text{O}$ ;

I = Ice.

Sat. Sol. wt. %			Solid Phase	Sat. Sol. wt. %			Solid Phase
$\frac{1}{2}$ O <sub>2</sub>	H <sub>2</sub> O <sub>2</sub>	Li <sub>2</sub> O		$\frac{1}{2}$ O <sub>2</sub>	H <sub>2</sub> O <sub>2</sub>	Li <sub>2</sub> O	
Results at -21°				Results at -10°			
10.80	22.96	4.29	I	1.49	3.17	7.31	L
9.73	20.69	3.85	1:1:3	2.15	4.57	7.80	"
13.13	27.91	4.44	"	1.98	4.21	7.76	" + 1:1:3
17.06	36.27	5.09	"	2.24	4.97	7.05	" + "
17.95	38.16	5.14	"	2.37	5.04	5.08	1:1:3
17.47	37.14	4.95	1:1:2	2.54	5.40	5.68	"
18.86	40.10	5.00	"	4.50	9.57	3.42	"
22.94	48.77	5.12	"	9.38	19.94	4.20	"
24.62	52.34	5.34	"	14.51	30.85	4.81	"
26.05	55.32	5.31	"	17.29	36.76	4.91	"
25.51	54.23	5.43	1:2	18.68	39.71	4.77	"
26.85	57.08	6.13	"	18.95	40.29	5.02	" + 1:1:2
27.59	58.66	4.08	"	22.00	46.47	5.25	1:1:2
27.90	59.32	4.01	"	24.05	51.13	5.37	"
31.18	66.29	4.69	"	25.61	54.45	5.59	" + 1:2
21.89	67.80	2.76	"	25.32	53.83	5.64	1:2
34.09	72.43	3.53	"	28.75	61.12	4.58	"
39.49	83.96	2.24	"	30.55	64.95	3.92	"
				35.59	75.66	2.38	"

(Cont.)

## THE SYSTEM LITHIUM HYDROXIDE - HYDROGEN PEROXIDE - WATER--Cont.

In these tables  $\text{Li}_2\text{O} + \frac{1}{2} \text{O}_2 + \text{H}_2\text{O} = 100\%$ .  $\% \text{H}_2\text{O}_2 = \% \frac{1}{2} \text{O}_2 \times \text{H}_2\text{O}_2/\text{O}$ .

1:1:3 =  $\text{Li}_2\text{O}_2 \cdot \text{H}_2\text{O}_2 \cdot 3\text{H}_2\text{O}$ ; 1:1:2 =  $\text{Li}_2\text{O}_2 \cdot \text{H}_2\text{O}_2 \cdot 2\text{H}_2\text{O}$ ; 1:2 =  $\text{Li}_2\text{O}_2 \cdot 2\text{H}_2\text{O}_2$

L =  $\text{LiOH} \cdot \text{H}_2\text{O}$ ;

I = Ice.

Sat. Sol. wt. %			Solid Phase	Sat. Sol. wt. %			Solid Phase
$\frac{1}{2} \text{O}_2$	$\text{H}_2\text{O}_2$	$\text{Li}_2\text{O}$		$\frac{1}{2} \text{O}_2$	$\text{H}_2\text{O}_2$	$\text{Li}_2\text{O}$	
Results at 0°				Results at 10°			
1.49	3.17	7.38	$\text{LiOH} \cdot \text{H}_2\text{O}$	0.97	2.06	7.03	$\text{LiOH} \cdot \text{H}_2\text{O}$
1.75	3.72	7.22	"	1.78	3.78	7.27	"
2.13	4.53	7.42	"	2.06	4.38	7.33	"
2.16	4.59	7.30	" + 1:1:3	2.25	4.78	8.57	" + 1:1:3
3.82	8.12	4.18	1:1:3	2.20	4.68	7.69	1:1:3
3.57	7.59	3.59	"	2.44	5.19	7.27	"
6.43	13.67	3.85	"	3.34	7.10	3.92	"
11.11	23.62	4.33	"	3.20	8.29	3.35	"
14.93	31.74	4.76	"	4.30	9.14	3.56	"
17.69	37.61	5.05	"	7.33	15.58	4.04	"
18.79	39.95	5.07	"	12.40	26.36	4.55	"
18.41	39.14	5.19	1:1:2	14.51	30.91	4.92	"
19.37	41.18	4.18	"	19.65	41.78	5.57	"
20.74	44.00	4.68	"	49.14	40.69	5.48	1:1:2
22.06	46.90	4.27	"	20.52	43.63	5.47	"
24.21	52.96	6.12	"	22.32	47.45	5.56	"
25.44	54.09	4.52	"	24.18	51.41	5.62	"
25.46	54.13	5.94	" + 1:1	26.45	55.30	5.94	"
25.86	54.98	4.80	1:1	27.55	58.57	6.22	"
27.39	58.23	5.00	"	26.91	57.21	5.81	" + 1:2
29.36	62.39	4.97	"	27.48	58.42	5.55	1:2
31.31	66.53	3.70	"	27.53	58.58	5.68	"
33.33	70.82	2.19	"	30.50	64.84	5.00	"

LITHIUM HYDROXIDE - LITHIUM SULFOANTIMONATE - WATER AT 30  
(Donk, 1908)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{LiOH}$	$\text{Li}_3\text{SbS}_4$		$\text{LiOH}$	$\text{Li}_3\text{SbS}_4$	
11.4	0.	$\text{LiOH} \cdot \text{H}_2\text{O}$	2.1	48.3	$\text{LiOH} \cdot \text{H}_2\text{O}$
9.1	8.3	"	2.1	52.1	" + $\text{Li}_3\text{SbS}_4 \cdot 10\text{H}_2\text{O}$
2.3	29.9	"	1.4	51.8	$\text{Li}_3\text{SbS}_4 \cdot 10\text{H}_2\text{O}$
			0	51.3	"

# Li LITHIUM

## THE SYSTEM LITHIUM HYDROXIDE - DIOXANE - WATER AT 25° (Laurent and Duhamel, 1953)

Crystals of  $\text{LiOH} \cdot 4(\text{C}_2\text{H}_4)_2\text{O}_2$  are formed.

	Sat. Sol. wt. %		Density	Sat. Sol. wt. %		Density
	LiOH	Dioxane		LiOH	Dioxane	
	12.25	0.00	1.110	1.21	29.30	1.036
	12.13	0.57	--	1.04	31.80	--
	9.96	1.14	--	0.84	37.10	1.040
	6.44	6.30	--	0.67	38.40	--
	5.63	8.02	1.075	0.54	43.65	1.039
	4.61	9.54	1.051	0.43	49.50	--
OH	3.85	12.12	--	0.33	56.30	1.040
	3.26	14.42	1.047	0.26	59.00	--
	2.86	15.67	--	0.24	59.56	--
	2.41	21.22	1.045	0.19	60.61	--
	1.95	23.10	--	0.16	62.54	--
	1.64	26.10	1.039	0.14	63.06	1.040
	1.39	27.70	--	0.05	83.78	--
				0.0	100.00	1.030

Some results for the system LiOH - acetone - water are reported by Laurent and Duhamel, 1953.

## THE SYSTEM LITHIUM HYDROXIDE, PHENOL AND WATER AT 25° (Van Meurs, 1916)

Mols. per 100 mols. sat. sol.			Mols. per 100 mols. sat. sol.		
LiOH	C <sub>6</sub> H <sub>5</sub> OH	Solid Phase	LiOH	C <sub>6</sub> H <sub>5</sub> OH	Solid Phase
8.79	0.0	$\text{LiOH} \cdot \text{H}_2\text{O}$	4.36	30.48	$\text{C}_6\text{H}_5\text{OLi} \cdot 2\text{H}_2\text{O}$
8.30	0.23	"	3.85	45.05	"
8.25	0.41	" + $\text{C}_6\text{H}_5\text{OLi} \cdot 2\text{H}_2\text{O}$	3.56	51.34	"
5.26	1.02	$\text{C}_6\text{H}_5\text{OLi} \cdot 2\text{H}_2\text{O}$	2.32	68.19	"
2.64	2.37	"	2.08	68.71	"
3.25	7.72	"	2.11	70.42	" + $\text{C}_6\text{H}_5\text{OH}$
3.79	14.38	"	2.14	71.94	" + "
4.28	22.64	"	1.82	73.11	$\text{C}_6\text{H}_5\text{OH}$

At concentrations of LiOH below 0.25 mol. percent, liquid layers with the following composition are formed:

Aqueous layer		Phenol layer	
Mol. % LiOH	Mol. % C <sub>6</sub> H <sub>5</sub> OH	Mol. % LiOH	Mol. % C <sub>6</sub> H <sub>5</sub> OH
0.0	1.79	0.0	32.33
0.23	3.34	0.35	17.97

Melting point data are given for:

LiOH + LiI	Searpa, 1915
LiOH + NaOH	Reshetnikov and Unzhakov, 1953
Li <sub>2</sub> O + B <sub>2</sub> O <sub>3</sub>	Mazzetti and DeCarli, 1926
Li <sub>2</sub> O + V <sub>2</sub> O <sub>5</sub>	Cauner, 1928
Li <sub>2</sub> O + SiO <sub>2</sub>	Austin, 1947

# LITHIUM HYDROGEN PHOSPHITE Li<sub>2</sub>HPO<sub>3</sub>·H<sub>2</sub>O

P0

SOLUBILITY OF LITHIUM HYDROGEN PHOSPHITE IN WATER  
(Rosenheim and Reglin, 1921)

t°	Gms. Li <sub>2</sub> HPO <sub>3</sub> per 100 gms. sat. sol.	Solid Phase	t°	Gms. Li <sub>2</sub> HPO <sub>3</sub> per 100 gms. sat. sol.	Solid Phase
0	9.07	Li <sub>2</sub> HPO <sub>3</sub> ·H <sub>2</sub> O	45	6.29	Li <sub>2</sub> HPO <sub>3</sub> ·H <sub>2</sub> O
25	7.47	"	51	6.09	"
30	7.07	"	61	5.75	"
35	6.82	"	98	4.24	"
40	6.64	"			

# LITHIUM PHOSPHATES Li<sub>3</sub>PO<sub>4</sub>, LiH<sub>2</sub>PO<sub>4</sub>

P0

SOLUBILITY IN WATER  
(Rollet and Lauffenburger, 1934)

t°	Solubility	Solid Phase
0	0.022 gms. Li <sub>3</sub> PO <sub>4</sub> per 100 gms. sat. sol.	Li <sub>3</sub> PO <sub>4</sub>
20	0.030 "	"
25	0.0297 gms. Li <sub>3</sub> PO <sub>4</sub> per 100 cc. sat. sol.*	"
0	55.8 gms. LiH <sub>2</sub> PO <sub>4</sub> per 100 gms. sat. sol.	LiH <sub>2</sub> PO <sub>4</sub>

\*Rosenheim and Reglin, 1921.

THE SYSTEM LITHIUM OXIDE - PHOSPHORUS PENTOXIDE - WATER  
(Rollet and Lauffenburger, 1934)

Results at 0°

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
P <sub>2</sub> O <sub>5</sub>	Li <sub>2</sub> O		P <sub>2</sub> O <sub>5</sub>	Li <sub>2</sub> O	
0.0	6.71	LiOH·H <sub>2</sub> O	0.0375	0.0185	Li <sub>3</sub> PO <sub>4</sub>
0.015	6.72	" + Li <sub>3</sub> PO <sub>4</sub>	0.058	0.025	"
0.02	5.58	Li <sub>3</sub> PO <sub>4</sub>	0.388	0.149	"
0.016	2.40	"	0.414	0.167	"
0.02	0.49	"	0.452	0.174	"
0.0148	0.0088	"	0.635	0.2285	"
0.0163	0.0098	"	0.782	0.266	"

(Cont.)

# Li LITHIUM

## THE SYSTEM LITHIUM OXIDE - PHOSPHORUS PENTOXIDE - WATER---Cont.

### Results at 0°---Cont.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
P <sub>2</sub> O <sub>5</sub>	Li <sub>2</sub> O		P <sub>2</sub> O <sub>5</sub>	Li <sub>2</sub> O	
0.80	0.270	Li <sub>3</sub> PO <sub>4</sub>	34.43	7.55	Li <sub>3</sub> PO <sub>4</sub>
0.96	0.33	"	37.95	8.19	LiH <sub>2</sub> PO <sub>4</sub>
1.355	0.403	"	38.10	8.08	"
1.88	0.520	"	38.20	7.68	"
2.74	0.74	"	38.45	7.54	"
11.03	2.55	"	38.85	7.18	"
17.2	3.90	"	47.5	4.62	"
20.26	4.58	"	53.05	3.21	"
22.16	4.97	"	55.65	2.74	"
24.30	5.42	"	58.8	2.22	"
31.13	6.86	"			

### Results at 20°

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
P <sub>2</sub> O <sub>5</sub>	Li <sub>2</sub> O		P <sub>2</sub> O <sub>5</sub>	Li <sub>2</sub> O	
0.017	7.05	LiOH·H <sub>2</sub> O + Li <sub>3</sub> PO <sub>4</sub>	0.409	0.150	Li <sub>3</sub> PO <sub>4</sub>
0.0165	0.077	Li <sub>3</sub> PO <sub>4</sub>	0.620	0.205	"
0.0210	0.0134	"	0.875	0.262	"
0.0272	0.0165	"	27.5	5.73	"
0.0345	0.0197	"	37.1	7.63	"
0.0360	0.0203	"	38.8	7.98	"
0.116	0.050	"	41.6	8.45	" + LiH <sub>2</sub> PO <sub>4</sub>
0.242	0.0965	"	41.7	7.73	LiH <sub>2</sub> PO <sub>4</sub>
0.305	0.118	"	43.5	6.62	"

## PO LITHIUM HYPOPHOSPHATE Li<sub>4</sub>P<sub>2</sub>O<sub>6</sub>·7H<sub>2</sub>O

100 gms. H<sub>2</sub>O dissolve 0.83 gm. hypophosphate at ord. temp.

(Rammelsberg, 1892)

## LITHIUM Sub PHOSPHATE Li<sub>2</sub>PO<sub>3</sub>·3-1/2H<sub>2</sub>O

100 gms. sat. solution of lithium subphosphate in water contain 0.1018 gm. Li<sub>2</sub>PO<sub>3</sub> at 0°, 0.0575 gm. at 25° and 0.048 gm. at 40°. These determinations are only approximately correct since it was impossible to obtain the saturated solution in a clear condition either by long standing or by filtration. A determination made by electrolytic conductivity gave 0.1267 gm. Li<sub>2</sub>PO<sub>3</sub> per liter sat. sol. in water at 25°.

(Rosenheim and Reglin, 1921)

LITHIUM PERRHENATE  $\text{LiReO}_4$ 

ReO

SOLUBILITY OF LITHIUM PERRHENATE IN WATER  
(Smith and Long, 1948)

t°	Moles $\text{LiReO}_4$ per 100 gms. $\text{H}_2\text{O}$	Solid Phase
0	1.00	$\text{LiReO}_4 \cdot \text{H}_2\text{O}$
30	1.40	"
50.3	1.40	"

Results for the partition of lithium perrhenate between nitromethane and water are given by Friedman and Haugen, 1954 and Haugen and Friedman, 1956.

LITHIUM SULFIDE  $\text{Li}_2\text{S}$ 

S

Fusion-point data are given for  $\text{Li}_2\text{S} + \text{S}$  by Pearson and Robinson, 1931.

LITHIUM ANTIMONY SULFIDE  $\text{Li}_3\text{SbS}_4 \cdot 10\text{H}_2\text{O}$ 

SbS

SOLUBILITY OF LITHIUM ANTIMONY SULFIDE IN WATER  
AND IN AQUEOUS ALCOHOL

In Water (Donk, 1908)			In Aqueous Alcohol at 10° and 30° (Schreinemakers and Jacobs, 1910)			
t°	Gms. $\text{Li}_3\text{SbS}_4$ per 100 gms. Sat. Sol.	Solid Phase	t°	Gms. per 100 Gms. Sat. Sol.		Solid Phase
				$\text{C}_2\text{H}_5\text{OH}$	$\text{Li}_2\text{SbS}_4$	
-1.7	7.1	Ice	10	10.7	41.8	$\text{Li}_3\text{SbS}_4 \cdot 10\text{H}_2\text{O}^*$
-3.2	12.8	"	10	26.2	36.5	" *
-5.1	17.5	"	10	66.2	20.6	" *
-10.8	23.2	"	30	13.3	46.3	$\text{Li}_3\text{SbS}_4 \cdot 8\frac{1}{2}\text{H}_2\text{O}$
-15.9	28.5	"	30	51.9	30.7	"
-26.2	35.3	"	30	54.8	29.9	"
-42	40.4	" + $\text{Li}_3\text{SbS}_4 \cdot 10\text{H}_2\text{O}$	30	58.4	30.8	"
0	45.5	$\text{Li}_3\text{SbS}_4 \cdot 10\text{H}_2\text{O}$	30	58.6	32.3	" + $\text{Li}_3\text{SbS}_4$
+10	46.9	"	30	65.26	39.31	$\text{Li}_3\text{SbS}_4$
30	50.1	"	30	74.3	24.1	"
50	51.3	"	30	79.5	20.5	"

\*These results by Donk, 1908.



# Li LITHIUM

## SO LITHIUM SULFATE $\text{Li}_2\text{SO}_4$

### SOLUBILITY OF LITHIUM SULFATE IN WATER (Friend, 1929; Campbell, 1943)

Friend reported a dihydrate at about  $-10^\circ$  which Campbell could not find. The data below are those of Friend except for solutions saturated with ICE, and above  $100^\circ$ . Campbell also gives vapor pressure data from  $60$ - $227^\circ$ . For cryoscopic data on very dilute solutions, see Indelli, 1953. The figures in parentheses are densities.

$t^\circ$	Gms. $\text{Li}_2\text{SO}_4$ per 100 gms. Sat. Sol.	Solid Phase	$t^\circ$	Gms. $\text{Li}_2\text{SO}_4$ per 100 gms. Sat. Sol.	Solid Phase
- 1.735	4.072	Ice	30	25.25 <sup>8</sup>	$\text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{O}$
- 3.30	7.791	"	30	25.10 <sup>12</sup>	"
- 5.11	11.30	"	31.8	25.47	"
- 7.04	14.33	"	35.0	24.76 <sup>3</sup>	"
- 9.67	17.67	"	38.0	25.28	"
-14.65	21.95	"	43.7	25.00	"
-18.45	24.85	"	45.6	24.88 <sup>11</sup>	"
-21.4	27.1	"	50	24.3 <sup>9</sup>	"
-23.0	27.9	" + $\text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{O}$	51.6	24.82	"
-16.0	27.32	$\text{Li}_2\text{SO}_4 \cdot 2\text{H}_2\text{O}$ (?)	52.4	24.71	"
-13.0	27.24	"	55	24.62 <sup>2</sup>	"
-11.5	27.18	"	65.7	24.34	"
- 6.5	26.73	$\text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{O}$	71.8	24.2 <sup>10</sup>	"
0.0	25.43 <sup>1</sup>	"	77.0	24.05	"
0.0	26.33 <sup>2</sup>	"	94.8	23.76	"
0.6	26.51	"	94.9	23.4 (1.182) <sup>4</sup>	"
12.5	25.98 <sup>6</sup>	"	95.2	24.21 <sup>10</sup>	"
14.0	26.07	"	100.1	23.5 (1.179) <sup>4</sup>	"
16.7	25.96	"	103.0	23.72	"
19.6	25.85	"	104.0	23.55 (1.176) <sup>4</sup>	"
20	25.20 <sup>5</sup>	"	142.5	22.65	"
25	25.50 <sup>2</sup>	"	186	22.7	"
25	25.79 <sup>3</sup>	"	214	23.0	"
25	25.69 <sup>7</sup>	"	232.8 ~23		" + $\text{Li}_2\text{SO}_4$
27	25.41 <sup>11</sup>	"			

<sup>4</sup>Sanders and Dobbins, 1931;

<sup>2</sup>Crockford and Webster, 1930;

<sup>3</sup>Massink, 1917-18;

<sup>4</sup>Applebey, Crawford and Gordon, 1934;

<sup>5</sup>Pani and Terrey, 1955;

<sup>6</sup>Monte Martini and Losana, 1928;

<sup>7</sup>Druzhinin and Yanko, 1954;

<sup>8</sup>Schreinemakers and Kayser, 1918;

<sup>9</sup>Schreinemakers, Cocheret, Filippo and de Waal, 1905, 1907;

<sup>10</sup>Campbell, McCulloch and Kartzmark, 1954;

<sup>11</sup>Cavalca and Nardelli, 1952;

<sup>12</sup>Schreinemakers and von Dorp, Jr., 1906.

THE SOLUBILITY OF LITHIUM SULFATE IN HYDROGEN  
PEROXIDE - WATER MIXTURES AT 20°  
(Pani and Terrey, 1955)

Solid phase  $\text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{O}$  in all cases.

Sat. Sol. wt. %		Sat. Sol. wt. %		Sat. Sol. wt. %	
$\text{H}_2\text{O}_2$	$\text{Li}_2\text{SO}_4$	$\text{H}_2\text{O}_2$	$\text{Li}_2\text{SO}_4$	$\text{H}_2\text{O}_2$	$\text{Li}_2\text{SO}_4$
0.0	25.20	22.58	16.74	55.55	6.49
7.70	22.04	29.17	13.77	68.0	4.07
12.50	20.58	44.31	9.30	71.0	3.58
17.42	18.59	52.86	6.98	80.8	2.30
				84.8	1.96

50

SOLUBILITY OF LITHIUM SULFATE IN SULFURIC ACID SOLUTIONS

Results at 12.5°  
(Montemartini and Losana, 1928)

Results at 30°  
(van Dorp, 1910)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{Li}_2\text{SO}_4$	$\text{H}_2\text{SO}_4$		$\text{H}_2\text{SO}_4$	$\text{Li}_2\text{SO}_4$	
1.2401	25.98	0.0	$\text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{O}$	5.05	22.74	$\text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{O}$
1.2498	22.75	8.75	"	12.23	20.45	"
1.2712	19.32	15.74	"	16.60	19.10	"
1.2992	15.82	23.72	"	32.70	13.37	"
1.3263	13.35	28.36	"	42.98	10.57	"
1.3618	10.42	38.12	" + $\text{Li}_2\text{SO}_4$	52.72	11.44	"
1.4021	8.76	42.20	$\text{Li}_2\text{SO}_4$	55.08	13.69	$\text{Li}_2\text{SO}_4$
1.5008	8.13	54.14	" + $\text{LiHSO}_4 \cdot \text{H}_2\text{O}$	61.46	17.10	"
1.6278	12.12	58.92	$\text{LiHSO}_4 \cdot \text{H}_2\text{O}$	62.49	18.89	$\text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{SO}_4$
1.7230	13.36	66.24	"	69.40	13.75	"
1.8154	10.08	75.58	$\text{LiHSO}_4$	78.23	11.64	"
1.8998	12.32	87.02	" + $\text{LiHSO}_4 \cdot \text{H}_2\text{SO}_4$	83.43	15.65	"

SOLUBILITY OF LITHIUM SULFATE IN PURE SULFURIC ACID  
(Bergius, 1910)

10 cc. sat. solution in abs.  $\text{H}_2\text{SO}_4$  contain 2.719 gms.  $\text{Li}_2\text{SO}_4$  and the crystalline solid phase has the composition  $\text{Li}_2\text{SO}_4 \cdot 7\text{H}_2\text{SO}_4$  and melts at about 12°.

Freezing point data for dilute solutions of  $\text{Li}_2\text{SO}_4$  in  $\text{H}_2\text{SO}_4$  by Gillespie and Oubridge, 1956 are as follows:

Molality $\text{Li}_2\text{SO}_4$ :	0.0	0.02	0.05	0.10	0.12
Freezing point:	10.365°	9.990°	9.280°	8.026°	7.498°

# Li LITHIUM

## THE SYSTEM LITHIUM SULFATE - LITHIUM CHLORIDE - WATER

At -12.25°		At 25°		At 30°		Solid Phase at each temperature
(Campbell, 1943)		(Druzhinin and Yanko, 1954)		(Schreinemakers and Kayser, 1918)		
Sat. Sol. wt. %	Sat. Sol. wt. %	Sat. Sol. wt. %	Sat. Sol. wt. %	Sat. Sol. wt. %	Sat. Sol. wt. %	
LiCl	Li <sub>2</sub> SO <sub>4</sub>	LiCl	Li <sub>2</sub> SO <sub>4</sub>	LiCl	Li <sub>2</sub> SO <sub>4</sub>	
--	--	45.65	0.0	46.10	0.0	LiCl·H <sub>2</sub> O
25.03	0.38	45.52	0.02	45.97	0.0	" + Li <sub>2</sub> SO <sub>4</sub> ·H <sub>2</sub> O
14.60	6.18	40.92	0.02	30.74	0.0	Li <sub>2</sub> SO <sub>4</sub> ·H <sub>2</sub> O
7.10	16.02	17.92	2.52	21.04	1.08	"
30 3.16	22.00	2.75	20.45	15.30	4.48	"
--	--	--	--	12.06	7.48	"
--	--	--	--	8.07	12.20	"
--	--	--	--	5.74	15.71	"
--	--	--	--	3.98	18.85	"
--	--	--	--	2.76	20.43	"
--	--	--	--	0.96	23.60	"
--	--	0.0	25.69	0.00	25.25	"

## THE SYSTEM LITHIUM SULFATE - AMMONIUM SULFATE - WATER

(Schreinemakers, Cocheret, Filippo and de Waal, 1905, 1907 (30, 50°);  
Campbell, McCulloch and Kartzmark, 1954 (0°, 72°, 95°); Skarulis,  
Horan, Maleeny, Felten, (0°, 25°))

Limited solid solutions of (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> in Li<sub>2</sub>SO<sub>4</sub>·H<sub>2</sub>O are formed.  
These were found by Campbell at 95°, and by careful work by Skarulis,  
at 0° and 25°. Additional data for the triple points of this system at  
20°, 57° and 97° are given by Spielrein (1913), but the terms in which  
the results are presented are not clearly shown.

L = Li<sub>2</sub>SO<sub>4</sub>·H<sub>2</sub>O; N = (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>; D = LiNH<sub>4</sub>SO<sub>4</sub>; S = Solid Solution

Sat. sol. wt. %		% (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> in Solid	Solid Phase	Sat. Sol. wt. %		% (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> in Solid	Solid Phase
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Li <sub>2</sub> SO <sub>4</sub>			(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Li <sub>2</sub> SO <sub>4</sub>		
Results at 0° (Skarulis)				Results at 25° (Skarulis)			
1.13	26.13	0.5	SL	5.50	24.45	0.1	SL
2.31	25.82	0.5	SL	8.29	23.53	5.0	SL
3.30	25.56	0.6	SL	10.98	23.13	1.8	SL
4.35	25.32	1.4	SL	10.82	22.87	7.4	SL
7.04	24.66	1.2	SL	12.38	22.37	7.3	SL
7.82	24.34	2.0	SL	12.45	22.37	6.9	SL
8.62	24.20	3.0	SL	12.51	22.31	--	SL+D
9.13	24.10	6.1	SL	12.55	22.29	--	SL+D
9.29	24.20	5.8	SL	17.07	18.37	--	D
9.94	23.72	--	SL+D	21.31	15.39	--	D
9.91	23.67	--	SL+D	32.11	9.61	--	D
10.05	23.74	--	D	39.58	6.71	--	D+N
16.39	18.39	--	D	39.56	6.69	--	D+N
27.56	11.57	--	D	42.12	2.21	--	N
36.52	7.59	--	D				
36.54	7.62	--	D+N				
36.54	7.60	--	D+N				
39.42	3.48	--	N				
(Cont.)							

(Cont.)

## THE SYSTEM LITHIUM SULFATE - AMMONIUM SULFATE - WATER—Cont.

L =  $\text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{O}$ ; N =  $(\text{NH}_4)_2\text{SO}_4$ ; D =  $\text{LiNH}_4\text{SO}_4$ ; S = Solid Solution

Sat. Sol. wt. %		Solid Phase	Sat. Sol. wt. %		Solid Phase
$(\text{NH}_4)_2\text{SO}_4$	$\text{Li}_2\text{SO}_4$		$(\text{NH}_4)_2\text{SO}_4$	$\text{Li}_2\text{SO}_4$	
Results at 30° (Schreinemakers)			Results at 50° (Schreinemakers)		
0.0	25.1	L	0.0	24.3	L
8.9	23	L	7.56	22.86	L
12.5	21.9	D+L	8.58	23.09	L
15.0	20	D	9.63	22.79	L
21.6	15	D	11.45	21.75	L
30.0	10	D	13.97	21.23	D+L
39.5	6.6	N+D	13.90	21.20	D
40.8	3	N	19.65	16.35	D
44.1	0	N	43.05	5.86	N+D
			45.70	0.0	N
Results at 71.8° (Campbell)			Results at 95.2° (Campbell)		
0.0	24.2	L	0.0	24.21	L
2.4	23.5	L	0.69	24.70	SL
5.6	23.1	L	4.64	23.09	SL
12.1	21.8	L+D	9.34	21.72	SL
20.1	17.1	D	15.89	20.46	SL+D
20.4	17.2	D	15.91	20.62	D
25.6	14.2	D	21.11	16.37	D
32.1	10.5	D	40.03	6.73	D+N
44.9	5.2	D+N	47.98	3.67	N
45.1	5.5	N	48.67	3.04	N
47.9	0.0	N	50.87	0.0	N

SOLUBILITY OF LITHIUM AMMONIUM SULFATE IN WATER  
(Schreinemakers, Cocheret, Filippo and deWaal, 1905, 1907)

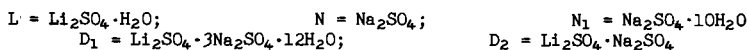
t°	Gms. $\text{NH}_4\text{LiSO}_4$ per 100 gms. Sat. Sol.	Solid Phase	t°	Gms. $\text{NH}_4\text{LiSO}_4$ per 100 gms. Sat. Sol.	Solid Phase
0	0	Ice	-10	35.25	$\text{NH}_4\text{LiSO}_4$
- 5	14	"	+10	35.58	"
-10	23.5	"	30	35.87	"
-15	29.7	"	50	36	"
-20.6 Eutec.	35.15	" + $\text{NH}_4\text{LiSO}_4$	70	36.18	"

Data for equilibrium in the quaternary system  $(\text{NH}_4)_2\text{SO}_4 + \text{LiSO}_4 + \text{H}_2\text{SO}_4 + \text{H}_2\text{O}$  at 30° are given by Van Dorp, 1923.Data for the quaternary system, ammonium sulfate, lithium sulfate, alcohol and water at 6.5°, 30° and 50° are given by Schreinemakers and van Dorp (1907).

# LITHIUM

THE SYSTEM LITHIUM SULFATE - SODIUM SULFATE - WATER  
(Skarulis and Horan, 1955 (0°); Cavalca and Nardelli, 1952 (27°, 45.6°))

The solid phases reported by Spielrein, 1913 have not been substantiated by later workers.



At 0°			At 27°			At 45.6°		
Sat. Sol. wt. %		Solid Phase	Sat. Sol. wt. %		Solid Phase	Sat. Sol. wt. %		Solid Phase
$\text{Li}_2\text{SO}_4$	$\text{Na}_2\text{SO}_4$		$\text{Li}_2\text{SO}_4$	$\text{Na}_2\text{SO}_4$		$\text{Li}_2\text{SO}_4$	$\text{Na}_2\text{SO}_4$	
3.17	4.40	N <sub>1</sub>	0.00	25.09	N <sub>1</sub>	0.00	31.95	N
9.09	4.83	N <sub>1</sub>	2.43	24.93	N <sub>1</sub>	3.98	29.17	N
13.58	4.95	N <sub>1</sub>	5.44	25.47	N <sub>1</sub> + D <sub>1</sub>	6.86	27.29	N
16.01	5.25	N <sub>1</sub>	6.43	24.18	D <sub>1</sub>	7.24	26.97	N
20.02	5.73	N <sub>1</sub>	7.42	22.63	D <sub>1</sub>	7.98	26.54	N
23.27	6.26	N <sub>1</sub> + D <sub>1</sub>	9.29	20.62	D <sub>1</sub>	9.83	25.32	N + D <sub>1</sub>
23.41	6.17	D <sub>1</sub>	11.25	18.41	D <sub>1</sub>	10.82	24.68	N + D <sub>1</sub>
23.37	6.23	D <sub>1</sub>	16.59	14.16	D <sub>1</sub>	9.94	25.01	D <sub>1</sub>
23.72	6.10	D <sub>1</sub>	17.50	12.60	D <sub>1</sub>	10.90	24.09	D <sub>1</sub>
23.80	6.04	D <sub>1</sub>	21.74	10.82	D <sub>1</sub> + L	11.97	23.11	D <sub>1</sub> + D <sub>2</sub>
24.14	5.85	D <sub>1</sub> + L	21.62	11.03	D <sub>1</sub> + L	11.82	23.29	D <sub>1</sub> + D <sub>2</sub>
24.03	5.99	L	22.37	8.88	L	11.58	23.61	D <sub>1</sub> + D <sub>2</sub>
25.52	2.36	L	23.36	5.81	L	13.37	21.45	D <sub>2</sub>
			25.41	0.0	L	14.06	20.60	D <sub>2</sub>
						16.33	16.33	D <sub>2</sub>
						19.40	13.14	D <sub>2</sub>
						21.54	10.57	D <sub>2</sub> + L
						21.53	10.58	D <sub>2</sub> + L
						22.77	6.63	L
						24.88	0.00	L

SOLUBILITY OF LITHIUM SULFATE IN AQUEOUS ALCOHOL AT 30°  
(Schreinemakers and van Dorp, Jr., 1906)

Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
$\text{C}_2\text{H}_5\text{OH}$	$\text{Li}_2\text{SO}_4$		$\text{C}_2\text{H}_5\text{OH}$	$\text{Li}_2\text{SO}_4$	
0	25.10	$\text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{O}$	47.28	3.04	$\text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{O}$
11.75	16.16	"	58.59	1.22	"
21.19	11.52	"	69.39	0.396	"
29.40	8.17	"	80.74	0	"
33.31	6.66	"	94.11	0	"

Melting point data are given for the following:

$\text{Li}_2\text{SO}_4 + \text{Ag}_2\text{SO}_4$	(Nacken, 1907b)
$\text{Li}_2\text{SO}_4 + \text{K}_2\text{SO}_4$	(Nacken, 1907)
$\text{Li}_2\text{SO}_4 + \text{MnSO}_4$	(Calcagni and Marotta, 1914)
$\text{Li}_2\text{SO}_4 + \text{Na}_2\text{SO}_4$	(Nacken, 1907; Akopov and Bergman, 1955b; Bergman and Akopov, 1953; Hilmy, 1953; Plyusachev, Zhdanov, Komissarova, and Uvad'eva, 1953)
$\text{Li}_2\text{SO}_4 + \text{SrSO}_4$	(Calcagni and Marotta, 1912; Kordes, Ziegler and Proeger, 1954)
$\text{Li}_2\text{SO}_4 + \text{LiCl}$	(Bergman and Akopov, 1953; Lesnykh and Bergman, 1953b)
$\text{Li}_2\text{SO}_4 + \text{Li}_2\text{WO}_4$	(Belyaev, 1955; Bergman and Kislova, 1955; Kislova, Poyapaiko and Bergman, 1955)
$\text{Li}_2\text{SO}_4 + \text{LiPO}_3$	(Bergman and Sholokhovish, 1953)
$\text{Li}_2\text{SO}_4 + \text{PbSO}_4$	(Kordes, Ziegler and Proeger, 1954; Belyaev, 1955)
$\text{Li}_2\text{SO}_4 + \text{Li}_2\text{MoO}_4$	(Bergman, Kislova and Korobka, 1954)
$\text{Li}_2\text{SO}_4 + \text{ZnSO}_4$	(Evaeveva and Bergman, 1951)
$\text{Li}_2\text{SO}_4 + \text{PbWO}_4 = \text{Li}_2\text{WO}_4 + \text{PbSO}_4$	(Belyaev, 1955)
$\text{Li}_2\text{SO}_4 + \text{H}_2\text{SO}_4$	(Kendall and Landon, 1920)

# LITHIUM SELENITE $4\text{Li}_2\text{SeO}_3 \cdot 3\text{H}_2\text{O}$

SeO

## SOLUBILITY OF LITHIUM SELENITE IN WATER (Rosenheim and Krause, 1921)

	t°	0°	25°	47.5°	60°	100°
Gms. $\text{Li}_2\text{SeO}_3$ per 100 gms. sat. sol.		19.99	16.76	14.53	12.75	9.05

# LITHIUM SELENATE $\text{Li}_2\text{SeO}_4$

## THE SYSTEM LITHIUM SELENATE - HYDROGEN PEROXIDE - WATER AT 20° (Pani and Terrey, 1955)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Li}_2\text{SeO}_4$	$\text{H}_2\text{O}_2$		$\text{Li}_2\text{SeO}_4$	$\text{H}_2\text{O}_2$	
40.64	0.0	$\text{Li}_2\text{SeO}_4 \cdot \text{H}_2\text{O}$	19.68	43.08	$\text{Li}_2\text{SeO}_4 \cdot \text{H}_2\text{O}$
38.29	4.03	"	17.36	46.62	"
35.45	9.61	"	15.29	51.1	$\text{Li}_2\text{SeO}_4$
33.45	13.15	"	14.96	52.9	"
29.86	19.88	"	12.61	58.9	"
27.77	24.29	"	10.42	64.4	"
22.59	35.56	"	8.26	71.5	"

## Li LITHIUM

### SiO LITHIUM SILICATES

Melting point data are given for:

$\text{Li}_4\text{SiO}_4 + \text{Ca}_2\text{SiO}_4$	(Schwarze and Haacke, 1921)
$\text{Li}_4\text{SiO}_4 + \text{ZrSiO}_4$	( " " " " )
$\text{Li}_2\text{SiO}_3 + \text{Na}_2\text{SiO}_3$	(Bergman, Nesterova and Bychkova, 1955)
$\text{Li}_2\text{SiO}_3 + \text{K}_2\text{SiO}_3$	( " " " " )
$\text{Li}_2\text{SiO}_3 + \text{BaF}_2 = 2\text{LiF} + \text{BaSiO}_3$	(Bychkova and Bergman, 1956)

### SnO LITHIUM STANNATE $\text{Li}_2\text{Sn}(\text{OH})_6$

SOLUBILITY OF LITHIUM STANNATE AND OF HYDRATED  
LITHIUM STANNATE IN WATER  
(Zocher, 1920)

t°	Gms. $\text{Li}_2\text{SnO}_3$ per 100 gms. sat. sol. in presence of	
	$\text{Li}_2\text{Sn}(\text{OH})_6$	$\text{Li}_2\text{Sn}(\text{OH})_6 \cdot 2\text{H}_2\text{O}$
28	3.14	2.08
40	3.25	2.02
61	3.66	2.58
80	4.36	2.99

### TaO LITHIUM TANTALATE $\text{LiTaO}_3$

SOLUBILITY IN WATER  
(Lapitskii, Stepanov, and Pehelkina, 1955)

t°	0	25	50	75	100
Moles per liter	$5.14 \times 10^{-5}$	$1.05 \times 10^{-4}$	$2.29 \times 10^{-4}$	$3.81 \times 10^{-4}$	$5.09 \times 10^{-4}$
Mg. $\text{LiTaO}_3$ per 100cc.	1.21	2.47	5.40	8.97	12.00

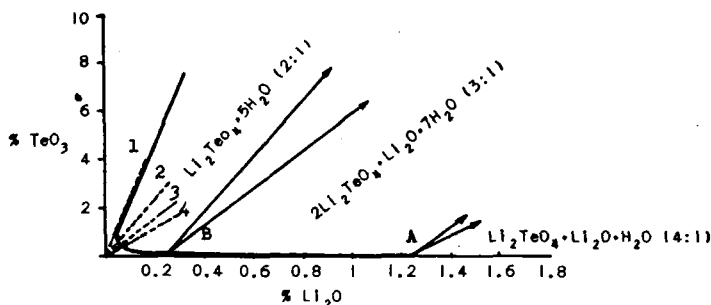
### TiO LITHIUM TITANATE $\text{Li}_2\text{TiO}_3$

Melting points are given for  $\text{Li}_2\text{TiO}_3 + \text{K}_2\text{TiO}_3$ ,  $+ \text{Na}_2\text{TiO}_3$ ,  $+ \text{KF}$ ,  $+ \text{NaF}$ ,  $+ \text{RbF}$ ,  $+ \text{Na}_2\text{SiO}_3$ ,  $+ \text{K}_4\text{P}_2\text{O}_7$ , and solubilities of  $\text{Li}_2\text{TiO}_3$  in several lithium salts are given by Belyaer and Sigida, 1956.

LITHIUM TELLURATES  $x\text{Li}_2\text{O} \cdot y\text{TeO}_3 \cdot z\text{H}_2\text{O}$ 

TeO

THE SYSTEM  $\text{Li}_2\text{O} - \text{TeO}_3 - \text{H}_2\text{O}$  AT  $25^\circ$   
(Souhay and Hessaby, 1953)



The dotted lines 1, 2, 3, and 4 indicate Li/Te mole ratios.  $\text{Li}_2\text{TeO}_4 \cdot 5\text{H}_2\text{O}$  is congruently soluble.

A = 1.26%  $\text{Li}_2\text{O}$

B = 0.25%  $\text{Li}_2\text{O}$

LITHIUM VANADATE  $\text{Li}_3\text{VO}_4 \cdot 9\text{H}_2\text{O}$ 

VO

SOLUBILITY OF LITHIUM VANADATE IN WATER  
(Rosenheim and Reglin, 1921)

$t^\circ$	Gms. $\text{Li}_3\text{VO}_4$ per 100 gms. sat. sol.	Solid Phase	$t^\circ$	Gms. $\text{Li}_3\text{VO}_4$ per 100 gms. sat. sol.	Solid Phase
0.0	2.40	$\text{Li}_3\text{VO}_4 \cdot 9\text{H}_2\text{O}$	38.4	5.09	$\text{Li}_3\text{VO}_4 \cdot \text{H}_2\text{O}$
20.8	4.60	"	40.0	4.20	"
28.6	5.25	"	45.0	3.70	"
30.2	5.91	"	50.0	2.80	"
35.2	6.25	"	60.0	2.60	"

LITHIUM TUNGSTATE  $\text{Li}_2\text{WO}_4$ 

WO

Fusion-point data for mixtures of  $\text{Li}_2\text{WO}_4 + \text{K}_2\text{WO}_4$ ,  $\text{Li}_2\text{WO}_4 + \text{Na}_2\text{WO}_4$  and  $\text{Li}_2\text{WO}_4 + \text{WO}_3$  are given by van Liempt, 1925.  
(Hoermann, 1929)

LUTETIUM SULFATE  $\text{Lu}_2(\text{SO}_4)_3 \cdot 8\text{H}_2\text{O}$   
(CASSIOPEIUM SULFATE)

SO

100 gms. sat. solution of lutetium sulfate in water contain 32.10 gm.  $\text{Lu}_2(\text{SO}_4)_3$  at  $20^\circ$  and 14.48 gms. at  $40^\circ$ . (Jackson and Rienacker, 1930)



## Mg MAGNESIUM

### MAGNESIUM Mg

#### THE SOLUBILITY OF MAGNESIUM AND OF MAGNESIUM ALLOYS IN AQUEOUS SALT SOLUTIONS AND SEA WATER (Whitby, 1932, 1933)

A method based upon the oxygen absorbed and hydrogen evolution was developed. No absorption of oxygen could be detected but the evolution of hydrogen could be accurately measured in samples of gas periodically removed from above the corroding liquid. Large variations in rate of dissolution of different grades of Mg, containing varying traces of impurities in 0.1 n to 3.0 n NaCl and 0.05 nHCl, was encountered. The presence of 0.02 percent Mn causes an acceleration of attack with time. The rate of attack in sea water was lower, due to the presence of sulfates. Traces of saponin increase the rate of H evolution. Three magnesium-base alloys and one type of duraluminum gave substantially the same results as pure Mg. Non metallic impurities such as inclusions of nitride or oxide do not act either as cathodes or nuclei for anodic attack in NaCl solutions. The initial rate of dissolution of Mg in H<sub>2</sub>O, conc. and dilute solutions of KCl, KBr, KI and K<sub>2</sub>SO<sub>4</sub> and in aqueous solutions of alkali is always practically the same. A theory of "primary preferential hydroxyl ion discharge" is proposed and supported by free energy calculations.

100 gms. sat. solution of magnesium in mercury contain 0.323 gm. Mg at 25°. (Loomis, 1922)

Fusion-points of mixtures of Mg + Hg are given by Cambi and Speroni, 1915.

Data are given for the systems:

Mg + MgCl<sub>2</sub> at 860°, 1000° (Ostertag, 1955)

Mg + PbCl<sub>2</sub> = MgCl<sub>2</sub> + Pb (Ruff & Busch, 1925; Palkin & Redchenko, 1956)

### AlO MAGNESIUM ALUMINATE

Data for the system MgO - Al<sub>2</sub>O<sub>3</sub> - SiO<sub>2</sub> - H<sub>2</sub>O from 430-990° are given by Yoder, 1952.

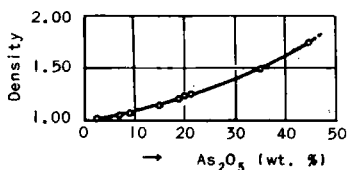
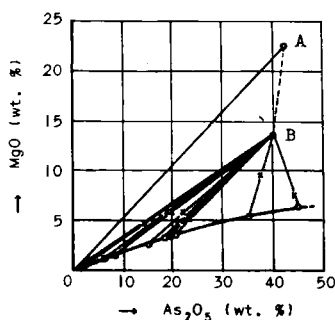
### AsO MAGNESIUM ARSENITES

Some results in the system magnesium oxide, arsenic trioxide and water at 25° are given by Story and Anderson, 1924.

MAGNESIUM ARSENATES  $Mg_3(AsO_4)_2$ ,  $MgHASO_4$ 

AsO

Results of Takahashi and Sasaki, 1953 at 30°

A:  $Mg_3(AsO_4)_2 \cdot 10H_2O$ B:  $MgHASO_4 \cdot 7H_2O$ Chukhlantsev, 1956 reports the  $K_{sp}$  of  $Mg_3(AsO_4)_2$  to be  $2.1 \times 10^{-20}$ .MAGNESIUM BORATES  $xMgO \cdot yB_2O_3 \cdot zH_2O$ 

BO

## THE SYSTEM MAGNESIUM OXIDE - BORIC OXIDE - WATER AT 25°

(Nikolaev and Chelishcheva, 1940)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$B_2O_3$	MgO		$B_2O_3$	MgO	
0.0	0.004	$Mg(OH)_2$	2.87	0.210	Diborate + Triborate
0.215	0.100	$Mg(OH)_2$ + Inderite	2.98	0.211	Triborate
0.573	0.060	Inderite	4.76	0.271	Triborate + $H_3BO_3$
1.47	0.119	Inderite + Diborate	3.17	0.0	$H_3BO_3$
2.72	0.206	Diborate			

Inderite =  $2MgO \cdot 3B_2O_3 \cdot 15H_2O$ ;Diborate =  $MgO \cdot 2B_2O_3 \cdot 9H_2O$ ;Triborate =  $MgO \cdot 3B_2O_3 \cdot 7.5H_2O$ 

Results for other salts:

Salt	Formula	Solubility at 25°	Author
Kaliborite	$4MgO \cdot K_2O \cdot 11B_2O_3 \cdot 18H_2O$	0.50 % $B_2O_3$ *	(Spiryagina, 1953)
Hydroboracite	$MgO \cdot CaO \cdot 3B_2O_3 \cdot 6H_2O$	0.24 " "	
Ascharite	$2MgO \cdot B_2O_3 \cdot H_2O$	0.008 " "	
	$MgO \cdot (NH_4)_2O \cdot 3B_2O_3 \cdot 7H_2O$	1.308 gms. salt/100 ml. $H_2O$ †	(Kessans and Svarcs, 1954)

\*in saturated gypsum or halite solutions.

†hydrolyzes to  $2MgO \cdot 3B_2O_3 \cdot 15H_2O$ .

## Mg MAGNESIUM

Results for the systems  $\text{MgO} - \text{K}_2\text{O} - \text{B}_2\text{O}_3 - \text{H}_2\text{O}$  and  $\text{MgO} - \text{Na}_2\text{O} - \text{B}_2\text{O}_3 - \text{H}_2\text{O}$  at  $25^\circ$  are given by Kurnakova, 1953.

Melting point data for the system  $\text{MgO} - \text{B}_2\text{O}_3$  are given by Toropov and Konovalov, 1940 (3 compounds: 1:1, 2:1, 3:1), Berger, 1949, and also M. A. Knight, 1942.

## Br MAGNESIUM BROMIDE $\text{MgBr}_2$

### SOLUBILITY OF MAGNESIUM BROMIDE IN WATER (Getman, 1935)

t°	Gms. $\text{MgBr}_2$ per 100 gms. $\text{H}_2\text{O}$	Solid Phase	t°	Gms. $\text{MgBr}_2$ per 100 gms. $\text{H}_2\text{O}$	Solid Phase
- 3.92	12.08	Ice	+10.4	99.3	$\text{MgBr}_2 \cdot 6\text{H}_2\text{O}$
- 6.85	18.36	"	19.9	101.1	"
-15.2	32.86	"	24.8	103.3	"
-37.5	53.93	"	25	101.5 <sup>a</sup>	"
-42.7*	58.20	" + $\text{MgBr}_2 \cdot 10\text{H}_2\text{O}$		99.7 <sup>b</sup>	"
-23.0	68.6	$\text{MgBr}_2 \cdot 10\text{H}_2\text{O}$	29.8	103.9	"
-15.0	73.6	"	34.8	105.4	"
- 9.0	78.7	"	39.8	106.5	"
- 7.0	79.7	"	60.1	112.0	"
- 6.0	81.2	"	65.5	114.5	"
- 0.83†	97.7	" + $\text{MgBr}_2 \cdot 6\text{H}_2\text{O}$	100.0	125.4	"
			172.4**	170.4	"

\*Eutec.

†tr. pt.

\*\*m. pt.

<sup>a</sup>Blidin, 1947a

<sup>b</sup>Scott and Durham, 1934

d. of sat. sol. at  $18^\circ = 1.655$  (Mylia and Funk, 1897).

The previous results of Menschutkin, 1906, are shown to be too low.

### SOLUBILITY OF MAGNESIUM BROMIDE IN AQUEOUS SOLUTIONS OF HYDROBROMIC ACID AT $25^\circ$ (Scott and Durham, 1930)

Gms. per 100 gms. sat. sol.		Solid Phase
HBr	$\text{MgBr}_2$	
0.0	49.93	$\text{MgBr}_2 \cdot 6\text{H}_2\text{O}$
4.70	45.40	"
9.83	40.33	"
14.79	35.55	"

THE SYSTEM MAGNESIUM BROMIDE - RUBIDIUM BROMIDE - WATER AT 25°  
(Blidin, 1947a)

Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
MgBr <sub>2</sub>	RbBr		MgBr	RbBr	
0.0	53.35	RbBr	40.31	9.6	RbBr
10.10	41.51	"	50.40	Trace	RbBr + MgBr <sub>2</sub> ·6H <sub>2</sub> O
20.50	28.20	"	50.38	0.0	MgBr <sub>2</sub> ·6H <sub>2</sub> O
30.40	17.0	"			

THE SYSTEM MAGNESIUM BROMIDE - ETHYL ETHER - WATER AT 25°  
(Rowley and Reed, 1950)

Br

[See also Rowley and Bartz, 1941]

Aqueous phase wt. %		Ether phase wt. %		
MgBr <sub>2</sub>	Ether	MgBr <sub>2</sub>	Ether	H <sub>2</sub> O
0.00	6.56	0.00	98.53	1.47
4.30	4.57	Trace	98.76	1.24
9.90	4.24	"	98.78	1.22
25.23	1.95	"	99.04	0.96
36.40	0.49	"	99.30	0.70
50.01	0.83*	"	99.73	0.27

\*Saturated with MgBr<sub>2</sub>·6H<sub>2</sub>O

SOLUBILITY OF MAGNESIUM BROMIDE IN ETHYL ETHER  
(Rowley, 1936)

The author made a very careful study of the factors influencing the accuracy of the results, including the effect of moisture and of light. The very greatest care is required to obtain accurate results. The values are considerably lower than those of Menschutkin.

t°	Gms. MgBr <sub>2</sub> per 100 gms. (C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	Solid Phase	t°	Gms. MgBr <sub>2</sub> per 100 gms. (C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	Solid Phase
-20	0.22	MgBr <sub>2</sub> ·3(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	20	2.50	MgBr <sub>2</sub> ·2(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O
-10	0.40	"	22	2.91	"
0	0.70	"	0	2.04	} Immiscible Liquid Phase
+10	1.18	"	+10	2.47	
14	1.58	MgBr <sub>2</sub> ·2(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	20	2.95	
16	1.84	"	30	3.49	
18	2.14	"			

## Mg MAGNESIUM

### THE SYSTEM MAGNESIUM BROMIDE - ETHER - BENZENE AT 25° (Grimes and Rowley, 1951)

Compositions of the conjugate layers.

Upper layer wt. % $\pm 0.1$			Lower layer wt. % $\pm 0.5$		
MgBr <sub>2</sub>	C <sub>6</sub> H <sub>6</sub>	(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	MgBr <sub>2</sub>	C <sub>6</sub> H <sub>6</sub>	(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O
3.2	0.0	96.8	39.5	0.0	60.5
3.4	3.7	92.9	35.5	3.0	61.5
5.5	11.6	82.9	33.5	4.5	62.0
9.0	14.6	76.4	28.5	8.0	63.5
13.3	15.0	71.7	26.0	9.5	64.5
20 $\pm$ 1	13 $\pm$ 1	67 $\pm$ 1	(Consolute point)		

## Br MAGNESIUM BROMIDE ETHERATES, ALCOHOLATES, ACIDATES, ETC.

### SOLUBILITIES RESPECTIVELY IN ETHER, ALCOHOL, ACIDS, ETC., AT VARIOUS TEMPERATURES (Boris N. Menachutkin, 1907)

(Monograph in the Russian language entitled "On Etherates and Other Molecular Combinations of Magnesium Bromide and Iodide." St. Petersburg, 1907, pp. 267 and XLVIII. Also published in the Memoirs of the St. Petersburg Polytechnic Institute, Vols. 1-7, 1904-1907, and in condensed form in Vols. 49-62 of the Zeit. anorg. Chem., 1906-1909.)

Preparation of Material. The dietherate of magnesium bromide, MgBr<sub>2</sub>·2(C<sub>2</sub>H<sub>5</sub>)<sub>2</sub>O (Z. anorg. Chem., 49, 34, '06) was prepared by the very gradual addition of bromine to a cold mixture of magnesium powder and dry ether. It is very hygroscopic and is stable only under its ethereal solution. It is decomposed by water and reacts with very many organic compounds as alcohols, acids, ketones, esters, aldehydes, etc. The addition products thus formed constitute the material employed in the author's succeeding studies. The monoetherate of magnesium bromide, MgBr<sub>2</sub>·(C<sub>2</sub>H<sub>5</sub>)<sub>2</sub>O, was prepared just as the dietherate, but the temperature during crystallization was kept above 30°, at which point the dietherate is converted to monoetherate. It is also precipitated by dry ligroin.

Method of Determination of Solubility. At temperatures below 30° the determinations were made by agitating an excess of the salt with the solvent and analyzing the saturated solution. At the higher temperatures the synthetic (sealed tube) method of Alexejeff (Wied. Ann., 1885) was used. See also Magnesium Iodide Etherates.

## MAGNESIUM BROMIDE ETHERATES

SOLUBILITY OF MAGNESIUM BROMIDE DIETHERATE,  $MgBr_2 \cdot 2(C_2H_5)_2O$ , AND OF MAGNESIUM BROMIDE ETHERATE,  $MgBr_2(C_2H_5)_2O$ , IN ETHYL ETHER,  $(C_2H_5)_2O$ , AT VARIOUS TEMPERATURES  
(Menschutkin, see preceding page.)

Solubility of the Dietherate in Ether

$t^\circ$	Gms. per 100 Gms. Sat. Sol.		Mols. $MgBr_2 \cdot 2(C_2H_5)_2O$ per 100 Mols. Sat. Sol.	
	$MgBr_2 \cdot 2(C_2H_5)_2O$	$MgBr_2$		
- 8	1.08	0.6	0.24	Br
0	1.44	0.8	0.32	
+10	2.3	1.27	0.52	
14	2.95	1.64	0.67	
16	3.48	1.93	0.80	
18	4.14	2.3	0.96	
20	4.86	2.7	1.125	
22.8	6.3	3.5	1.6	

Two liquid layers separate between these concentrations of  $MgBr_2 \cdot 2(C_2H_5)_2O$ .

23	72.3	40.1	36.8
24	75.3	41.8	40.5
26	79.5	44.1	46.6
28.5	84.2	46.7	54.2
30	85.5	47.4	56.9

Solubility of the Monoetherate in Ether

$t^\circ$	Gms. per 100 Gms. Sat. Sol.		Mols. $MgBr_2 \cdot (C_2H_5)_2O$ per 100 Mols. Sat. Sol.	
	$MgBr_2 \cdot (C_2H_5)_2O$	$MgBr_2$		
0	68.8	49.1	28.1	
20	67.2	47.9	27.1	
30	66.5	47.3	26.6	
40	65.5	46.7	26.1	
60	63.8	45.5	25.1	
80	62.1	44.3	24.2	
100	60.7	43.3	23.5	
120	59.6	42.5	22.9	
140	58.5	41.7	22.3	
158	57.5	41	21.9	

Two liquid layers separate between these concentrations of  $MgBr_2 \cdot (C_2H_5)_2O$

158	5.8	4.15	1.6
158	4.8	3.4	1.36
159	1.96	1.4	0.56
162	0.38	0.27	0.11
170	0.18	0.13	0.05

At  $22.8^\circ$  and  $158^\circ$  the saturated solutions of the dietherate and monoetherate, respectively, separate into two liquid layers which have at the intervening temperatures the following composition. Determinations of the specific gravity of the lower layer gave  $d_{17} = 1.1628$  and  $d_{30} = 1.1492$ .

## Mg MAGNESIUM

SOLUBILITY OF MAGNESIUM BROMIDE DIETHERATE,  $\text{MgBr}_2 \cdot 2(\text{C}_2\text{H}_5)_2\text{O}$ , AND OF MAGNESIUM BROMIDE ETHERATE,  $\text{MgBr}_2(\text{C}_2\text{H}_5)_2\text{O}$ , IN ETHYL ETHER,  $(\text{C}_2\text{H}_5)_2\text{O}$ , AT VARIOUS TEMPERATURES--Cont.

	Gms. per 100 Gms. Solution				
	Lower Layer		Upper Layer		
t°	MgBr <sub>2</sub> ·2(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	MgBr <sub>2</sub>	MgBr <sub>2</sub> ·2(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	MgBr <sub>2</sub>	
-10	75.75	42	3.2	1.8	unstable
0	73.9	41	4.1	2.3	"
+10	72.2	40.1	5	2.8	"
20	70.8	39.3	5.9	3.3	stable
30	69.8	38.7	6.8	3.8	
40	68.8	38.2	7.7	4.3	
50	68	37.8	8.5	4.7	
60	67.7	37.6	9.2	5.1	
70	67.7	37.6	9.7	5.4	
80	68	37.8	10	5.6	
90	68.6	38.1	10.2	5.7	
100	69.4	38.5	10.4	5.8	
120	71	39.3	10.1	5.6	
140	72.4	40.15	9.2	5.1	
158	74	41	7.8	4.3	

## Br MAGNESIUM BROMIDE ALCONOLATES

SOLUBILITY OF ETHYL, METHYL, PROPYL, ETC., ALCOHOLATES OF MAGNESIUM BROMIDE IN THE RESPECTIVE ALCOHOLS (Menschutkin, 1907)

These compounds were all prepared by the action of magnesium bromide dietherate upon the several alcohols. The ether was expelled and the new alcoholate addition product recrystallized from the respective alcohol. The solubility determinations were made by the synthetic method.

Solubility of $\text{MgBr}_2 \cdot 6\text{CH}_3\text{OH}$ in Methyl Alcohol		Solubility of $\text{MgBr}_2 \cdot 6\text{C}_2\text{H}_5\text{OH}$ in Ethyl Alcohol		Solubility of $\text{MgBr}_2 \cdot 6\text{C}_3\text{H}_7\text{OH}$ in Propyl Alcohol		Solubility of $\text{MgBr}_2 \cdot 6\text{C}_4\text{H}_9\text{OH}$ in IsoButyl Alcohol	
Gms. $\text{MgBr}_2 \cdot 6\text{CH}_3\text{OH}$ per 100 Gms.	t° Sat. Sol.	Gms. $\text{MgBr}_2 \cdot 6\text{C}_2\text{H}_5\text{OH}$ per 100 Gms.	t° Sat. Sol.	Gms. $\text{MgBr}_2 \cdot 6\text{C}_3\text{H}_7\text{OH}$ per 100 Gms.	t° Sat. Sol.	Gms. $\text{MgBr}_2 \cdot 6\text{C}_4\text{H}_9\text{OH}$ per 100 Gms.	t° Sat. Sol.
0	42.6	0	17.2	0	77.9	0	55.8
20	44.6	10	24.9	10	81.5	10	60.5
40	46.7	20	32.7	20	85.1	20	65.2
60	48.9	30	40.3	30	88.5	30	69.8
80	51.4	40	47.8	40	92	40	74.3
100	55.5	60	62.2	43	93	50	78.5
120	60.7	80	73.8	46	94.3	60	82.4
140	66.8	90	78.7	48	95.8	65	84.2
160	74	100	86.7	50	97.8	71	88
180	84.5	103	90	52*	100	75	92
185	88	106	94.4			77	94.6
190*	100	108.5*	100			80*	100

\* = m. pt.

# MAGNESIUM Mg

Solubility of  
MgBr<sub>2</sub>·6 IsoC<sub>5</sub>H<sub>11</sub>OH  
in IsoAmyl Alcohol

Solubility of  
MgBr<sub>2</sub>·4(CH<sub>3</sub>)<sub>2</sub>CHOH  
in Dimethyl Carbinol

Solubility of  
MgBr<sub>2</sub>·4(CH<sub>3</sub>)<sub>3</sub>COH  
in Trimethyl Carbinol

Gms. MgBr <sub>2</sub> ·6C <sub>5</sub> H <sub>11</sub> OH per 100 Gms.		Gms. MgBr <sub>2</sub> ·4(CH <sub>3</sub> ) <sub>2</sub> CHOH per 100 Gms.		Gms. MgBr <sub>2</sub> ·4(CH <sub>3</sub> ) <sub>3</sub> COH per 100 Gms.	
t°	Sat. Sol.	t°	Sat. Sol.	t°	Sat. Sol.
0	70.2	0	40	24.7 m. pt. of (CH <sub>3</sub> ) <sub>2</sub> COH	
10	75.6	20	42.2	24.4 Eutec.	0.06
20	80.2	40	45	25	1
30	84.5	60	48.5	35	9.5
35	86.7	80	53.3	45	19.1
38	88.7	100	59	55	32.2
40	90	120	67.3	60	40.5
42	92	130	74	70	62.5
44	94.2	136	83.6	75	77
46 m. pt.	100	138	90	79	91.5
		139 m. pt.	100	80 m. pt.	100

## MAGNESIUM BROMIDE ANILINATES

Br

SOLUBILITY OF MAGNESIUM BROMIDE ANILINATES IN ANILINE  
AT DIFFERENT TEMPERATURES  
(Menschutkin, 1907)

The compounds were formed by the action of aniline on magnesium bromide dietherate. The three compounds were: MgBr<sub>2</sub>·6C<sub>6</sub>H<sub>5</sub>NH<sub>2</sub>, MgBr<sub>2</sub>·4C<sub>6</sub>H<sub>5</sub>NH<sub>2</sub> and MgBr<sub>2</sub>·2C<sub>6</sub>H<sub>5</sub>NH<sub>2</sub>.

Gms. MgBr <sub>2</sub> ·4C <sub>6</sub> H <sub>5</sub> NH <sub>2</sub> per 100 Gms.			Gms. MgBr <sub>2</sub> ·4C <sub>6</sub> H <sub>5</sub> NH <sub>2</sub> per 100 Gms.		
t°	Sat. Sol.	Solid Phase	t°	Sat. Sol.	Solid Phase
10	3.2	MgBr <sub>2</sub> ·6C <sub>6</sub> H <sub>5</sub> NH <sub>2</sub>	160	26	MgBr <sub>2</sub> ·4C <sub>6</sub> H <sub>5</sub> NH <sub>2</sub>
50	5.1	"	180	28.3	"
70	7.5	"	200	33.5	"
90	12.8	"	220	45	"
100	18.5	"	230	55	"
103.5	27.5	"	237*	76.3	"
103*	24	MgBr <sub>2</sub> ·4C <sub>6</sub> H <sub>5</sub> NH <sub>2</sub>	250	77.3	MgBr <sub>2</sub> ·2C <sub>6</sub> H <sub>5</sub> NH <sub>2</sub>
120	24.3	"	260	78.1	"
140	24.3	"	270	79	"

\* = tr. pt.



## Mg MAGNESIUM

### MAGNESIUM BROMIDE PHENYLHYDRAZINATES

#### SOLUBILITY OF MAGNESIUM BROMIDE PHENYLHYDRAZINATES IN PHENYLHYDRAZINE (Menschutkin, 1907)

(Approximate determinations)

t°	Gms. MgBr <sub>2</sub> ·6C <sub>6</sub> H <sub>5</sub> NHNH <sub>2</sub> per 100 Gms.		Solid Phase	t°	Gms. MgBr <sub>2</sub> ·6C <sub>6</sub> H <sub>5</sub> NHNH <sub>2</sub> per 100 Gms.		Solid Phase
	Sat. Sol.				Sat. Sol.		
20	3		MgBr <sub>2</sub> ·6C <sub>6</sub> H <sub>5</sub> NHNH <sub>2</sub>	100*	54.8		MgBr <sub>2</sub> ·4C <sub>6</sub> H <sub>5</sub> NHNH <sub>2</sub>
40	7		"	140	60.8		"
60	16.4		"	180	68.4		"
80	33		"	200	73.4		"
99	54.8		"				

\*tr. pt.

### Br MAGNESIUM BROMIDE compounds with BENZALDEHYDE and with ACETONE

#### SOLUBILITY RESPECTIVELY IN BENZALDEHYDE AND IN ACETONES (Menschutkin, 1907)

The compounds were prepared by the action of benzaldehyde and of acetone on magnesium bromide dietherate. On account of the nature of the compounds the results are only approximately correct.

#### Solubility of MgBr<sub>2</sub>·3C<sub>6</sub>H<sub>5</sub>COH in Benzaldehyde

t°	Gms. MgBr <sub>2</sub> ·3C <sub>6</sub> H <sub>5</sub> COH per 100 Gms.		t°	Gms. MgBr <sub>2</sub> ·3C <sub>6</sub> H <sub>5</sub> COH per 100 Gms.	
	Sat. Sol.			Sat. Sol.	
0	0.7		140	17.8	
30	1.3		145	37.5	
60	1.9		146	65	
100	3.4		148	84.5	
120	6		153	93.2	
130	9.5		159 m. pt.	100	

#### Solubility of MgBr<sub>2</sub>·3CH<sub>3</sub>·CO·CH<sub>3</sub> in Acetone\*

t°	Gms. MgBr <sub>2</sub> ·3CH <sub>3</sub> ·CO·CH <sub>3</sub> per 100 Gms.		t°	Gms. MgBr <sub>2</sub> ·3CH <sub>3</sub> ·CO·CH <sub>3</sub> per 100 Gms.	
	Sat. Sol.			Sat. Sol.	
0	0.2		75	50	
30	0.8		76	71.6	
60	1.45		80	83.3	
70	2		84	89.8	
73	5.5		88	95.2	
74	14		92 m. pt.	100	

\*at 20°, 0.533 gms. MgBr<sub>2</sub> dissolve in 100 gms. acetone. (Altaba, 1951)

**MAGNESIUM BROMIDE compounds with METHYLAL, ORTHO ETHYLFORMATE,  
FORMIC ACID and ACETIC ACID**

SOLUBILITY RESPECTIVELY IN METHYLAL, ORTHO ETHYLFORMATE,  
FORMIC ACID AND ACETIC ACID  
(Menschutkin, 1907a)

The compounds were prepared by the action of methylal, ortho ethylformate and absolutely dry formic and acetic acids on magnesium dietherate. In the case of the latter compounds the results are only approximately correct, due to their extreme hygroscopicity.

Solubility of  
 $\text{MgBr}_2 \cdot 2\text{CH}_2(\text{OCH}_3)_2$   
in Methylal

Gms.  $\text{MgBr}_2 \cdot 2\text{CH}_2(\text{OCH}_3)_2$   
per 100 Gms.  
sat. sol.

t°	
20	0.3
40	0.45
60	0.6
80	0.75
100	0.9
106	1.1
2 liquid layers here	
106	86.2
108	90.8
110	95.4
112 m. pt.	100

Solubility of  
 $\text{MgBr}_2 \cdot 2\text{CH}(\text{OC}_2\text{H}_5)_3$   
in Orthoethylformate

Gms.  $\text{MgBr}_2 \cdot 2\text{CH}(\text{OC}_2\text{H}_5)_3$   
per 100 Gms.  
sat. sol.

t°	
0	11.1
20	12.5
40	14.8
60	18.6
80	25.7
90	35
95	41
100	50
105	66
110	88.5
114 m. pt.	100

Br

Solubility of  
 $\text{MgBr}_2 \cdot 6\text{HCOOH}$   
in Formic Acid

Gms.  $\text{MgBr}_2 \cdot 6\text{HCOOH}$   
per 100 Gms.  
Sat. Sol.

t°	
0	49.8
20	57.5
40	65.1
60	73.1
70	78.1
80	86
86	95
88 m. pt.	100

Solubility of  
 $\text{MgBr}_2 \cdot 6\text{CH}_3\text{COOH}$   
in Acetic Acid

Gms.  $\text{MgBr}_2 \cdot 6\text{CH}_3\text{COOH}$   
per 100 Gms.  
Sat. Sol.

t°	
17	0.3
30	1.5
50	4.5
60	7.9
70	16.2
80	38.5
90	57.7
100	71.8
105	80
110	89.5
112 m. pt.	100

# Mg MAGNESIUM

## MAGNESIUM BROMIDE compounds with ACETAMIDE, ACETANILIDE and ACETIC ANHYDRIDE

SOLUBILITY RESPECTIVELY IN ACETAMIDE, ACETANILIDE AND ACETIC ANHYDRIDE (Menschutkin, 1909)

The compounds were prepared by reaction with magnesium bromide dietherate.

### Solubility of $\text{MgBr}_2 \cdot 6\text{CH}_3\text{CONH}_2$ in Acetamide

Br	t°	Gms. $\text{MgBr}_2 \cdot 6\text{CH}_3\text{CONH}_2$ per 100 Gms. Sat. Sol.	Solid Phase
82 m. pt. of $\text{CH}_3\text{CONH}_2$		0	$\text{CH}_3\text{CONH}_2$
80		3.1	"
70		21.7	"
60		40	"
50.5*		56	$\text{CH}_3\text{CONH}_2 + \text{MgBr}_2 \cdot \text{CH}_3\text{CONH}_2$
70		57.8	$\text{MgBr}_2 \cdot \text{CH}_3\text{CONH}_2$
90		60.5	"
110		65	"
130		71.5	"
150		80	"
160		85	"
165		90	"
169†		100	"

### Solubility of $\text{MgBr}_2 \cdot 6\text{CH}_3\text{CONHC}_6\text{H}_5$ in Acetanilide

### Solubility of $\text{MgBr}_2 \cdot 6(\text{CH}_3\text{CO})_2\text{O}$ in Acetic Anhydride

t°	Gms. $\text{MgBr}_2 \cdot 6\text{CH}_3\text{CONHC}_6\text{H}_5$ per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. $\text{MgBr}_2 \cdot 6(\text{CH}_3\text{CO})_2\text{O}$ per 100 gms. Sat. Sol.
112 m. pt. of $\text{CH}_3\text{CONHC}_6\text{H}_5$			0	26.4
110	3.7	$\text{CH}_3\text{CONHC}_6\text{H}_5$	20	28.7
108	7.7	"	40	31.6
107.5*	9	" + $\text{MgBr}_2 \cdot \text{CH}_3\text{CONHC}_6\text{H}_5$	80	41.1
120	13.1	$\text{MgBr}_2 \cdot \text{CH}_3\text{CONHC}_6\text{H}_5$	100	48.4
140	19.3	"	120	57.8
160	25.5	"	130	69.8
180	35.3	"	133	77
200	59.5	"	135	85
205	73.2	"	136.5†	100
207	82.5	"		
209	100†	"		

\*Eutec.

†m. pt.

## MAGNESIUM BROMIDE compounds with URETHAN and with UREA

SOLUBILITY RESPECTIVELY IN URETHAN AND WITH UREA  
(Menschutkin, 1909)

Solubility of Magnesium Bromide Urethan Compounds in Urethan

t°	Gms. $\text{MgBr}_2 \cdot 4\text{C}_2\text{H}_5\text{OCONH}_2$ per 100 gms. Sat. Sol.	Solid Phase
49 m. pt. of urethan	0	$\text{C}_2\text{H}_5\text{OCONH}_2$
45	18.5	"
39	36.5	"
35 Eutec.	43.3	" + $\text{MgBr}_2 \cdot 6\text{C}_2\text{H}_5\text{OCONH}_2$
50	45.6	$\text{MgBr}_2 \cdot 6\text{C}_2\text{H}_5\text{OCONH}_2$ Br
70	51.3	"
80	56.2	"
90	66.5	"
91.5	75.5	"
91 tr. pt.	69.4	" + $\text{MgBr}_2 \cdot 4\text{C}_2\text{H}_5\text{OCONH}_2$
100	73.8	$\text{MgBr}_2 \cdot 4\text{C}_2\text{H}_5\text{OCONH}_2$
110	80	"
115	84.1	"
120	90	"
123	100	"

Solubility of Magnesium Bromide Urea Compounds in Urea

t°	Gms. $\text{MgBr}_2 \cdot 4\text{CO}(\text{NH}_2)_2$ per 100 Gms. Sat. Sol.	Solid Phase
132 m. pt. of urea	0	$\text{CO}(\text{NH}_2)_2$
126	9.5	"
120	17.2	"
114	21.8	"
108.5*	24.2	" + $\text{MgBr}_2 \cdot 6\text{CO}(\text{NH}_2)_2$
115	29.8	$\text{MgBr}_2 \cdot 6\text{CO}(\text{NH}_2)_2$
120	35	"
127	45.5	"
130	60	"
130†	58	" + $\text{MgBr}_2 \cdot 4\text{CO}(\text{NH}_2)_2$
145	60.7	$\text{MgBr}_2 \cdot 4\text{CO}(\text{NH}_2)_2$
160	67.2	"
165	71.4	"
170	83.7	"
171	96	"

\*Eutec †tr. pt.

100 cc. acetonitrile dissolve 13.35 gms.  $\text{MgBr}_2$  at 25°.

100 cc. pyridine dissolve 0.49 gms.  $\text{MgBr}_2$  at 18°, 0.54 gms. at 25°  
and 2.5 gms. at 60°. (Muller, R., 1924)

100 gms. sat. solution of Magnesium Bromide in Liquid Ammonia contain 0.004 gm.  $\text{MgBr}_2$  at 0°. (Linhard and Stephan, 1933, 1934.)

Fusion point data for mixtures of  $\text{MgBr}_2$  + KBr and  $\text{MgBr}_2$  + NaBr are given by Kellner, 1917.

# Mg MAGNESIUM

## BrO MAGNESIUM BROMATE $\text{Mg}(\text{BrO}_3)_2$

### THE SYSTEM MAGNESIUM BROMATE - WATER (Linke, 1955)

Temp., °C	Saturated Solution		Temp., °C	Satd. Soln. $\text{Mg}(\text{BrO}_3)_2$ wt. %
	$\text{Mg}(\text{BrO}_3)_2$ , wt. %	Density		
	Ice			$\text{Mg}(\text{BrO}_3)_2 \cdot 6\text{H}_2\text{O} + \text{Mg}(\text{BrO}_3)_2 \cdot 2\text{H}_2\text{O}$
- 1.6	9.34	--	80.0 <sup>a</sup>	70.1 <sup>a</sup>
- 4.2	20.94	--		
-10.1	34.66	--		$\text{Mg}(\text{BrO}_3)_2 \cdot 2\text{H}_2\text{O}$
	Ice + $\text{Mg}(\text{BrO}_3)_2 \cdot 6\text{H}_2\text{O}$			
-13.0	38.5 <sup>a</sup>	1.448	81	70.1
	$\text{Mg}(\text{BrO}_3)_2 \cdot 6\text{H}_2\text{O}$		90	70.8
0	42.34	1.512	100	71.9
10	45.58	1.562	117	72.6
20	48.66	1.609	130	73.3
30	51.4	1.662	134 <sup>a, b</sup>	73.6 <sup>a</sup>
40	54.5	1.722		
50	57.3	1.787	B. p. of unsaturated solns.	
65	62.5	1.900	101.0	15.15
75	66.8	2.013	102.6	27.2
78	68.3	2.070	106.5	44.3
80.5 <sup>c</sup>	70.15	--	116	60.9
			131	72.2

<sup>a</sup>Estimated graphically.

<sup>b</sup>Boiling point.

<sup>c</sup>Metastable melting point.

### SOLUBILITY OF $\text{Mg}(\text{BrO}_3)_2$ IN $\text{Mg}(\text{NO}_3)_2$ SOLUTIONS AT 85° (Linke, 1955)

Saturated soln., wt. %		Solid Phase	Saturated soln., wt. %		Solid Phase
$\text{Mg}(\text{NO}_3)_2$	$\text{Mg}(\text{BrO}_3)_2$		$\text{Mg}(\text{NO}_3)_2$	$\text{Mg}(\text{BrO}_3)_2$	
0	70.4 <sup>a</sup>	$\text{Mg}(\text{BrO}_3)_2 \cdot 2\text{H}_2\text{O}$	7.35	61.12	$\text{Mg}(\text{BrO}_3)_2 \cdot 2\text{H}_2\text{O}$
4.72	64.30	"	8.85	59.62	"
6.00	62.99	"	9.50	58.04	"

MAGNESIUM FORMATE  $\text{Mg}(\text{HCOO})_2 \cdot 2\text{H}_2\text{O}$ 

CH

SOLUBILITY OF MAGNESIUM FORMATE IN WATER  
(Ashton, Houston, and Saylor, 1933)

t°	Gms. $\text{Mg}(\text{HCOO})_2$ per 100 gms. $\text{H}_2\text{O}$		Solid Phase	t°	Gms. $\text{Mg}(\text{HCOO})_2$ per 100 gms. $\text{H}_2\text{O}$		Solid Phase
-5.05*	14.0		Ice + $\text{Mg}(\text{HCOO})_2 \cdot 2\text{H}_2\text{O}$	50	16.8		$\text{Mg}(\text{HCOO})_2 \cdot 2\text{H}_2\text{O}$
0	14.0		$\text{Mg}(\text{HCOO})_2 \cdot 2\text{H}_2\text{O}$	60	18.0		"
10	14.1		"	70	19.2		"
20	14.4		"	80	20.6		"
30	15.0		"	90	22.2		"
40	15.9		"	100	24.0		"

\*Eutec.

SOLUBILITY OF MAGNESIUM FORMATE IN AQUEOUS SOLUTIONS  
OF FORMIC ACID AT 25°  
(Dunn and Philip, 1934)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
HCOOH	$\text{Mg}(\text{HCOO})_2$		HCOOH	$\text{Mg}(\text{HCOO})_2$	
0.00	12.23	$\text{Mg}(\text{HCOO})_2 \cdot 2\text{H}_2\text{O}$	60.9	4.68	$\text{Mg}(\text{HCOO})_2 \cdot 2\text{H}_2\text{O}$
15.73	10.10	"	76.2	3.19	"
31.28	8.01	"	90.8	2.15	"
46.7	6.22	"			

MAGNESIUM METHANOLATE  $\text{Mg}(\text{CH}_3\text{O})_2 \cdot 2\text{CH}_3\text{OH}$ 

CH

SOLUBILITY OF MAGNESIUM METHANOLATE IN METHYL ALCOHOL  
(Quinet, 1935)

t°	Gm. Mols. $\text{Mg}(\text{CH}_3\text{O})_2$ per 100 gms. sat. solution	Solid Phase
-20	0.074	$\text{Mg}(\text{CH}_3\text{O})_2 \cdot 4\text{CH}_3\text{OH}$
+20	0.118	$\text{Mg}(\text{CH}_3\text{O})_2 \cdot 2\text{CH}_3\text{OH}$
66	0.079	" (decomposition begins)

MAGNESIUM DIETHYL  $\text{Mg}(\text{C}_2\text{H}_5)_2$ 

(Results of Strohmeier, 1955)

Solvent	Solubility at 20°
Heptane	0.099 gms. $\text{Mg}(\text{C}_2\text{H}_5)_2$ per liter
Benzene	1.3 "
Dioxane	∞ "
Ethyl Ether	165. "

# Mg MAGNESIUM

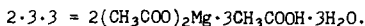
## CH MAGNESIUM ACETATE $\text{Mg}(\text{CH}_3\text{COO})_2$

### SOLUBILITY OF MAGNESIUM ACETATE IN WATER (Rivett, 1926)

t°	Gms. $\text{Mg}(\text{CH}_3\text{COO})_2$ per 100 gms. sat. sol.	Solid Phase
- 0.364	1.068	Ice
- 0.531	1.804	"
- 1.083	3.08	"
- 2.179	5.92	"
- 4.687	11.45	"
- 9.99	19.81	"
-15.28	25.00	"
-29.0	34.5	" + $\text{Mg}(\text{CH}_3\text{COO})_2 \cdot 4\text{H}_2\text{O}$
+ 0.1	36.2	$\text{Mg}(\text{CH}_3\text{COO})_2 \cdot 4\text{H}_2\text{O}$
14.9	37.97	"
24.9	39.61	"
35.0	41.78	"
45.0	44.76	"
55.0	49.46	"
+68.0	66.4 approx. m. pt. of	"

### THE SYSTEM MAGNESIUM OXIDE - ACETIC ACID - WATER AT 25° (Iwaki, 1914)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{CH}_3\text{COOH}$	$\text{MgO}$		$\text{CH}_3\text{COOH}$	$\text{MgO}$	
3.36	1.73	$\text{MgO}$	31.37	7.99	$(\text{CH}_3\text{COO})_2\text{Mg} \cdot 4\text{H}_2\text{O}$
5.65	2.93	"	36.23	8.18	" + 2.3.3
8.06	4.21	"	35.77	8.17	2.3.3
12.46	6.54	"	40.87	7.42	"
15.46	8.24	" + $(\text{CH}_3\text{COO})_2\text{Mg} \cdot 4\text{H}_2\text{O}$	47.86	6.74	"
15.38	8.31	$(\text{CH}_3\text{COO})_2\text{Mg} \cdot 4\text{H}_2\text{O}$	56.16	5.81	"
14.25	7.24	"	61.59	4.68	"
20.19	7.47	"	69.13	3.75	"
22.93	7.60	"	75.93	2.85	"
26.61	7.74	"	82.90	2.23	"



More careful work in the region of the double salt showed that a second double salt of the composition  $5(\text{CH}_3\text{COO})_2\text{Mg} \cdot 10\text{CH}_3\text{COOH} \cdot 7\text{H}_2\text{O}$  was obtained. This compound usually separated from the more concentrated acetic acid solutions.

100 gms. Methyl Alcohol sat. with anhydrous magnesium acetate dissolve 5.25 gm.  $\text{Mg}(\text{CH}_3\text{COO})_2$  at 15° and 7.50 gm. at 68.20° (b. pt.).  
(Henstock, 1934)

MAGNESIUM TARTRATE  $\text{Mg}(\text{C}_4\text{H}_4\text{O}_6) \cdot 2-1/2\text{H}_2\text{O}$ 

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100 cc. of sat. solution of  $\text{Mg}(\text{C}_4\text{H}_4\text{O}_6) \cdot 2\frac{1}{2}\text{H}_2\text{O}$  in water contain 0.76 gm.  $\text{Mg}(\text{C}_4\text{H}_4\text{O}_6)$  at  $30^\circ$  and 1.44 gm. at  $90^\circ$ .

(Chatterjee and Dher, 1924)

SOLUBILITY OF ACTIVE MAGNESIUM TARTRATE AND OF RACEMIC  
MAGNESIUM TARTRATE IN WATER AT SEVERAL TEMPERATURES  
(Duboux and Cuttat, 1921)

Results for the Active Salt			Results for the Racemic Salt		
t°	Gms. $\text{MgC}_4\text{H}_4\text{O}_6$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{Mg}_2\text{C}_3\text{H}_8\text{O}_{12}$ per 100 gms. sat. sol.	Solid Phase
0	0.540	$\text{MgC}_4\text{H}_4\text{O}_6 \cdot 4\text{H}_2\text{O}$	0	0.403	$\text{Mg}_2\text{C}_3\text{H}_8\text{O}_{12} \cdot 10\text{H}_2\text{O}$
12.5	0.848	"	12.5	0.582	"
25	1.174	"	25.0	0.826	"
26.2	1.220	" + $\text{MgC}_3\text{H}_4\text{O}_6 \cdot 2\text{H}_2\text{O}$	37.5	1.095	"
37.5	1.050	$\text{MgC}_4\text{H}_4\text{O}_6 \cdot 2\text{H}_2\text{O}$			

MAGNESIUM SUCCINATE  $\text{C}_4\text{H}_4\text{O}_4\text{Mg} \cdot 5\text{H}_2\text{O}$ 

100 gms. sat. solution in water contain 24.35 gms. succinate at  $15^\circ$  and 66.36 gms. at  $100^\circ$ .

(Tarugi and Checchi, 1901)

MAGNESIUM MALATE active,  $\text{C}_4\text{H}_4\text{O}_5\text{Mg} \cdot 3\text{H}_2\text{O}$ ; racemic,  $\text{C}_8\text{H}_8\text{O}_{10}\text{Mg}_2 \cdot 5\text{H}_2\text{O}$ 

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SOLUBILITY OF EACH FORM IN WATER  
(Duboux and Cuttat, 1921)

Active Salt			Racemic Salt		
t°	Gms. $\text{C}_4\text{H}_4\text{O}_5 \cdot \text{Mg}$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{C}_8\text{H}_8\text{O}_{10} \cdot \text{Mg}_2$ per 100 gms. sat. sol.	Solid Phase
0	2.02	$\text{C}_4\text{H}_4\text{O}_5 \cdot \text{Mg} \cdot 3\text{H}_2\text{O}$	0	0.93	$\text{C}_8\text{H}_8\text{O}_{10}\text{Mg}_2 \cdot 5\text{H}_2\text{O}$
12.5	2.28	"	12.5	1.08	"
25.0	2.54	"	25.0	1.23	"
37.5	2.80	"	37.5	1.38	"

Saturation was obtained by continuous rotation for 7 to 10 hours.

MAGNESIUM LACTATE  $\text{Mg}(\text{C}_3\text{H}_5\text{O}_2)_2 \cdot 3\text{H}_2\text{O}$ 

100 gms. Methyl Alcohol sat. with anhydrous magnesium lactate dissolve 2.27 gms.  $\text{Mg}(\text{C}_3\text{H}_5\text{O}_2)_2$  at  $15^\circ$  and 1.14 gms. at  $66.1^\circ$  (b. pt.).

(Henstock, 1934)



## 1.5 MAGNESIUM

CH MAGNESIUM diLACTATE  $\text{Mg}(\text{C}_6\text{H}_8\text{O}_5)_2 \cdot 6\text{H}_2\text{O}$  racemic,  $\text{Mg}(\text{C}_6\text{H}_8\text{O}_5)_2 \cdot 3\text{H}_2\text{O}$ , Inactive

### SOLUBILITY OF RACEMIC AND OF INACTIVE MAGNESIUM diLACTATE IN WATER (Jungfleisch, 1912)

100 gms.  $\text{H}_2\text{O}$  dissolve 7 to 8 gms. racemic and 2.28 gms. inactive lactate at  $15^\circ$ .

MAGNESIUM GLUCONATE  $\text{Mg}(\text{C}_6\text{H}_{11}\text{O}_7)_2 \cdot 3\text{H}_2\text{O}$

100 gms. sat. solution of  $\text{Mg}(\text{C}_6\text{H}_{11}\text{O}_7)_2 \cdot 3\text{H}_2\text{O}$  in Water contain 7.8 gms.  $\text{Mg}(\text{C}_6\text{H}_{11}\text{O}_7)_2$  at  $25^\circ$ . (May, Weisberg and Herrick, 1929)

MAGNESIUM DIPHENYL  $\text{Mg}(\text{C}_6\text{H}_5)_2$

### Results of Strohmeier, 1955

Solvent	Solubility at $20^\circ$
Heptane	0.0001 gms. $\text{Mg}(\text{C}_6\text{H}_5)_2$ per liter
Benzene	0.11 "
Dioxane	42.9 "
Ethyl ether	$\infty$ "

MAGNESIUM BENZOATE  $\text{Mg}(\text{C}_6\text{H}_5\text{COO})_2 \cdot 4 \text{H}_2\text{O}$

100 gms.  $\text{H}_2\text{O}$  dissolve 6.16 gms.  $\text{Mg}(\text{C}_6\text{H}_5\text{COO})_2$  at  $15^\circ$  and 19.6 gms. at  $100^\circ$ .  
(Tarugi and Checchi, 1901)

100 cc. sat. solution of Magnesium benzoate in water contain 6.364 gms.  $\text{Mg}(\text{C}_6\text{H}_5\text{COO})_2$  at  $20^\circ$ .  
(Ephraim and Pfister, 1925)

100 gms.  $\text{H}_2\text{O}$  dissolve 3.33 gms.  $\text{Mg}(\text{C}_6\text{H}_5\text{COO})_2$  at  $15-20^\circ$ .  
(Squire and Caines, 1905)

100 gms. Acetone sat. with anhydrous  $\text{Mg}$  benzoate dissolve 2.38 gm.  $\text{Mg}(\text{C}_6\text{H}_5\text{COO})_2$  at  $15^\circ$ .  
(Henctock, 1934)

MAGNESIUM 4-Nitro BENZOATE  $\text{Mg}(\text{C}_6\text{H}_4\cdot\text{NO}_2\cdot\text{COO})_2 \cdot 6\text{H}_2\text{O}$

100 cc. sat. solution of Magnesium 4-Nitro benzoate in water contain 1.840 gms.  $\text{Mg}(\text{C}_6\text{H}_4\text{NO}_2\text{COO})_2$  at  $20^\circ$ .  
(Ephraim and Pfister, 1925)

MAGNESIUM BENZOATE Tri Methyl Alcoholate  $\text{Mg}(\text{C}_6\text{H}_5\text{COO})_2 \cdot 3\text{CH}_2\text{OH}$ 

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100 gms. Methyl Alcohol sat. with the tri alcoholate dissolve 1.24 gms.  $\text{Mg}(\text{C}_6\text{H}_5\text{COO})_2$  at 15° and 70.98 gms. at 71.9° (b. pt.).  
(Henstock, 1934)

MAGNESIUM SALICYLATE  $\text{Mg}(\text{C}_7\text{H}_5\text{O}_3)_2 \cdot 4\text{H}_2\text{O}$ 

100 gms. sat. solution in water contain 20.4 gms. salicylate at 15° (14.3 gms. Squire and Gaines, 1905), and 79.7 gms. at 100°.  
(Tarugi and Checchi, 1901)

100 gms. 90% alcohol dissolve 0.6 gm. salicylate at 15°-20°.  
(Squire and Gaines, 1905)

MAGNESIUM PHTHALATE  $\text{MgC}_6\text{H}_4(\text{COO})_2$ 

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THE SYSTEM MAGNESIUM PHTHALATE - PHTHALIC ACID - WATER  
(Smith and Ely, 1938)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
A	M		A	M	
Results at 0°			Results at 25°		
0.0	30.63	M	0.0	34.11	M
0.39	30.78	M + HP	0.47	34.16	M
0.47	26.58	HP	1.03	34.26	M
0.76	16.20	HP	1.16	34.40	M + HP
1.06	7.69	HP	1.21	32.26	HP
1.58	1.95	HP + A	1.30	30.98	HP
1.00	0.99	A	1.36	27.49	HP
0.29	0.0	A	1.54	23.49	HP
Results at 50°			1.60	22.75	HP
0.0	42.28	M	1.72	20.46	HP
3.12	42.71	M	1.79	19.17	HP
3.53	42.80	M + HP	2.33	8.92	HP
3.67	41.19	HP	3.23	4.71	HP
3.88	38.25	HP	3.61	4.16	HP + A
4.64	31.51	HP	2.70	2.66	A
5.52	24.20	HP	1.69	1.27	A
6.56	18.72	HP	0.69	0.0	A
7.95	13.68	HP			
10.21	11.19	HP + A			
9.47	9.95	A			
7.43	6.95	A			
6.15	5.36	A			
4.13	2.85	A			
1.72	0.0	A			

M =  $2\text{MgC}_8\text{H}_4(\text{COO})_2 \cdot 11\text{H}_2\text{O}$

HP =  $\text{MgC}_6\text{H}_4(\text{COO})_2 \cdot \text{C}_6\text{H}_4(\text{COOH})_2 \cdot 8\text{H}_2\text{O}$

A =  $\text{C}_6\text{H}_4(\text{COOH})_2$

# Mg MAGNESIUM

MAGNESIUM 2,4-DINITROPHENATE  $[\text{C}_6\text{H}_3(\text{OH})(\text{NO}_2)_2]_2\text{Mg}$

MAGNESIUM 2,4-DINITROCRESYLATE  $[\text{C}_6\text{H}_2(\text{CH}_3)(\text{OH})(\text{NO}_2)_2]_2\text{Mg}$

The solubility of each compound is about 3% in water at room temperature.

(Pastac and Lecrivain, 1948)

## CH MAGNESIUM MANDELATE (r), (l), $\text{Mg}(\text{C}_6\text{H}_5\text{CH}(\text{OH})\text{COO})_2$

### SOLUBILITY OF MAGNESIUM MANDELATES IN WATER (Findlay and Campbell, 1930)

Gms. $\text{Mg}(\text{C}_6\text{H}_5\text{CH}(\text{OH})\text{COO})_2$ per 100 gms. $\text{H}_2\text{O}$			Results (l) for Solutions in equilibrium with Solid Phases composed of both active and racemic Salt.		
t°	Results for r-Salt	Results for l-Salt	Solid Phase in solutions sat. with racemic salt	t°	Gms. per 100 gms. $\text{H}_2\text{O}$
					1 Salt      d Salt
0	1.52	1.60	$\text{Mg}(\text{Man})_2 \cdot \text{H}_2\text{O}$	0	1.94      0.24
5	1.36	1.68	"	5	2.12      0.55
10	1.15	0.72	"	10	1.59      0.32
15	1.06	1.77	$\text{Mg}(\text{Man})_2 \cdot \frac{1}{2}\text{H}_2\text{O}$	15	2.66      0.60
20	1.04	1.83	"	20	2.23      0.39
25	0.95 (2.61)	1.97 (6.08)	"	25	1.96      0.41
30	0.88	2.12	$\text{Mg}(\text{Man})_2$	30	2.16      0.49
35	1.16	2.72	"	35	2.40      0.49
40	1.33	5.07	"	40	2.50      0.50

Man  $= (\text{C}_6\text{H}_5\text{CH}(\text{OH})\text{COO})_2$

(l) = Determined polarimetrically

Other values for the solubility of the (r) and (l) salts in water are as follows:

Gms. $\text{Mg}(\text{C}_8\text{H}_7\text{O}_3)_2$ per 100 gms. sat. sol.			Authority
t°	(r) Salt	(l) Salt	
16	--	4.5	McKenzie, 1899
18	1.8	--	" "
25	2.61	--	Ross and Morrison, 1936
25	--	6.08	" " " and Johnstone, 1937

Ross and Morrison, 1936 also give results for the system Magnesium (r) Mandelate + (r) Mandelic Acid +  $\text{H}_2\text{O}$  at 25° in which the acid salt,  $2\text{Mg}(\text{C}_8\text{H}_7\text{O}_3)_2 \cdot \text{C}_8\text{H}_7\text{O}_3 \cdot 2\text{H}_2\text{O}$  is formed.

Ross, Morrison and Johnstone, 1937, give results for the system Magnesium (l) Mandelate + (l) Mandelic Acid +  $\text{H}_2\text{O}$  at 25° in which the acid salt which is formed probably has the same composition as that of the (r) compound but, due to analytical difficulties, metastability and slowness with which equilibrium is attained, conclusive results were not obtained.

MAGNESIUM CINNAMATE  $Mg(C_6H_5CH=CHCOO)_2 \cdot 1$  or  $\frac{1}{2} H_2O(?)$ 

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## SOLUBILITY OF MAGNESIUM CINNAMATE IN WATER

t°	Gms. $Mg(C_6H_5CH=CHCOO)_2$ per 100 cc. sat. solution	Authority
15	0.85*	(Tarugi and Checchi, 1901)
18	1.114	(Fredholm, 1934)
20	1.225	(Ephraim and Pfister)
100	1.94*	(Tarugi and Checchi, 1901)

\* = per 100 gms. sat. solution

SOLUBILITY OF MAGNESIUM CINNAMATE IN AQUEOUS SOLUTIONS  
OF AMMONIUM CHLORIDE AND AMMONIA AT 18°  
(Fredholm, 1934)

Comp. of Aq. solvent in Gm. Equiv. per liter	Gm. Equiv. Mg per liter sat. sol.	Comp. of Aq. solvent in Gm. Equiv. per liter	Gm. Equiv. Mg per liter sat. sol.
Water alone	0.07	0.2994 $NH_4Cl + 0.5988NH_3$	0.0957
0.2994 $NH_4Cl$	0.0847	0.2994 " + 0.798 "	0.0981
0.2994 " + 0.1996 $NH_3$	0.0889	0.2994 " + 1.000 "	0.1004
0.2994 " + 0.3992 "	0.0928		

## MAGNESIUM QUINOLATES

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## SOLUBILITIES IN WATER

Salt	Temp.	Ksp	Author
Mg-8-hydroxy quinolate (oxine)	Room	$6.5 \times 10^{-16}$	(1)
" " "	25°	$2.7 \times 10^{-13}$	(2)
" " "	Room	$6.8 \times 10^{-12}$	(3)
" " "	Room, pH 10	$1 \times 10^{-10}$	(4)
Mg-8-quinolinol-5-sulfonate	25°	$7.8 \times 10^{-7}$	(5)
Mg 5 and 7 isoquinoline carboxylates	25°, 100°	See Tyson, 1939	
(1) Tinovskaya, 1950	(4) Stone and Friedman, 1947		
(2) Popel and Gladkova, 1955	(5) Nasanen and Uusitalo, 1954		
(3) Borrel and Paris, 1952			

Solubility of Mg 8-hydroxyquinolate in aq. Ethanol at 25°  
(Popel and Gladkova, 1955)

Water	-	$1.9 \times 10^{-4}$ moles/liter
15% Ethanol	-	$3.3 \times 10^{-2}$ gms./liter
60% Ethanol	-	$7.3 \times 10^{-2}$ gms./liter

## Mg MAGNESIUM

### CH MAGNESIUM CAMPHORATE $C_{10}H_{14}O_4Mg \cdot 14H_2O$

SOLUBILITY OF MAGNESIUM CAMPHORATE IN d CAMPHORIC ACID  
AT 15° AND VICE VERSA  
(Jungfleisch and Landrieu, 1914)

Gms. per 100 Gms. Sat. Sol.		Solid Phase
$C_{10}H_{16}O_4$	$C_{10}H_{14}O_4Mg$	
0.622 (13.5°)	0	$C_{10}H_{16}O_4$
1.20	1.29	"
1.98	3.53	"
2.36	5.66	"
2.85	8.19	"
3.16	10.30	"
3.5	16.5	" + $C_{10}H_{14}O_4Mg \cdot 14H_2O$
3.6	16.7	$C_{10}H_{14}O_4Mg \cdot 14H_2O$
1.91	15.1	"
0	14.25	"

### MAGNESIUM CAMPHOR CARBONATE $Mg(C_{10}H_{15}O_2COO)_2$

SOLUBILITY OF MAGNESIUM CAMPHOR CARBONATE IN ALCOHOLS  
(Picom, 1931)

Solvent	Formula	t°	Gms. $Mg(C_{10}H_{15}O_2COO)_2$ per liter sat. sol.
Methyl Alcohol	$CH_3OH$	10.5	10.5
Ethyl Alcohol	$C_2H_5OH$	9	0.36

### CH MAGNESIUM Alkyl SULFONATES

SOLUBILITY OF EACH SEPARATELY IN WATER  
(Reed and Tartar, 1936)

Compound	Formula	Gms. Compound per 100 gms. $H_2O$ at	
		25°	50°
Magnesium n Decyl Sulfonate	$Mg(CH_3(CH_2)_8CH_2SO_3)_2$	0.268	--
" Lauryl "	$Mg(CH_3(CH_2)_{10}CH_2SO_3)_2$	0.033	48.0
" Myristyl "	$Mg(CH_3(CH_2)_{12}CH_2SO_3)_2$	0.0035	0.016
" Cetyl "	$Mg(CH_3(CH_2)_{14}CH_2SO_3)_2$	0.0012	0.006
" n Octadecyl "	$Mg(CH_3(CH_2)_{16}CH_2SO_3)_2$	0.0010	0.003

## MAGNESIUM Anthracene, Benzene and Naphthalene SULFONATES

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## SOLUBILITY OF EACH IN WATER

(Ephraim and Pfister, 1925, 1925a; Ephraim and Seger, 1925; Federov and Lodygin, 1942\*)

and Lodygin, 1942\*)

Compound	Formula	t°	Gms. anhydrous compd. per 100 cc. sat. sol.
Magnesium Anthracene-1-sulfonate	$Mg(C_{14}H_9SO_3)_2 \cdot 4H_2O$	20	0.0799
"	"	100	0.0784*
" -2-	$Mg(C_{14}H_9SO_3)_2 \cdot 4H_2O$	20	0.2528*
"	"	20	0.0077
" -1,5-disulfonate	$1,5-C_{14}H_8S_2O_6Mg \cdot 3H_2O$	100	0.1213*
"	"	20	0.1472*
" -1,8-	$1,8-C_{14}H_8S_2O_6Mg \cdot 3H_2O$	100	0.3077*
"	"	20	2.0383*
" -2,6-	$2,6-C_{14}H_8S_2O_6Mg \cdot 4H_2O$	100	9.0043*
"	"	20	0.1196*
" -2,7-	$2,7-C_{14}H_8S_2O_6Mg \cdot 2H_2O$	100	0.3022*
"	"	20	0.0661*
" Benzene sulfonate	$Mg(C_6H_5SO_3)_2 \cdot 6H_2O$	100	0.2369*
"	"	17	7.496
"	"	20	7.639
"	"	36	11.153
"	"	50	14.569
"	"	65	20.420
"	"	80.5	26.045
"	"	82.0	26.804
" Naphthalene-1-sulfonate	$Mg(C_{10}H_7SO_3)_2 \cdot 6H_2O$	17	6.978
" -2-	$Mg(C_{10}H_7SO_3)_2 \cdot 4H_2O$	16.5	0.2
" -2-	$Mg(C_{10}H_7SO_3)_2 \cdot 6H_2O$	20.0	0.223
"	"	32	0.373
"	"	45	0.490
"	"	59	0.790
"	"	74	1.336
"	"	82	1.737
" -6 oxy-2-sulfonate	$Mg(C_{10}H_7SO_3)_2 \cdot 8H_2O$	20	0.964

Results for the solubility of Magnesium Benzene Sulfonate in aqueous solutions of Benzene Sulfonic Acid at 25°, are given by Dunn and Philip, 1934.

## SOLUBILITY OF MAGNESIUM NAPHTHALENE-2-SULFONATE IN AQUEOUS SOLUTIONS OF AMMONIUM CHLORIDE AND AMMONIA AT 18°

(Fredholm, 1934)

Composition of Aq. Solvent in Gm. Equiv. per liter	Gm. Equiv. Mg. per liter sat. sol.	Composition of Aq. Solvent in Gm. Equiv. per liter	Gm. Equiv. Mg per liter sat. sol.
Water alone	0.010	0.1984 $NH_4Cl$ + 0.784 $NH_3$	0.0170
0.1984 $NH_4Cl$	0.014	" " + 1.000 "	0.0175
" " + 0.196 $NH_3$	0.0151	0.2976 " "	0.0150
" " + 0.392 "	0.0155	" " + 0.392 "	0.0166
" " + 0.588 "	0.0161	" " + 1.000 "	0.0191

MAGNESIUM Naphthalamine Di SULFONATES  $MgC_{10}H_5(NH_2)(SO_3)_2$ , 2.6.8 and 2.5.7

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100 gms. sat. sol. of the 2.6.8 compd. in water contain 8.7 gms.  $MgC_{10}H_5(NH_2)(SO_3)_2$  at 15°. (Braunschweig, 1922, 1926)

100 gms. sat. sol. of the 2.5.7 compd. in water contain 21.09 gms.  $MgC_{10}H_5(NH_2)(SO_3)_2$  at 15°. (Braunschweig, 1922, 1926)

## Mg MAGNESIUM

One liter water sat. with Magnesium-1-Naphthalamine 2-4-7 Tri Sulfonate contains 193 gms.  $\text{MgC}_{10}\text{H}_4\text{NH}_2(\text{SO}_3)_3\text{H}$  at  $20^\circ$  and 235 gms. at  $80^\circ$ .  
(Frisch, 1930)

## CH MAGNESIUM Anthraquinone SULFONATES

SOLUBILITY OF EACH SEPARATELY IN WATER  
(Fierz-David, Krebsen and Anderau, 1927)

Compound	Formula	t°	Gms. anhydrous (?) compound per 100 cc. H <sub>2</sub> O
Magnesium Anthraquinone:	$\text{MgC}_{14}\text{H}_7\text{O}_2\text{SO}_3 \cdot 2\text{H}_2\text{O}$	18	0.36
2- Sulfonate	"	100	1.03
1.5 DiSulfonate	$\text{MgC}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2 \cdot 8\text{H}_2\text{O}$	18	2.04
"	"	100	18.2
1.8 "	$\text{MgC}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	18	1.0
"	"	100	7.1
1.6 "	$\text{MgC}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2 \cdot 8\text{H}_2\text{O}$	18	14.3
"	"	100	40.4
1.7 "	$\text{MgC}_{14}\text{H}_8\text{O}_2(\text{SO}_3)_2 \cdot 10\text{H}_2\text{O}$	18	33.3
"	"	100	100.0
2.6 "	$\text{MgC}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2 \cdot 3\text{H}_2\text{O}$	18	2.53
2.7 "	$\text{MgC}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2 \cdot 5\text{H}_2\text{O}$	18	41.0
1.5 Chlorosulfonate	$\text{MgC}_{14}\text{H}_6\text{O}_2\text{ClSO}_3 \cdot 8\text{H}_2\text{O}$	18	0.34

## MAGNESIUM Phenanthrene SULFONATES

SOLUBILITY OF EACH SEPARATELY IN WATER  
(Sandquist, 1912)

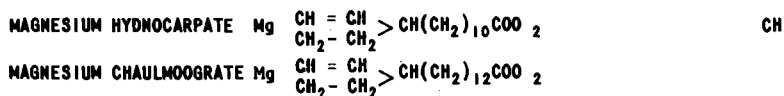
Compound	Gms. anhydrous Salt per 100 gms. H <sub>2</sub> O
Magnesium Phenanthrene -2- MonoSulfate	0.051
" " -3- " "	0.116
" " -10- " "	0.220

## CH MAGNESIUM o and p Xylol SELENATES

SOLUBILITY OF EACH IN WATER  
(Anschutz, Kallen and Riepenkroger, 1919)

Compound	Formula	t°	Gms. anhydrous compd. per 100 gms. H <sub>2</sub> O
Ortho compound	$[\text{C}_6\text{H}_3(\text{CH}_3)_2(1.2)\text{SeO}_3(4)]_2\text{Mg}$	20	0.85
Para "	$[\text{C}_6\text{H}_3(\text{CH}_3)_2(1.4)\text{SeO}_3]_2\text{Mg} \cdot 8\text{H}_2\text{O}$	15	2.02

MAGNESIUM Mg



SOLUBILITIES OF EACH SEPARATELY IN SEVERAL SOLVENTS  
(Cole, 1932)

Solvent	t°	Gms. Mg Hydnocarpate per 100 cc. sat. solution	Gms. Mg Chaulmoograte per 100 cc. sat. solution
95% Ethyl Alcohol	15	0.51	0.37
" " "	30	0.67	0.44
" " "	b. pt.	0.56	0.46
Ethyl Ether	15	0.04	0.02
" " "	30	0.045	0.036
" " "	b. pt.	0.036	0.024
Benzene	15	0.02	0.01
"	30	0.04	0.004
"	b. pt.	21.42	20.07
Petroleum Ether	30	0.0008	0.0005

MAGNESIUM ERUCATE  $\text{C}_8\text{H}_{17}\text{CH}:\text{CH}(\text{CH}_2)_{11}\text{COOMg}$

SOLUBILITY OF MAGNESIUM ERUCATE IN AQUEOUS ETHYL ALCOHOL AT 25°  
(Thomas and Mattikow, 1926)

Wt. percent $\text{C}_2\text{H}_5\text{OH}$	$d_{25}^4$ of Sat. Sol.	Gms. $\text{C}_8\text{H}_{17}\text{CH}:\text{CH}(\text{CH}_2)_{11}\text{COOMg}$ per	
		100 cc. sat. sol.	100 gms. solvent
0.0 (= $\text{H}_2\text{O}$ )	—	0.006	0.006
18.13	0.9690	0.004	0.005
28.37	0.9535	0.007	0.008
45.67	0.9194	0.019	0.020
65.82	0.8734	0.142	0.171
75.40	0.8504	0.179	0.240
88.38	0.8177	0.268	0.34
94.28	0.8018	0.323	0.420

MAGNESIUM HELIANTHATE  $\text{Mg}(\text{C}_{14}\text{H}_{14}\text{N}_3\text{SO}_3)_2 \cdot 4\text{H}_2\text{O}$

CH

100 cc.  $\text{H}_2\text{O}$  dissolve 0.035 gm. magnesium helianthate at 20-25°.  
(Stark and Dehn, 1918)

MAGNESIUM LIGNOCERATE

100 gms.  $\text{H}_2\text{O}$  dissolve 0.002 gm. magnesium lignocerate at 25°.  
100 gms. 44.13 percent aq. alcohol dissolve 0.003 gm., and 100 gm.,  
91.53 percent alcohol dissolve 0.006 gm.  
(Thomas and Yu, 1923)



## Mg MAGNESIUM

### CH MAGNESIUM OLEATE $(\text{CH}_3(\text{CH}_2)_{13}\text{CH}=\text{CH}\cdot\text{CH}_2\text{COO})_2\text{Mg}$

One liter  $\text{H}_2\text{O}$  dissolves about 0.23 gm. oleate (soap).

(Fahrion, 1916)

100 gms. glycerol ( $d$  1.114) dissolve 0.94 gm. oleate.

(Asselin, 1873)

### MAGNESIUM OLEATE $(\text{C}_{17}\text{H}_{33}\text{COO})_2\text{Mg}$

Solutions prepared by rubbing magnesium oleate (prepared from technical sodium oleate) with water or salt solution and allowing to stand at room temperature for 36 hours, contained from 4.28 to 5.42 milligrams Mg per liter of water and 5.85 to 5.77 milligrams Mg per liter of 0.05 or 0.1 percent aqueous NaCl solution.

(Zink and Liere, 1915)

Solutions prepared by heating a suspension of magnesium oleate in water or aqueous salt solution to the boiling point and allowing to cool, contained 50.6 parts Mg per liter of water, 99.89 parts Mg per liter of 0.1 percent aq. NaCl and 90.26 parts Mg per liter of 0.1 percent aq. KCl solution.

(Haupt, 1914)

100 gms. 63.07 wt. % aq. alcohol dissolve 4.60 gms.  $(\text{C}_{17}\text{H}_{33}\text{COO})_2\text{Mg}$  at 25°

" 72.17

6.64

" 86.16

8.60

(Thomas and Yu, 1923)

### CH MAGNESIUM PALMITATE $(\text{C}_{16}\text{H}_{31}\text{COO})_2\text{Mg}$

(Also see below)

Solutions prepared by rubbing magnesium palmitate (prepared from pure sodium palmitate) with water or aqueous salt solution and allowing to stand at room temperature for 36 hours contained from 2.82 to 3.03 milligrams Mg per liter of water and 3.12 to 3.03 milligrams Mg per liter of 0.05 to 0.10 percent aqueous NaCl solution.

(Zink and Liere, 1915)

Solutions prepared by heating a suspension of magnesium palmitate in water or aqueous salt solution to the boiling point and allowing to cool, contained 55.68 parts Mg per liter of water 92.21 parts Mg per liter of 0.1 percent aq. NaCl and 72.39 parts Mg per liter of 0.1 percent aq. KCl.

(Haupt, 1914)

### MAGNESIUM STEARATE $(\text{C}_{17}\text{H}_{35}\text{COO})_2\text{Mg}$

(Also see below)

Solutions prepared by rubbing magnesium stearate (prepared from commercial sodium stearate) with water or salt solutions and allowed to stand at room temperature for 36 hours contained from 3.17 to 3.23 milligrams Mg per liter of water and 3.70 to 3.84 milligrams Mg per liter of 0.05 to 0.1% aq. NaCl solution.

(Zink and Liere, 1915)

Solutions prepared by heating a suspension of magnesium stearate in water or aqueous salt solution to the boiling point and allowing to cool, contained 65.89 parts Mg per liter of  $\text{H}_2\text{O}$ , 95.79 parts Mg per liter of 0.1% aq. NaCl solution and 99.62 parts Mg per liter of 0.1% aq. KCl solution.

(Haupt, 1914)

SOLUBILITY OF MAGNESIUM STEARATE IN AQUEOUS SOLUTIONS OF  
ETHYL ALCOHOL AT 25°  
(Thomas and Yu, 1923)

Constant agitation was employed for obtaining saturation.

Wt. percent $C_2H_5OH$ in solvent	$d_{25}^4$ of sat. sol.	Gms. $(C_{17}H_{35}COO)_2Mg$ per	
		100 cc. sat. sol.	100 gms. solvent
0.0 (= $H_2O$ )	0.99709	0.004	0.004
19.9	0.97122	0.004	0.004
27.29	0.95792	0.003	0.003
44.13	0.92275	0.003	0.003
63.07	0.87783	0.004	0.005
72.17	0.85821	0.005	0.006
86.16	0.82356	0.006	0.007
91.53	0.80935	0.006	0.007

MAGNESIUM LAURATE, MYRISTATE, PALMITATE and STEARATE

CH

SOLUBILITY OF EACH IN SEVERAL SOLVENTS  
(Jacobson and Holmes, 1916)

Gms. Each Salt Determined Separately per 100 Gms. Solvent					
Solvent	t°	Mg Laurate ( $C_{11}H_{23}COO$ ) <sub>2</sub> Mg	Mg Myristate ( $C_{13}H_{27}COO$ ) <sub>2</sub> Mg	Mg Palmitate ( $CH_3(CH_2)_{14}COO$ ) <sub>2</sub> Mg	Mg Stearate ( $CH_3(CH_2)_{16}COO$ ) <sub>2</sub> Mg
Water	15	0.010	0.006	0.005	0.003
"	25	0.007	0.006	0.008	0.004
"	35	0.010	0.007	0.006	0.007
"	50	0.026	0.014	0.009	0.008
Abe. Ethyl Alcohol	15	0.519	0.158	0.034	0.017
"	25	0.591	0.236	0.058	0.023
"	35	0.805	0.373	0.085	0.031
"	50	1.267	0.577	0.151	—
Methyl Alcohol	15	1.095	0.571	0.227	0.084
"	25	1.108	0.763	0.36	0.100
"	51.5	—	—	0.50	0.166
Ether	25	0.015	0.010	0.004	0.003
Ethyl Acetate	15	0.004	0.004	0.004	0.004
"	35	0.011	0.010	0.007	0.008
"	50	0.024	0.021	0.013	—
Amyl Alcohol	15	0.191	0.086	0.043	0.014
"	25	0.236	0.145	0.066	0.018
"	35	1.481	0.438	0.104	0.039
"	50	4.869	1.893	0.263	0.105
Amyl Acetate	15	0.119	0.063	0.039	0.029
"	25	0.162	0.073	0.045	0.030
"	34.6	0.259	0.105	0.057	0.046
"	50	1.939	0.605	0.216	0.115

MAGNESIUM FERROCYANIDES

CN

SOLUBILITY IN WATER AT 17°  
(Robinson, 1909)

One liter sat. sol. contains 1.95 gms. magnesium potassium ferrocyanide,  $MgK_2FeC_6N_6$ .

One liter sat. sol. contains 2.48 gms. Magnesium ammonium ferrocyanide,  $Mg(NH_4)_2FeC_6N_6$ .

**Mg MAGNESIUM****CN MAGNESIUM PLATINIC CYANIDE  $\text{MgPt(CN)}_4$** 

SOLUBILITY IN WATER  
(Buxhoeveden and Tamman - Z. anorg. Ch. 15, 319 '97)

Gms.			Gms.		
t°	MgPt(CN) <sub>4</sub> per 100 gms. Solution	Solid Phase	t°	MgPt(CN) <sub>4</sub> per 100 Gms. Solution	Solid Phase
-4.12	24.90	MgPt(CN) <sub>4</sub> ·6.8-8.1H <sub>2</sub> O	48.7	40.89	MgPt(CN) <sub>4</sub> ·4H <sub>2</sub> O
0.5	26.9	" (Red)	55	41.33	"
5.5	28.65	"	58.1	42.15	"
18.0	32.46	"	69.0	43.40	"
36.6	39.53	"	77.8	44.90	"
45.0	41.33	"	87.4	45.52	"
46.2	42.0	"	90.0	45.65	"
42.2	40.21	MgPt(CN) <sub>4</sub> ·4H <sub>2</sub> O	93.0	45.04	"
46.3	39.85	" (Bright Green)	96.4	44.33	MgPt(CN) <sub>4</sub> ·2H <sub>2</sub> O
			100.0	44.0	" (White)

**CO MAGNESIUM CARBONATE  $\text{MgCO}_3$** **HCO MAGNESIUM BICARBONATE  $\text{Mg(HCO}_3)_2$** 

SOLUBILITY IN "CO<sub>2</sub>-FREE" WATER

At 15°

Extrapolation of the data of Treadwell and Reuter, 1898 shows that at 0 partial pressure of CO<sub>2</sub> and at 15° and mean barometric pressure, one liter of saturated aqueous solution contains 0.641 gm. of MgCO<sub>3</sub> plus 1.954 gms. Mg(HCO<sub>3</sub>)<sub>2</sub>.

At 100°

(Leick, 1932, 1933)

The determinations showed that 0.030 gm. MgO = 0.063 gm. MgCO<sub>3</sub> per liter was dissolved at 100°. It was found that the solubility is increased by NaCl and Na<sub>2</sub>SO<sub>4</sub>. NaOH and Na<sub>2</sub>CO<sub>3</sub> do not reduce the solubility of MgCO<sub>3</sub> as much as they do that of CaCO<sub>3</sub>. Results for the simultaneous solubility of MgCO<sub>3</sub> and CaCO<sub>3</sub> in water at 100° show that with increasing time of boiling, from 1-1/2 to 48 hours, the dissolved CaO increased about 5 times while the dissolved MgO decreases about 10 times. The results are of interest in connection with the purification of boiler waters.

RESULTS IN WATER WITH UP TO 1 ATM. PARTIAL PRESSURE OF CO<sub>2</sub>

At 15°

Considerable data are given by Treadwell and Reuter, 1898, giving total Mg<sup>++</sup>, HCO<sub>3</sub><sup>-</sup>, and CO<sub>3</sub><sup>=</sup>, but it is pointed out by Johnston (1915) that although Treadwell and Reuter made very painstaking analyses, their mode of working did not secure equilibrium conditions, a fact which is borne out by the lack of constancy of the calculated solubility-product constant.

At 18°  
(Johnston, 1915)

It is shown that if the CO<sub>2</sub> pressure is kept constant at P and the water evaporated off so slowly at 18° that equilibrium conditions are continuously maintained, the following amounts of Mg(OH)<sub>2</sub> or of MgCO<sub>3</sub>·3H<sub>2</sub>O will be obtained.

Partial Pressure P of CO <sub>2</sub> in Atms.	Total Mg Mols./l	Gms. per Liter	
0	0.00015	0.0087	Mg(OH) <sub>2</sub>
0.00020	0.01934	1.13	"
0.00025	0.02218	1.29	"
0.00030	0.02486	1.45	"
0.00035	0.02742	1.60	"
0.00040	0.02868	3.97	MgCO <sub>3</sub> ·3H <sub>2</sub> O
0.00045	0.02924	4.05	"
0.00050	0.02976	4.12	"

CO  
NCO

At 20°  
(Wells, 1915)

Mixture	Milligrams per Liter of Sat. Solution		
	Mg	Free CO <sub>2</sub>	CO <sub>2</sub> as Bicarbonate
Natural Magnesite in Distilled H <sub>2</sub> O	0.018	trace	0.065
" in Aq. NaCl (27.2 g. per l)	0.028	trace	0.086
MgCO <sub>3</sub> ·3H <sub>2</sub> O (equilibrium from bicarbonate end)	0.038	0.28*	0.83
MgCO <sub>3</sub> ·3H <sub>2</sub> O (" " undersaturation")	0.034	0.32*	0.59

\* = CO<sub>2</sub> as carbonate

At 25°  
(Kline, 1929)

The saturated solutions were prepared by bubbling mixtures of carbon dioxide and air in constant proportions through conductivity water in contact with finely divided solid for periods of three to five days.

Partial Pressure of CO <sub>2</sub> in Atmospheres	Millimols per 1000 gms. H <sub>2</sub> O			Partial Pressure of CO <sub>2</sub> in Atmospheres	Millimols per 1000 gms. H <sub>2</sub> O		
	[Mg <sup>++</sup> ]	[HCO <sub>3</sub> <sup>-</sup> ]	[CO <sub>2</sub> <sup>-</sup> ]		[Mg <sup>++</sup> ]	[HCO <sub>3</sub> <sup>-</sup> ]	[CO <sub>2</sub> <sup>-</sup> ]
0.000107	0.00433	0.00488	0.00189	0.000510	0.01437	0.01710	0.00582
0.000113	0.00445	0.00501	0.00195	0.000680	0.01512	0.01872	0.00576
0.000170	0.00577	0.00745	0.00205	0.000845	0.01566	0.01990	0.00571
0.000179	0.00593	0.00763	0.00212	0.000887	0.01593	0.02046	0.00570
0.000197	0.00658	0.00795	0.00261	0.000930	0.01624	0.02119	0.00565
0.000210	0.00708	0.00806	0.00305	0.00160	0.01859	0.02698	0.00510
0.000233	0.00780	0.00837	0.00361	0.00334	0.02210	0.03548	0.00436
0.000251	0.00807	0.00855	0.00380	0.00690	0.02507	0.04468	0.00273
0.000310	0.01013	0.01184	0.00421	0.0150	0.03127	0.06022	0.00116
0.000376	0.01296	0.01404	0.00594	0.0432	0.04601	0.08998	0.00102
0.000380	0.01355	0.01432	0.00639	0.1116	0.06266	0.1236	0.00085
				0.9684	0.2135	0.4269	—

The activity product constant of magnesium carbonate at 25° is taken as  $1 \times 10^{-5}$  and that of magnesium hydroxide similarly as  $5 \times 10^{-12}$ .

# Mg MAGNESIUM

## SOLUBILITY PRODUCTS OF VARIOUS HYDRATES (Lannung and Torborg-Jensen, 1949)

$\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$	$K_{sp} = 8.9 \times 10^{-6}$
$\text{MgCO}_3 \cdot 2\text{H}_2\text{O}$	$K_{sp} = 2.3 \times 10^{-5}$
$\text{MgCO}_3 \cdot \text{H}_2\text{O}$	$K_{sp} = 2.7 \times 10^{-5}$

### AT OTHER TEMPERATURES

#### EQUILIBRIUM IN THE SYSTEM MAGNESIUM OXIDE, CARBON DIOXIDE AND WATER (Takahashi, 1927)

CO HCO	t°	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
			CO <sub>2</sub>	MgO	
-1.80		1.0411	3.410	1.526	$\text{MgCO}_3 \cdot 5\text{H}_2\text{O}$
0		1.0407	3.219	1.496	"
+5		1.0395	2.942	1.423	"
10		1.0383	2.962	1.363	"
15		1.0373	2.744	1.312	"
20		1.0363	2.606	1.256	"
5		1.0407	3.232	1.530	$\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$
10		1.0360	2.736	1.314	"
15		1.0320	2.270	1.143	"
20		1.0287	2.109	0.9858	"
25		1.0250	1.839	0.8654	"
30		1.0210	1.572	0.7634	"
35		1.0170	1.381	0.6780	"
40		1.0135	1.206	0.6017	"
45		1.0097	1.044	0.5323	"
50		1.0050	0.922	0.4718	"
55		1.0008	0.833	0.4083	"
60		0.9980	0.746	0.3648	"

Results are also given for the solubility of  $5\text{MgO} \cdot 4\text{CO}_2 \cdot 7\text{H}_2\text{O}$  in Water saturated with  $\text{CO}_2$  at one atmosphere pressure.

Determinations of the equilibrium in the system  $\text{MgCO}_3 + \text{CO}_2 + \text{H}_2\text{O}$  made by passing  $\text{CO}_2$  at atmospheric pressure through mixtures of  $\text{H}_2\text{O} + \text{MgO}$  and  $\text{H}_2\text{O} + \text{MgCO}_3$  at temperatures from 0° to 40°, are given by Tereda, 1928. There is, however, some uncertainty in regard to the exact terms in which the results are expressed.

Data for the system magnesium carbonate-carbonic acid-water at 20°, 25°, 30°, 34° and 39° are given by Leather and Sen (1914). In connection with these results, it is pointed out by Johnston (1915), that it is questionable whether equilibrium was really obtained and furthermore, the accuracy of the analytical results cannot be trusted since the ratio of total amount of  $\text{CO}_2$  in solution, to the magnesia is very irregular. The results when plotted directly show great inconsistencies.

SOLUBILITY IN WATER SATURATED WITH CO<sub>2</sub> AT ONE ATMOSPHERE  
(Engel, 1888)

t°	Gms. MgCO <sub>3</sub> * per Liter	t°	Gms. MgCO <sub>3</sub> * per Liter	t°	Gms. MgCO <sub>3</sub> * per Liter
5	36	30	21	60	11
10	31	40	17	80	5
20	26			100	0

\*Dissolved as Mg(HCO<sub>3</sub>)<sub>2</sub>

RESULTS AT HIGH PARTIAL PRESSURES OF CO<sub>2</sub>

CO  
HCO

At 25°

(Data of Mitchell, 1923)

A silver lined steel bulb was used. The mixture was stirred by a current of CO<sub>2</sub>.

Atmospheres pressure of Carbon Dioxide	Mols. per liter of sat. solution	
	Total (Mg)	Total (CO <sub>2</sub> )
6	0.376	0.896
9	0.450	1.147
11	0.485	1.250
13	0.505	1.350
16	0.530	1.395
21	0.613	1.738

(Data of Kline, 1929)

The author also gives the following interpolated values of the molarity of magnesium in aqueous solutions saturated with MgCO<sub>3</sub>·3H<sub>2</sub>O at 25° and at partial pressures of Carbon Dioxide up to 15 atmospheres.

Partial Pressure of CO <sub>2</sub> in Atms.	Millimols (Mg) per 1000 gms. H <sub>2</sub> O	Partial Pressure of CO <sub>2</sub> in Atms.	Millimols (Mg) per 1000 gms. H <sub>2</sub> O
0.001	0.0178	0.7	0.181
0.01	0.0270	1.0	0.217
0.05	0.0489	2.0	0.287
0.10	0.0660	5.0	0.384
0.3	0.117	10.0	0.471
0.5	0.152	15.0	0.526

AT OTHER TEMPERATURES

(Results of Engel and Ville, 1881; Engel, 1888)

Pressure of CO <sub>2</sub> in Atmospheres	Gms. MgCO <sub>3</sub> per Liter		Pressure of CO <sub>2</sub> in Atmospheres	Gms. MgCO <sub>3</sub> per Liter	
	At 12°	At 19°		At 12°	At 19°
0.5	20.5	—	4.0	42.8	—
1.0	26.5	25.8	4.7	—	43.5
2.0	34.2	33.1 (2.1 At.)	6.0	50.6	48.5 (6.2 At.)
3.0	39.0	37.2 (3.2 At.)	9.0	—	56.6

# Mg MAGNESIUM

(Results of Haehnel, 1924)

The saturated solutions were prepared in a platinum vessel provided with an electrically driven stirrer and contained in an autoclave. After stirring one hour and allowing to stand one-half hour the saturated solution was withdrawn through a platinum tube and analyzed by evaporating and weighing the ignited MgO. Equilibrium was approached from above. Magnesium carbonate from different sources was used.

Results at 18°				Results at different temperatures			
CO HCO	Atmospheres Pressure	Gms. MgCO <sub>3</sub> per 100 gms. sat. sol.	t°	Gms. MgCO <sub>3</sub> per 100 gms. sat. sol. at			at
				1 atmosphere of CO <sub>2</sub> (Engel & Ville)	5 atmospheres of CO <sub>2</sub> (Beckurts)	34 atmospheres of CO <sub>2</sub> (Haehnel)	
	2.0	3.5	0	--	--		8.58
	2.5	3.74	5	--	--		8.32
	4.0	4.28	10	--	3.57		7.93
	10.0	5.90	30	1.58	--		6.88
	16.0	7.05	40	1.18	1.37		6.44
	18.0	7.49	50	0.95	--		6.18
	35.0	7.49	60	--	--		5.56
	56.0	7.49					

## THE SYSTEM MAGNESIUM CARBONATE - CALCIUM CARBONATE - WATER (Yanat'eva, 1954a, 1955)

C = Calcite, CaCO<sub>3</sub>; D = Dolomite, CaCO<sub>3</sub>·MgCO<sub>3</sub>; M = Magnesite, MgCO<sub>3</sub>

mmol. per 1000 gms. solution			pH	Solid Phase	mmol. per 1000 gms. solution			pH	Solid Phase
Ca(HCO <sub>3</sub> ) <sub>2</sub>	Mg(HCO <sub>3</sub> ) <sub>2</sub>				Ca(HCO <sub>3</sub> ) <sub>2</sub>	Mg(HCO <sub>3</sub> ) <sub>2</sub>			
At 0°, 1 atm. CO <sub>2</sub>					At 55°, 1 atm. CO <sub>2</sub>				
15.08	0.0	--	C		6.09	0.0	--	C	
13.64	1.32	--	C + D		4.23	2.17	6.69	C + D	
5.34	5.40	--	D		3.00	3.08	--	D	
3.40	12.27	--	D + M		2.15	7.39	6.92	D + M	
0.0	22.52	--	M		0.0	15.59	--	M	
At 25°, 1 atm. CO <sub>2</sub>					At 70°, 1 atm. CO <sub>2</sub>				
8.98	0.0	--	C		3.45	0.0	--	C	
8.10	1.18	5.8	C + D		2.03	2.55	--	C + D	
3.21	3.28	5.7	D		1.55	5.89	--	D + M	
2.50	11.26	6.0	D + M						
0.0	16.50	--	M						
At 25°, 0.0012 atm. CO <sub>2</sub>									
0.81	0.0	--	C						
0.39	0.94	7.76	C + D						
0.40	1.02	7.78	D						
0.32	1.20	7.87	D + M						
0.0	1.65	--	M						

THE SYSTEM  $\text{MgCO}_3 + \text{CaSO}_4 = \text{MgSO}_4 + \text{CaCO}_3 (+ \text{H}_2\text{O})$   
(Yanai'teva, 1955a, 1957, 1957a)

Millimoles per 1000  
gms. solution

Ca	Mg	HCO <sub>3</sub>	SO <sub>4</sub>	Density	Solid Phase	
Results at 0°, P <sub>CO<sub>2</sub></sub> = 1 atm.						
15.08	--	15.08	--	--	Calcite	
5.34	5.40	10.74	--	--	Dolomite	
13.64	1.32	14.96	--	1.0040	Calcite + Dolomite	
--	22.52	22.52	--	--	Magnesite	
3.40	12.27	15.67	--	1.0042	Calcite + Gypsum	
24.20	--	13.40	10.80	1.0043	Dolomite + Calcite + Gypsum	CO
25.88	1.63	15.29	12.22	1.0053	Dolomite + Gypsum	
20.65	7.17	14.60	13.22	--	Dolomite + Gypsum	
18.96	10.48	15.26	14.18	--	" + "	
20.08	11.47	15.66	15.89	--	" + "	
19.70	12.64	16.08	16.26	1.0058	Dolomite + Gypsum + Magnesite	
Results at 25°, P <sub>CO<sub>2</sub></sub> = 1 atm.						
8.10	1.18	9.28	--	--	Dolomite + Calcite	
21.10	1.07	1.36	13.14	--	Dolomite + Calcite + Gypsum	
2.50	11.26	13.76	--	--	Dolomite + Magnesite	
21.08	17.31	15.95	22.44	--	Dolomite + Magnesite + Gypsum	
20.47	0.0	7.52	12.95	--	Calcite + Gypsum	
Results at 25°, P <sub>CO<sub>2</sub></sub> = 0.0012 atm.						
0.39	0.94	1.36	--	--	Dolomite + Calcite	
15.33	2.58	0.39	17.52	--	Dolomite + Calcite + Gypsum	
0.32	1.20	1.52	--	--	Dolomite + Magnesite	
15.47	3.53	0.47	18.53	--	Dolomite + Magnesite + Gypsum	
15.97	--	0.38	15.59	--	Calcite + Gypsum	
Results at 55°, P <sub>CO<sub>2</sub></sub> = 1 atm.						
6.09	--	6.09	--	--	Calcite	
3.02	3.06	6.08	--	--	Dolomite	
4.23	2.17	6.40	--	1.0009	Calcite + Dolomite	
--	15.59	15.59	--	--	Magnesite	
2.15	7.39	9.54	--	--	Magnesite + Dolomite	
20.55	--	5.23	15.32	--	Calcite + Gypsum	
19.94	2.28	5.74	16.48	1.0032	Dolomite + Calcite + Gypsum	
19.80	2.45	5.65	16.60	--	" + " + "	
19.34	3.11	5.89	16.56	--	Dolomite + Gypsum	
17.72	13.00	8.18	22.54	1.0070	Dolomite + Gypsum + Magnesite	
14.60	17.62	8.50	23.72	--	Magnesite + Gypsum	
13.75	50.95	10.58	54.12	--	" + "	
13.49	79.24	12.78	79.95	--	" + "	
12.56	149.91	15.55	146.92	--	" + "	
12.08	188.15	15.35	184.88	--	" + "	

Calcite =  $\text{CaCO}_3$

Gypsum =  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$

Dolomite =  $\text{CaCO}_3 \cdot \text{MgCO}_3$

Magnesite =  $\text{MgCO}_3$



# Mg MAGNESIUM

## SOLUBILITY OF MAGNESIUM CARBONATE IN AQUEOUS SOLUTIONS OF POTASSIUM BICARBONATE (Auerbach, 1904)

The conditions necessary for preventing changes in equilibrium due to hydrolysis and loss of  $\text{CO}_2$  are discussed. The mixtures were shaken from 1-4 days. The sat. sol. analyzed for total alkali ( $\text{K} + \text{Mg}/2$ ) by titration with standard  $\text{HCl}$  using methyl orange as indicator. The neutralized solution was boiled to expel  $\text{CO}_2$  and then excess  $0.1 \text{ N NaOH}$  added and the filtrate from magnesium precipitate back titrated with  $0.1 \text{ N HCl}$ . The  $\text{Mg}/2$  was calculated from the used  $0.1 \text{ N NaOH}$  and the  $\text{K}$  obtained by difference. Additional data for this system are given by Nanty, 1911.

CO	Results at 15°			Results at 25°			Results at 35°		
	Mols. per Liter		Solid Phase	Mols. per Liter		Solid Phase	Mols. per Liter		Solid Phase
	$\text{KHCO}_3$	$\text{MgCO}_3$		$\text{KHCO}_3$	$\text{MgCO}_3$		$\text{KHCO}_3$	$\text{MgCO}_3$	
	0	0.0095 M		0	0.0087 M		0	0.0071 M	
	0.0992	0.0131 "		0.0985	0.0115 "		0.1092	0.0098 "	
	0.1943	0.0617 "		0.2210	0.0149 "		0.2811	0.0142 "	
	0.3992	0.0211 " (labil)		0.3434	0.0181 "		0.4847	0.0177 "	
	0.2681	0.0192 " + 1.1		0.4985	0.0217 " (labil)		0.5807	0.0198 " (labil)	
	0.5243	0.0097 1.1		0.3906	0.0196 " + 1.1		0.5088	0.0184 " + 1.1	
	0.6792	0.0074 "		0.5893	0.0128 1.1		0.6231	0.0153 1.1	
	0.981	0.0028 "		0.6406	0.0117 "		0.8535	0.0119 "	
				1.125	0.0061 "				

M =  $\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$

1.1 =  $\text{MgCO}_3 \cdot \text{KHCO}_3 \cdot 4\text{H}_2\text{O}$

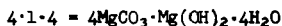
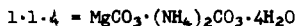
## SOLUBILITY OF MAGNESIUM CARBONATE IN POTASSIUM BICARBONATE SOLUTIONS CONTAINING 10% SUCROSE AT 20° (Denisov and Belova, 1956)

Gms. $\text{K}_2\text{CO}_3$ per 100 ml solvent	Gms. $\text{MgO}$ per 100 ml sat. sol.	pH
0.0	0.009	--
0.1	0.0203	9.22
0.5	0.0295	9.78
2.0	0.0457	9.98
4.0	0.0482	9.98
8.0	0.0562	9.98

THE SYSTEM MAGNESIUM CARBONATE - AMMONIUM CARBONATE -  
WATER AT 30°  
(Lafontaine, 1925)

To a concentrated solution of magnesium bicarbonate containing 20-25 grams  $\text{Mg}(\text{HCO}_3)_2$  per liter, increasing quantities of ammonia, ammonium bicarbonate or of mixtures of the two were added. The solutions were agitated mechanically 10 hours per day for 8 days. The composition of the solid phase did not change but its quantity increased with time. The zones of formation of the several solid phases were determined.

Mols. per 100 mols. $\text{H}_2\text{O}$			Solid Phase	Mols. per 100 mols. $\text{H}_2\text{O}$			Solid Phase
MgO	$\text{CO}_2$	$\text{NH}_3$		MgO	$\text{CO}_2$	$\text{NH}_3$	
0.160	1.487	1.193	$\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$	0.006	1.593	10.386	1-1.4
0.103	2.508	2.099	"	0.091	2.172	1.932	" + $\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$
0.097	2.256	0.129	"	0.021	0.463	1.351	" "
0.041	0.816	0.875	"	0.019	0.888	1.402	" "
0.021	0.089-0.144	"	"	0.012	1.300	1.582	" "
0.020	0.292	1.168	"	0.008	0.084	5.562	4-1.4 + "
0.055	0.952	0.970	"	0.008	0.095	11.029	" "
0.075	2.427	2.233	1-1.4	0.020	0.220	3.783	" +5(")
0.056	1.065	1.087	"	0.006	0.178	4.369	" "
0.026	1.315	1.514	"	0.015	0.196	5.524	" "
0.024	3.357	3.269	"	0.012	0.152	8.604	" "
0.016	0.623	1.277	"	0.001	0.010	10.981	" "
0.008	3.745	3.837	"	0.007	0.102	15.710	" "



SOLUBILITY OF MAGNESIUM CARBONATE IN  
SODIUM CARBONATE SOLUTIONS

At 25°  
(Cameron and Seidell, 1903)

(Partial pressure  $\text{CO}_2 = 1 \text{ atm.}$ )

Grams per Liter		Density	Grams per Liter		Density
$\text{Na}_2\text{CO}_3$	$\text{MgCO}_3$		$\text{Na}_2\text{CO}_3$	$\text{MgCO}_3$	
0.00	0.223	0.9968	127.3	1.314	1.1189
23.12	0.288	1.0199	160.8	1.636	1.1477
50.75	0.510	1.0477	181.9	1.972	1.1661
86.42	0.879	1.0825	213.2	2.317	1.1894

# Mg MAGNESIUM

## SOLUBILITY OF MAGNESIUM CARBONATE IN SODIUM CARBONATE SOLUTIONS--Cont.

At 35°

(Oboukhov and Gordon, 1935)

The authors also present data to show the existence of the compound  $\text{MgCO}_3 \cdot \text{Na}_2\text{CO}_3$  in solutions containing about 33%  $\text{Na}_2\text{CO}_3$ .

	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{MgCO}_3$	$\text{Na}_2\text{CO}_3$		$\text{MgCO}_3$	$\text{Na}_2\text{CO}_3$	
CO HCO	0.074	0.0	$\text{MgCO}_3$	0.498	20.25	$\text{MgCO}_3$
	0.056	1.00	"	0.508	22.81	"
	0.100	2.89	"	0.516	26.14	"
	0.146	4.75	"	0.546	28.40	"
	0.285	8.82	"	0.531	31.12	"
	0.308	12.78	"	0.698	33.50	"
	0.386	16.39	"	0.830	33.53	" + $\text{Na}_2\text{CO}_3$

## SOLUBILITY OF MAGNESIUM BICARBONATE AND OF MAGNESIUM CARBONATE IN AQUEOUS SOLUTIONS OF SODIUM CHLORIDE AT 23° (Cameron and Seidell, 1903)

In Presence of 1 atm. $\text{CO}_2$ as Gas Phase			In Presence of Air Free from $\text{CO}_2$	
Gms. NaCl per Liter	Gms. $\text{Mg}(\text{HCO}_3)_2$ per Liter	Density	Gms. NaCl per Liter	Gms. $\text{MgCO}_3$ per Liter
7.0	30.64	0.9969	0.0	0.176
56.5	30.18	1.0168	28.0	0.418
119.7	27.88	1.0411	59.5	0.527
163.9	24.96	1.0705	106.3	0.585
224.8	20.78	1.0945	147.4	0.544
306.6	10.75	1.1425	231.1	0.460
		1.1701	272.9	0.393
		1.1993	331.4	0.293

Data for the solubility of  $\text{MgCO}_3$  in aq. NaCl and other salt solutions, determined by prolonged boiling and subsequent cooling of the solution out of contact with air, are given by Gothe (1915).

SOLUBILITY OF MAGNESIUM CARBONATE IN AQUEOUS SOLUTIONS  
OF SODIUM SULPHATE  
(Cameron and Seidell, 1903)

The solutions were in equilibrium with an atmosphere free from  $\text{CO}_2$ .

Results at 24°			Results at 35.5°		
Density	Gms. $\text{Na}_2\text{SO}_4$ per Liter	Gms. $\text{MgCO}_3$ per Liter	Density	Gms. $\text{Na}_2\text{SO}_4$ per Liter	Gms. $\text{MgCO}_3$ per Liter
0.9975	0.00	0.216	0.9951	0.32	0.131
1.0212	25.12	0.586	1.0329	41.84	0.577
1.0476	54.76	0.828	1.0672	81.84	0.753
1.0809	95.68	1.020	1.0948	116.56	0.904
1.1338	160.8	1.230	1.1204	148.56	0.962
1.1573	191.9	1.280	1.1517	186.7	1.047
1.2060	254.6	1.338	1.1798	224.0	1.088
1.2420	305.1	1.388	1.2365	299.2	1.130

Data for the system  $\text{MgCO}_3 + \text{Na}_2\text{CO}_3 + \text{NaCl} + \text{NaOH} + \text{H}_2\text{O}$  at 100° are given by Itkina, 1953.

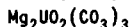
For a discussion of the system  $\text{Mg}^{++}, \text{Ca}^{++}, \text{Na}^+ \text{Cl}^-, \text{SO}_4^{=}, \text{HCO}_3^-$  (+  $\text{H}_2\text{O}$ ) see Perel'man, 1954.

**Basic MAGNESIUM CARBONATE  $3\text{MgCO}_3 \cdot \text{Mg}(\text{OH})_2 \cdot 3\text{H}_2\text{O}$**

CO

100 gms. of a saturated solution in furfural contain 0.01 gms.  
 $3\text{MgCO}_3 \cdot \text{Mg}(\text{OH})_2 \cdot 3\text{H}_2\text{O}$  at 25°. (Trimble, 1941)

**MAGNESIUM URANIUM CARBONATE**



SOLUBILITY OF THE ANHYDROUS SALT IN WATER  
(Bachelet, Cheylan, DAVIS and Goulette, 1952)

t°	23	32	42	52
Gms. salt/liter	82.25	87.6	122.0	171.0

**MAGNESIUM OXALATE  $\text{MgC}_2\text{O}_4$**

CO

SOLUBILITY IN WATER

Solid phase is  $\text{MgC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$  throughout. See also Karaoglanov, 1942.

t°	Solubility	Author
18 0.300	gms. $\text{MgC}_2\text{O}_4$ /liter sat. sol.	Britton and Jarrett, 1936
0.304	"	Fredholm, 1936
25 0.345	"	Walker, 1925
0.417	"	Barney, Argersinger and Reynolds, 1951
36 0.32	"	Chatterjee and Dhar, 1924
92 0.40	"	" " " "

# Mg MAGNESIUM

## SOLUBILITY OF MAGNESIUM OXALATE IN OXALIC ACID SOLUTIONS

(Solid Phase  $\text{MgC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$  in all cases)

At 18°

(Britton and Jarrett, 1936)

At 15°, 100°

(Bobtelsky and Malkowa-Janowski, 1927)

	Gm. Mols. per liter sat. sol.		t°	Gm. Mols. per liter sat. sol.	
	$\text{H}_2\text{C}_2\text{O}_4$	$\text{MgC}_2\text{O}_4$		$\text{H}_2\text{C}_2\text{O}_4$	Mg
CO	0.0	0.00230	15	0.71	0.04703
	0.02	0.00997	"	2.14	0.06885
	0.05	0.0155	"	3.57	0.07757
	0.10	0.0217	100	1.79	0.0891
	0.25	0.0322	"	4.64	0.1234
	0.50	0.0513	"	7.15	0.1340
			"	8.57	0.1446
			"	14.29	0.1485

## SOLUBILITY OF MAGNESIUM OXALATE IN AQUEOUS SOLUTIONS OF SULFURIC ACID AT 18°

(Britton and Jarrett, 1936)

Gm. Mols. per liter sat. sol.		
$\text{H}_2\text{SO}_4$	$\text{MgC}_2\text{O}_4$	Solid Phase
0.05	0.0437	$\text{MgC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$
0.125	0.0877	"
0.25	0.1498	"
0.50	0.2633	"
1.00	0.4407	"

## THE SYSTEM MAGNESIUM OXALATE - SODIUM OXALATE - WATER AT 18°

(Britton and Jarrett, 1936)

Gm. Mols. per liter sat. sol.			Gm. Mols. per liter sat. sol.		
$\text{Na}_2\text{C}_2\text{O}_4$	$\text{MgC}_2\text{O}_4$	Solid Phase	$\text{Na}_2\text{C}_2\text{O}_4$	$\text{MgC}_2\text{O}_4$	Solid Phase
0.00	0.00230	$\text{MgC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$	0.2384	0.0126	$\text{MgC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$
0.01	0.00246	"	0.2881	0.0164	"
0.02	0.00261	"	0.3093	0.0188	"
0.04	0.00325	"	0.3295	0.0205	"
0.06	0.00380	"	0.3249	0.0185	$\text{Na}_2\text{C}_2\text{O}_4$
0.08	0.00439	"	0.308	0.0149	"
0.10	0.00529	"	0.296	0.0117	"
0.15	0.00794	"	0.2691	0.0062	"
0.20	0.01031	"	0.240	0.000	"

## SOLUBILITY OF MAGNESIUM OXALATE IN OTHER SALT SOLUTIONS

(Solid phase  $\text{MgC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$  in all cases)

(Walker, 1925)		(Bottelsky and Malkowa-Janowski, 1927)		(Barney, Argersinger and Reynolds, 1951)	
Magnesium sulfate		Ammonium Oxalate		Potassium oxalate	
Gms. per liter sat. solution		Gms. per 100 gms. sat. sol.		Moles per liter sat. sol.	
$\text{MgSO}_4$	$\text{MgC}_2\text{O}_4$	$(\text{NH}_4)_2\text{C}_2\text{O}_4$	Mg	$\text{K}_2\text{C}_2\text{O}_4$	$\text{MgC}_2\text{O}_4$
At 25°		At 15°			
0.0	0.345	0.87	0.01097	0.0	0.00320
0.327	0.264	2.62	0.02492	0.007	0.00244
0.591	0.241	4.36	0.03557	0.03	0.0034
		At 100°			
		2.18	0.04286		
		5.24	0.1194		
		8.73	0.2269		
		10.47	0.3281		
		13.09	0.4845		
		17.45	0.7545		

## SOLUBILITY OF MAGNESIUM OXALATE IN AMMONIUM CHLORIDE SOLUTIONS

(Fredholm, 1934)		(Bottelsky and Malkowa-Janowski, 1927)	
At 18°		At 15°, 100°	
Solvent:	Sat. Sol.: Gm. equiv. Mg. per liter	t°	Gms. per 100 gms. sat. sol.
Gm. equiv. per liter			$\text{NH}_4\text{Cl}$ Mg
Water alone	0.066*	15	1.0 0.01057
0.0996 $\text{NH}_4\text{Cl}$	0.0976	"	2.0 0.02774
" + 0.1996 $\text{NH}_3$	0.0999	"	5.0 0.03235
" + 0.3999 "	0.1013	"	10.0 0.03385
" + 0.599 "	0.1044	"	20.0 0.03365
" + 0.798 "	0.1050	100	1.0 0.03467
" + 1.000 "	0.1079	"	4.0 0.0441
		"	8.0 0.0513
		"	18.0 0.0508

\*In the original, the results are erroneously reported as one-tenth the values listed above.

# Mg MAGNESIUM

## Cl MAGNESIUM CHLORIDE $MgCl_2$

### SOLUBILITY IN WATER

Averages of results of van't Hoff and Meyerhoffer, 1898; Engel, Lowenherz; Prutton, 1932 (below 0°); Sieverts and Mullar, 1930; Kupper, 1927; Queianer, 1921; Achumow and Wassilijew, 1932 (above 100°); Rodebush, 1918 (ice curve); and many other isolated determinations.

t°	Gms. $MgCl_2$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $MgCl_2$ per 100 gms. sat. sol.	Solid Phase
-10	11.1	Ice	25	35.5	$MgCl_2 \cdot 6H_2O$
-15	14.5	"	30	35.8	"
-20	16.3	"	35	36.1	"
-30	19.8	"	40	36.5	"
-33.6	21.0	" + $MgCl_2 \cdot 12H_2O$	50	37.2	"
-30	22.2	$MgCl_2 \cdot 12H_2O$	60	37.9	"
-20	26.7	"	70	38.8	"
-16.4†	30.6	"	80	39.8	"
-16.8	31.6	" + $MgCl_2 \cdot 8H_2O$ α	90	41.0	"
-17.4	32.3*	" + $MgCl_2 \cdot 8H_2O$ β	100	42.3	"
-19.4	33.3*	" + $MgCl_2 \cdot 6H_2O$	116.7	46.2	" + $MgCl_2 \cdot 4H_2O$
- 9.6	33.9*	$MgCl_2 \cdot 8H_2O$ β + "	130	48.6	$MgCl_2 \cdot 4H_2O$
-15	31.85	$MgCl_2 \cdot 8H_2O$ α	150	51.8	"
- 3.4	34.4	" + $MgCl_2 \cdot 6H_2O$	170	54.6	"
-15	33.86*	$MgCl_2 \cdot 6H_2O$	ca. 181.5	55.8	" + $MgCl_2 \cdot 2H_2O$
0	34.6	"	186	56.1	$MgCl_2 \cdot 2H_2O$
10	34.9	"	200	56.8	"
15	35.1	"	220	59.5	"
20	35.3	"	300	67.8	"

\* metastable

† m. pt.

### SOLUBILITY OF MAGNESIUM CHLORIDE IN HYDROCHLORIC ACID SOLUTIONS AT 0° (Engel, 1887)

Sp. Gr. of Solutions	Grams per Liter sat. sol.		Sp. Gr. of Solution	Grams per Liter sat. sol.	
	HCl	$MgCl_2$		HCl	$MgCl_2$
1.362	0.0	474.2	1.281	103.9	338.3
1.354	14.93	454.8	--	153.1	286.4
1.344	34.63	428.6	--	214.2	220.3
1.300	61.97	393.0	--	277.1	152.0
1.297	74.74	376.2		sat. HCl	6.5*

\*Ditte

EQUILIBRIUM IN THE SYSTEM MAGNESIUM CHLORIDE, MAGNESIUM  
OXIDE AND WATER

(Results of Bury and Davies, 1932 at 25°)

Due to the formation of either cement or gels equilibrium is reached very slowly. Continuous shaking for two months is required. It is also necessary to keep the solid phase reduced to a fine powder by repeatedly breaking up the lumps. In order to avoid metastable equilibrium it is necessary to add a trace of finely ground magnesium cement which contains hydroxide and oxychloride. The MgO contained about 0.3% CaO. It was prepared by heating magnesium carbonate (light) to 850°. MgO which has been heated to higher temperatures or "burnt" is very slow in attaining equilibrium. Both the filtered saturated solutions and the solid phases were analyzed. The identities of the latter were ascertained by extrapolation by the Jancke method.

C1

Gms. MgCl <sub>2</sub> per 100 gms. sat. sol.		Solid Phase	Gms. MgCl <sub>2</sub> per 100 gms. sat. sol.		Solid Phase	Gms. MgCl <sub>2</sub> per 100 gms. sat. sol.		Solid Phase
2.12		Mg(OH) <sub>2</sub>	12.08*		Mg(OH) <sub>2</sub>	26.59		1.3.11
2.65		"	15.32*		"	31.14		"
6.44		"	10.98	1.3.11	"	33.69		"
8.61		"	14.98	"	"	34.77		"
10.52		"	17.36	"	"	35.71		" + MgCl <sub>2</sub> ·6H <sub>2</sub> O
10.89	" + 1.3.11	"	21.12	"	"	35.72		MgCl <sub>2</sub> ·6H <sub>2</sub> O
10.62*	1.3.11	"	24.21	"	"			"

\* = Metastable

1.3.11 = MgCl<sub>2</sub>·3MgO·11H<sub>2</sub>O.

The authors consider that Robinson and Waggamans value for the triple point Mg(OH)<sub>2</sub> + 1.3.11, viz. 16.0% MgCl<sub>2</sub> (below), erroneous due to their failure to recognize metastable equilibrium.

In a later paper, Bury and Davies, 1933, give results for the four component (reciprocal Salt pair) system MgCl<sub>2</sub> + CaO + H<sub>2</sub>O at 25°. The authors discuss these results in their relation to the properties of magnesium oxychloride cements.

SOLUBILITY OF BASIC MAGNESIUM CHLORIDE IN WATER AT 25°  
(Robinson and Waggaman, 1909)

An excess of MgO was shaken with each of 20 MgCl<sub>2</sub> solutions at 25° for six months and the supernatant clear solutions and solid phases with adhering liquid, analyzed. The solutions were titrated with 0.02 N HCl for dissolved MgO (present as Mg(OH)<sub>2</sub>). The composition of the solid phase in each case was ascertained by plotting the analytical results on a triangular diagram.

d <sub>25</sub> of Gms. per 100 gms. sat. sol.		Solid Phase	d <sub>25</sub> of Gms. per 100 gms. sat. sol.		Solid Phase
Sat. Sol.	MgCl <sub>2</sub> MgO		Sat. Sol.	MgCl <sub>2</sub> MgO	
1.019	2.36 0.00008	Indefinite	1.141	17.53 0.0024	2MgO·HCl·5H <sub>2</sub> O
1.038	4.47 0.00028	Solid Solution	1.162	18.52 0.0025	"
1.056	6.79 0.00048	"	1.192	22.04 0.00245	"
1.075	9.02 0.00080	"	1.245	26.88 0.0025	"
1.111	13.14 0.00115	"	1.274	29.80 0.0024	"
			1.321	34.22 0.0030	"



## Mg MAGNESIUM

Results of d'Ans, Busse, and Freund, 1955 at 20°

Solid Phase $\text{Mg}(\text{OH})_2$			Solid Phase $\text{Mg}_2(\text{OH})_3\text{Cl}\cdot 4\text{H}_2\text{O}$		
pH	Wt. % $\text{MgCl}_2$	Wt. % $\text{Mg}(\text{OH})_2$	pH	Wt. % $\text{MgCl}_2$	Wt. % $\text{Mg}(\text{OH})_2$
--	~ 5	~ 0.003*	--	8.45	0.00311
8.52	6.27	0.00347	--	18.84	0.00441
8.69	9.01	0.00509	--	24.04	0.00558
8.64	12.59	0.00758	6.52	31.76	0.00930
8.02	17.65	0.02248	--	32.52	0.01140
6.46	34.32	0.21220	5.93	33.70	0.01502
*Saturated with both $\text{Mg}(\text{OH})_2$			6.07	33.90	0.01666
and $\text{Mg}_2(\text{OH})_3\text{Cl}\cdot 4\text{H}_2\text{O}$			5.66	34.62	0.01688

C1 The system  $\text{MgCl}_2 - \text{MgO} - \text{H}_2\text{O}$  was studied by Feitknecht, 1926, 1927, 1930 and Feitknecht and Held, 1944 as a function of time, concentration, and the method of preparation of the  $\text{MgO}$ . Other results at 25° and 50° are given by Magda and Yamane, 1928. See also Chassevent, 1933.

THE SYSTEM MAGNESIUM CHLORIDE - MAGNESIUM NITRATE - WATER  
(Sieverts and Muller, 1930, 1931)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	MgCl <sub>2</sub>	Mg(NO <sub>3</sub> ) <sub>2</sub>			MgCl <sub>2</sub>	Mg(NO <sub>3</sub> ) <sub>2</sub>	
Results at 15°				Results at 50°--Cont.			
1.336	35.0	0.0	MgCl <sub>2</sub> ·6H <sub>2</sub> O	1.462	21.6	26.5	MgCl <sub>2</sub> ·6H <sub>2</sub> O + Mg6
1.352	35.5	4.29	"	1.443	18.2	28.6	Mg6
1.371	29.9	8.24	"	1.425	13.0	32.7	"
1.386	27.7	12.2	"	1.419(?)	9.75	35.9	"
1.397	26.1	14.9	" + Mg6	1.414(?)	6.16	39.3	"
1.379	20.0	19.5	Mg6	1.415	3.32	42.4	"
1.373	15.0	24.2	"	1.418	0.0	46.0	"
1.372	9.54	29.9	"	Results at 75°			
1.373	5.04	34.4	"				
1.377	0.0	40.5	"	1.360	39.1	0.0	MgCl <sub>2</sub> ·6H <sub>2</sub> O
Results at 25°				1.380	34.6	7.3	"
				1.390	33.4	9.4	"
1.338	35.5	0.0	MgCl <sub>2</sub> ·6H <sub>2</sub> O	--	28.5	17.6	"
1.353	33.1	4.06	"	--	24.3	28.2	"
1.372	30.7	8.25	"	--	25.8	30.2	" + MgCl <sub>2</sub> ·4H <sub>2</sub> O
1.386	28.6	11.5	"	1.575	23.0	37.5	MgCl <sub>2</sub> ·4H <sub>2</sub> O
1.412	24.9	17.8	" + Mg6	--	17.1	46.2	"
1.392	18.3	22.7	Mg6	--	13.1	54.0	" + Mg2
1.384	13.7	27.1	"	--	11.6	56.1	Mg2
1.376	8.72	32.7	"	1.679	4.9	63.1	"
1.382	4.60	36.8	"	--	3.9	65.3	"
1.387	0.0	41.9	"	--	1.8	67.8	"
Results at 50°				--	0.0	68.8	"
				1.461	0.0	50.6	Mg6
1.345	37.0	0.0	MgCl <sub>2</sub> ·6H <sub>2</sub> O	1.528	9.9	43.2	"
1.372	33.3	6.5	"	--	9.0	48.0	"
1.424	26.4	18.5	"	1.581	6.5	53.3	"
1.452	23.0	24.4	"	--	7.0	57.7	"
				--	0.0	63.4	"
Mg2 = Mg(NO <sub>3</sub> ) <sub>2</sub> ·2H <sub>2</sub> O				(Cont.)			
Mg6 = Mg(NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O							

## THE SYSTEM MAGNESIUM CHLORIDE - MAGNESIUM NITRATE - WATER--Cont.

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	MgCl <sub>2</sub>	Mg(NO <sub>3</sub> ) <sub>2</sub>			MgCl <sub>2</sub>	Mg(NO <sub>3</sub> ) <sub>2</sub>	
Results at 110°							
1.40	44.3	0.0	MgCl <sub>2</sub> ·6H <sub>2</sub> O	1.58	17.5	54.0	MgCl <sub>2</sub> ·2H <sub>2</sub> O
--	43.95	3.65	" + MgCl <sub>2</sub> ·4H <sub>2</sub> O	--	16.3	46.9	"
--	28.3	29.1	MgCl <sub>2</sub> ·4H <sub>2</sub> O	--	16.6	57.8	"
--	23.1	41.7	"	--	16.0	57.8	"
--	22.4	45.2	"	--	15.9	58.7	"
--	23.3	46.0	"	--	14.9	58.5	"
--	22.2	47.4	" + MgCl <sub>2</sub> ·2H <sub>2</sub> O	--	14.2	59.3	"
1.60	20.1	50.8	MgCl <sub>2</sub> ·2H <sub>2</sub> O	--	15.0	61.0	" + Mg <sub>2</sub> Cl
--	19.3	51.8	"	--	9.95	65.0	Mg <sub>2</sub>
				--	0.0	73.5	"
Mg <sub>2</sub> = Mg(NO <sub>3</sub> ) <sub>2</sub> ·2H <sub>2</sub> O							
Mg <sub>6</sub> = Mg(NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O							

Mg<sub>2</sub> = Mg(NO<sub>3</sub>)<sub>2</sub>·2H<sub>2</sub>OMg<sub>6</sub> = Mg(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O

Data for the system  $\text{MgCl}_2 + 2\text{NaNO}_3 = \text{Mg(NO}_3)_2 + 2\text{NaCl} (+\text{H}_2\text{O})$  at 15°, 25°, 50°, 75°, and 100° are given by Sieverts and Muller, 1930, 1931.

## THE SYSTEM MAGNESIUM CHLORIDE - MAGNESIUM SULFATE - WATER

Kuznetzow gives a diagram for the system from -40° to +120°. Additional data at 25° are given by Lowenherz, 1894. Numbers indicate degree of hydration of solid phase, for example, Cl6 = MgCl<sub>2</sub>·6H<sub>2</sub>O, S7 = MgSO<sub>4</sub>·7H<sub>2</sub>O. (Figures in parentheses are densities.) See also p. 526.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
MgCl <sub>2</sub>	MgSO <sub>4</sub>		MgCl <sub>2</sub>	MgSO <sub>4</sub>	
At 0°			At 25°--Cont.		
(Kournakow & Zemcuznyj, 1919, 1924)					
			30.97	3.87	S5
34.55	0.0	Cl6	29.89*	3.93 (1.3239)	" + S6
33.55	1.48	Cl6 + S7	34.36*	2.13 (1.3545)	S4 + S6
30.30	1.50	S7	32.36	3.85	S6
28.81	1.54	"	32.14	3.77	"
27.08	1.67	"	31.39	3.75	"
24.80	2.05	"	30.91	3.76	"
17.70	4.23	"	30.08	3.80	"
10.11	9.08	"	28.72	4.14	"
3.94	14.96	"	28.21	4.35	"
0.0	20.63	"	27.84	4.29	"
At 25°			26.36	4.90	"
(Takegami, 1921)			26.06	5.02	" + S7
			26.06*	4.92 (1.2966)	" + "
35.86	0.0	Cl6	28.5†	4.15	" + "
34.80	1.45	"	23.53	5.44	S7
33.89	2.99	"	16.22	10.14	"
34.03	2.96	" + S4	14.77	11.08	"
33.56	2.81	S4	14.05	10.68	"
33.09	2.82	"	10.51	14.02	"
32.09*	3.06 (1.3398)	" + S5	9.42	14.89	"
32.97	2.91	S5	5.31	19.63	"
32.48	3.04	"	1.62	24.43	"
			0.0	26.68	"

\*Kuznetzow, 1937 †Kournakow and Zemcuznyj, 1919, 1924.

(Cont.)

# Mg MAGNESIUM

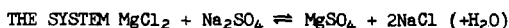
## THE SYSTEM MAGNESIUM CHLORIDE - MAGNESIUM SULFATE - WATER--Cont.

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
MgCl <sub>2</sub>	MgSO <sub>4</sub>	MgCl <sub>2</sub>		MgSO <sub>4</sub>			
At 35° (Kusnetzow, 1937)			At 35°--Cont.				
36.14	0.0 (1.3363)	C16	12.55	14.93	S7		
35.20	1.72 (1.3570)	C16 + S1	5.70	22.21 (1.3000)	S7		
34.79	2.58	S3.9	0.0	29.32 (1.3399)	S7		
35.09	2.82	S3.77	At 100°				
35.09	2.82	S4 + C16	(Campbell, Downes and Samis, 1934)				
C1 31.56	3.49	S3.85	42.40	0.00	C16		
30.58	3.88	S3.77	41.20	1.08	S		
30.58	3.88	S4	41.50	1.23	"		
30.21	4.47	S4.2	40.25	0.87	"		
30.28	5.33	S5	40.60	0.60	"		
27.01 <sup>m</sup>	5.84	S5.5	33.16	0.37	"		
26.82 <sup>m</sup>	5.77	S6 + S5	29.0	0.99	"		
26.14 <sup>m</sup>	6.08	S6	37.6	2.12	"		
26.14 <sup>m</sup>	6.08	S6	36.9	2.81	"		
25.71	6.26	S5	37.35	2.82	S + S-1		
25.61	6.44 (1.3122)	S5.5	31.0	3.30	S-1		
25.61	6.44 (1.3122)	S6 + S5	20.85	9.05	"		
25.33	6.45 (1.3104)	S6	19.85	8.65	"		
24.72	6.56	S6	12.50	16.30	"		
21.95	8.14 (1.2889)	S6	8.42	21.20	"		
20.79	8.97 (1.2896)	S6	2.83	29.50	"		
19.56	9.54 (1.2872)	S6	0.0	33.50	"		
19.54	9.62	S7 + S6					
19.22	9.79 (1.2846)	S7					

<sup>m</sup> metastable

## EQUILIBRIUM IN AQUEOUS SOLUTIONS CONTAINING MAGNESIUM CHLORIDE AND VARIOUS OTHER SALTS

Several exhaustive papers describing the heterogeneous systems encountered in the technical production of particular salts from oceanic salt deposits have appeared. Among these should be mentioned those of Janecke, 1917, 1918, Serowy, 1923 and Frowein and von Muhlendahl, 1926. The experiments of Serowy are a repetition with great care, and an extension of the fundamental work of Van't Hoff, D'Ans and others. The compositions of the solutions saturated at regular intervals of temperature between 0° and 120° with all possible combinations of the solid phases, are shown in tables and triangular diagrams. The results are expressed in ion percent of the constituents of the salts, Mg, K, Na, Cl and SO<sub>4</sub>, and are also calculated to the molecular percent and weight percent basis and by the aid of density determinations, which are also given, to grams per liter. The paper of Janecke gives an exhaustive treatment of equilibria in heterogeneous systems. That of Frowein and von Muhlendahl is concerned particularly with double ternary mixtures derived from Mg, K<sub>2</sub>, Na<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub> and Cl<sub>2</sub>.



This system has been studied in considerable detail by several investigators. In addition to the results given below, see Kupper, 1927 for data at 17 temperatures between 0° and 83°; also Pel'sh, 1949, 1953, 1953a who studied the system at low temperatures (-10° to +35°); other results in this range (-14° to +25°) are given by Druzhinin, Nikolaev et al. (1949), and by Feigelson and Bergman, 1940 (-20° to +25°). For further data at 25° see Levina, 1935; at 55° Tollert, 1952; at 0° and 50° Leinbach and Pfeiffenberger, 1929, 1930; at 110° Tanaka, Takasago and Komatsu, 1950; Zdanovskii, 1949.

Results at 0°, 25°  
(Kournakoff and Zemcuznyj, 1919, 1924)

Cl

Mols. per 1000 mole. H <sub>2</sub> O				Solid Phase
MgCl <sub>2</sub>	MgSO <sub>4</sub>	NaCl <sub>2</sub>	Na <sub>2</sub> SO <sub>4</sub>	
At 0°				
96.5	7.9	1.1	0.0	MgCl <sub>2</sub> ·6H <sub>2</sub> O + MgSO <sub>4</sub> ·7H <sub>2</sub> O + NaCl
85.7	2.9	1.0	0.0	MgSO <sub>4</sub> ·7H <sub>2</sub> O + NaCl
48.2	6.0	11.0	0.0	"
25.2	12.0	25.3	0.0	MgSO <sub>4</sub> ·7H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O + NaCl
23.7	13.3	19.2	0.0	MgSO <sub>4</sub> ·7H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
11.0	23.8	9.7	0.0	"
0.0	38.5	0.0	6.5	"
At 25°				
100.0 (101.85)	9.5 (3.78)	2.5 (0.28)	0.0	MgCl <sub>2</sub> ·6H <sub>2</sub> O + MgSO <sub>4</sub> ·6H <sub>2</sub> O + NaCl
-- (103.9)	0.0	0.0	0.0	" + NaCl
-- (102.1)	-- (5.4)	0.0	0.0	" + MgSO <sub>4</sub> ·6H <sub>2</sub> O
-- (77.0)	-- (9.53)	0.0	0.0	MgSO <sub>4</sub> ·7H <sub>2</sub> O + "
77.7 (75.5)	9.8 (9.78)	2.3 (3.39)	0.0	" + " + NaCl
-- (71.5)	-- (18.0)	-- (15.08)	0.0	" + " + " + "
30.2	5.1	22.0	0.0	MgSO <sub>4</sub> ·7H <sub>2</sub> O + NaCl
53.6	18.8	8.8	0.0	"
44.2	17.0	12.4	0.0	"
37.4	16.1	16.4	0.0	"
35.6	16.2	17.1	0.0	"
24.2	15.3	26.6	0.0	1.1·4 + NaCl
17.6	15.0	31.9	0.0	"
13.1	16.0	36.1	0.0	"
4.1	16.9	43.6	0.0	"
30.2	14.3	21.0	0.0	" + MgSO <sub>4</sub> (7H <sub>2</sub> O)
21.9	22.2	19.8	0.0	"
4.5	38.6	18.1	0.0	"
3.8	39.8	19.7	0.0	"
0.0	45.1	14.2	8.9	"
0.0	44.2	8.2	18.3	"
0.0	45.3 (47.99)	0.0	28.1 (24.97)	"
0.0	16.0	46.9	2.03	" + NaCl + Na <sub>2</sub> SO <sub>4</sub>
0.0	15.9 (18.84)	46.8 (45.72)	2.5 (1.28)	"
0.0	15.6	39.7	9.7	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub>
0.0	17.2 (11.54)	30.4 (23.89)	16.6 (23.67)	"
0.0	-- (11.6)	-- [26.3]	-- [26.0]	" (Ross, 1925)
0.0	-- [30.8]	-- [10.2]	-- [32.3]	" (Takagami, 1920)
0.0	17.7	28.5	18.6	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
0.0	18.1	25.4	20.1	"
0.0	19.3	22.6	24.3	"
0.0	20.2	20.8	25.6	"
0.0	25.0	11.8	31.3	"
0.0	36.2 (37.96)	0.0	35.8 (34.36)	"
0.0	17.2	30.1	16.6	" + " + Na <sub>2</sub> SO <sub>4</sub>
0.0	16.0	46.8	2.2	" + NaCl + "
0.0	0.0	31.4 (29.0)	26.9 (27.5)	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub>
0.0	5.7	30.2	23.1	"
0.0	12.1	30.1	19.8	"
0.0	0.0	50.9 (49.56)	12.4 (12.44)	NaCl + Na <sub>2</sub> SO <sub>4</sub>
0.0	8.1	48.6	7.0	" + "
0.0	4.7	35.8	21.0	Na <sub>2</sub> SO <sub>4</sub>
0.0	11.8	41.5	11.0	"

1.1·4 = astrakhanite, MgSO<sub>4</sub>·Na<sub>2</sub>SO<sub>4</sub>·4H<sub>2</sub>O. The results in parentheses are by Blandale, 1920.

## Mg MAGNESIUM

THE SYSTEM  $\text{MgCl}_2 + \text{Na}_2\text{SO}_4 = \text{MgSO}_4 + 2\text{NaCl} (+\text{H}_2\text{O})$ --Cont.Results at 55°  
(Yanatieva, 1948)

Gms. per 100 gms. Sat. Sol.					Density	Solid Phase
$\text{MgCl}_2$	$\text{MgSO}_4$	$\text{NaCl}$	$\text{Na}_2\text{SO}_4$			
--	34.40	--	--	--	--	$\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$
--	33.66	--	5.37	1.4396	--	$\text{MgSO}_4 \cdot 6\text{H}_2\text{O} + \text{Astrakanite}$
--	12.93	--	23.49	1.4038	--	$\text{Astrakanite} + \text{Na}_2\text{SO}_4$
--	--	--	31.56	--	--	$\text{Na}_2\text{SO}_4$
--	--	24.36	5.16	1.2344	--	$\text{Na}_2\text{SO}_4 + \text{NaCl}$
--	--	26.92	--	--	--	$\text{NaCl}$
36.56	--	2.76	--	--	--	$\text{NaCl} + \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$
37.60	--	--	--	--	--	$\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$
37.33	0.44	--	--	1.3592	--	$\text{MgCl}_2 \cdot 6\text{H}_2\text{O} + \text{MgSO}_4 \cdot \text{H}_2\text{O}$
14.90	18.09	--	--	1.3503	--	$\text{MgSO}_4 \cdot \text{H}_2\text{O} + \text{MgSO}_4 \cdot 6\text{H}_2\text{O}$
Cl	--	12.18	5.61	17.05	--	$\text{MgSO}_4 + \text{Astrakanite}$
	--	10.89	9.28	12.82	1.3265	$\text{Na}_2\text{SO}_4 + \text{Astrakanite} + \text{Vanthoffite}$
	--	10.09	12.60	8.82	--	$\text{Na}_2\text{SO}_4 + \text{Vanthoffite}$
	--	9.42	13.69	8.16	--	"
	--	9.95	17.74	3.39	--	"
	1.14	7.97	21.60	--	1.2658	$\text{Na}_2\text{SO}_4 + \text{Vanthoffite} + \text{NaCl}$
	--	4.21	23.89	2.07	--	$\text{Na}_2\text{SO}_4 + \text{NaCl}$
	--	3.17	24.04	2.72	--	$\text{Na}_2\text{SO}_4 + \text{NaCl}$
	2.51	7.82	20.21	--	--	$\text{NaCl} + \text{Vanthoffite}$
	4.97	7.63	17.59	--	1.2906	$\text{NaCl} + \text{Vanthoffite} + \text{Astrakanite}$
--	12.42	16.64	2.16	--	--	$\text{Astrakanite} + \text{Vanthoffite}$
--	11.39	11.94	8.99	--	--	"
6.35	7.69	16.41	--	--	--	$\text{Astrakanite} + \text{NaCl}$
9.74	7.87	12.86	--	--	--	"
12.92	7.62	9.43	--	--	--	"
13.64	8.24	8.90	--	1.3141	--	$\text{Astrakanite} + \text{L\"oweite} + \text{NaCl}$
10.60	16.32	6.07	--	--	--	$\text{Astrakanite} + \text{L\"oweite}$
8.54	22.42	3.91	--	--	--	"
7.51	23.73	3.73	--	--	--	"
7.32	24.95	3.16	--	1.3825	--	$\text{Astrakanite} + \text{L\"oweite} + \text{MgSO}_4 \cdot 6\text{H}_2\text{O}$
5.21	26.73	4.12	--	--	--	$\text{Astrakanite} + \text{MgSO}_4 \cdot 6\text{H}_2\text{O}$
0.35	33.51	4.02	--	--	--	"
10.80	21.65	2.10	--	1.3510	--	$\text{MgSO}_4 \cdot 6\text{H}_2\text{O} + \text{L\"oweite}$
13.24	19.95	1.37	--	--	--	"
14.36	19.02	1.14	--	1.3369	--	$\text{MgSO}_4 \cdot 6\text{H}_2\text{O} + \text{L\"oweite} + \text{MgSO}_4 \cdot \text{H}_2\text{O}$
15.47	17.15	1.77	--	--	--	$\text{MgSO}_4 \cdot \text{H}_2\text{O} + \text{L\"oweite}$
17.70	15.00	1.50	--	--	--	"
18.41	14.41	1.55	--	--	--	"
24.24	7.38	2.16	--	1.3165	--	$\text{MgSO}_4 \cdot \text{H}_2\text{O} + \text{L\"oweite} + \text{NaCl}$
32.74	2.81	1.20	--	--	--	$\text{MgSO}_4 \cdot \text{H}_2\text{O} + \text{NaCl}$
37.52	0.40	0.30	--	1.3625	--	$\text{MgSO}_4 \cdot \text{H}_2\text{O} + \text{NaCl} + \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$

(Cont.)

THE SYSTEM  $\text{MgCl}_2 + \text{Na}_2\text{SO}_4 \rightleftharpoons \text{MgSO}_4 + 2\text{NaCl} (+\text{H}_2\text{O})$ —Cont.Results at 105°  
(Mayeda, 1920)

Mols. per 1000 mols. $\text{H}_2\text{O}$				Solid Phase
$\text{MgCl}_2$	$\text{MgSO}_4$	$\text{Na}_2\text{Cl}_2$	$\text{Na}_2\text{SO}_4$	
133.0	--	0.225	--	NaCl
139.5	--	trace	--	$\text{MgCl}_2 \cdot \text{NaCl} \cdot 6\text{H}_2\text{O}$
138.5	1.5	--	--	$\text{MgCl}_2 \cdot 6\text{H}_2\text{O} + \text{MgSO}_4 \cdot \text{H}_2\text{O}$
123.1	2.09	--	--	$\text{MgSO}_4 \cdot \text{H}_2\text{O}$
--	76.69	--	--	"
--	64.31	--	13.07	" + $2\text{Na}_2\text{SO}_4 \cdot 2\text{MgSO}_4 \cdot 5\text{H}_2\text{O}$
--	41.84	--	32.22	$3\text{Na}_2\text{SO}_4 \cdot \text{MgSO}_4 + 2\text{Na}_2\text{SO}_4 \cdot 2\text{MgSO}_4 \cdot 5\text{H}_2\text{O}$ Cl
--	49.88	--	11.05	" + $\text{Na}_2\text{SO}_4$
--	--	--	52.99	$\text{Na}_2\text{SO}_4$
--	--	57.99	8.054	" + NaCl
4.632	--	52.78	7.382	" + " + $3\text{Na}_2\text{SO}_4 \cdot \text{MgSO}_4$
33.64	--	27.02	10.12	$\text{NaCl} + 3\text{Na}_2\text{SO}_4 \cdot \text{MgSO}_4 + 2\text{Na}_2\text{SO}_4 \cdot 2\text{MgSO}_4 \cdot 5\text{H}_2\text{O}$
55.40	--	9.978	11.32	$\text{NaCl} + 2\text{Na}_2\text{SO}_4 \cdot 2\text{MgSO}_4 \cdot 5\text{H}_2\text{O} + \text{MgSO}_4 \cdot \text{H}_2\text{O}$

Data for the system  $\text{MgCl}_2 + \text{K}_2\text{SO}_4 \rightleftharpoons \text{MgSO}_4 + 2\text{KCl} (+\text{H}_2\text{O})$  at 100° are given by Campbell, Downes and Samis, 1934.Data for the systems composed of Magnesium and Sodium Chlorides, Nitrates and Sulfates at 0°, 10°, 25° and 50° are given by Leinbach and Pfeifferberger, 1929, 1930.The 55° and 90° isotherms in the system  $\text{MgCl}_2 - \text{MgSO}_4 - \text{KCl} - \text{NaCl} - \text{H}_2\text{O}$  in solutions saturated with NaCl are reported by Autenrieth, 1955.THE SYSTEM MAGNESIUM CHLORIDE - BARIUM CHLORIDE - WATER  
(Assarsson, 1956)

Results at 50°

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{MgCl}_2$	$\text{BaCl}_2$	
37.4	0.0	$\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$
36.9	0.05	" + $\text{BaCl}_2 \cdot \text{H}_2\text{O}$
36.7	0.05	$\text{BaCl}_2 \cdot \text{H}_2\text{O}$
34.1	0.15	"
32.5	0.20	$\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$
26.8	0.40	"
20.7	2.30	"
12.2	10.60	"
0.0	30.4	"

Results at 100°

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{MgCl}_2$	$\text{BaCl}_2$	
42.2	0.0	$\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$
40.9	0.02	$\text{BaCl}_2$
37.6	0.2	"
31.5	0.9	"
24.0	2.9	"
18.4	8.0	"
13.9	14.0	"
12.7	15.7	"
11.3	17.7	$\text{BaCl}_2 \cdot \text{H}_2\text{O}$
9.9	20.2	"
4.2	29.7	"
2.4	33.2	"
0.0	37.3	$\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$

# Mg MAGNESIUM

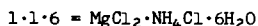
## THE SYSTEM MAGNESIUM CHLORIDE - BERYLLIUM CHLORIDE - WATER AT 25° (Blidin, 1957)

Sat. sol. wt. %		Solid Phase	Sat. sol. wt. %		Solid Phase
BeCl <sub>2</sub>	MgCl <sub>2</sub>		BeCl <sub>2</sub>	MgCl <sub>2</sub>	
0.0	35.34	MgCl <sub>2</sub> ·6H <sub>2</sub> O	30.82	7.30	MgCl <sub>2</sub> ·6H <sub>2</sub> O
6.82	27.40	"	34.45	5.48	"
14.00	21.19	"	36.51	4.65	"
18.22	17.30	"	38.50	2.70	" + BeCl <sub>2</sub> ·4H <sub>2</sub> O
25.13	11.61	"	40.37	2.40	BeCl <sub>2</sub> ·4H <sub>2</sub> O
26.25	10.59	"	41.72	0.0	"

For results at 25° and 100° in the system MgCl<sub>2</sub> + CaCl<sub>2</sub> + H<sub>3</sub>BO<sub>3</sub> + H<sub>2</sub>O see Zdanovskii, 1949.

## THE SYSTEM MAGNESIUM CHLORIDE - AMMONIUM CHLORIDE - WATER (Woskrassenski, 1934)

The author also made a long series of determinations by the freezing-point method (observing the temperature of the appearance of first crystal) and from these results obtained the values for the isotherms at -10°, -20°, -25°, as well as for the invariant points of the system at other temperatures.



Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
MgCl <sub>2</sub>	NH <sub>4</sub> Cl		MgCl <sub>2</sub>	NH <sub>4</sub> Cl	
<u>Results at 3.5°(*)</u>			<u>Results at 60°</u>		
34.43	0.09	1.1.6 + MgCl <sub>2</sub> ·6H <sub>2</sub> O	37.9	0.0	MgCl <sub>2</sub> ·6H <sub>2</sub> O
21.41	5.93	1.1.6 + NH <sub>4</sub> Cl	38.2	0.15	" + 1.1.6
<u>Results at 25°</u>			35.9	0.49	1.1.6
35.7	0.0	MgCl <sub>2</sub> ·6H <sub>2</sub> O	31.7	1.2	"
35.55	0.08	" + 1.1.6	27.8	3.6	"
35.41	0.09(*)	" + "	22.1	11.8	"
28.05	1.31	1.1.6	20.7	14.3	" + NH <sub>4</sub> Cl
25.71	3.0	"	18.5	15.9	NH <sub>4</sub> Cl
23.88	4.88	"	15.5	18.6	"
21.08	8.69	" + NH <sub>4</sub> Cl	8.4	20.0	"
20.95	8.78(*)	" + "	0.0	35.6	"
12.36	15.75	NH <sub>4</sub> Cl	<u>Results at 115°</u>		
7.50	20.45	"	45.0	0.0	MgCl <sub>2</sub> ·6H <sub>2</sub> O
0.0	28.26	"	44.8	0.17	" + 1.1.6
<u>Results at 50°(*)</u>			41.9	0.54	1.1.6
36.92	0.15	1.1.6 + MgCl <sub>2</sub> ·6H <sub>2</sub> O	35.6	2.29	"
20.84	12.46	1.1.6 + NH <sub>4</sub> Cl	26.7	12.4	"
			21.2	22.3	" + NH <sub>4</sub> Cl
			19.0	24.1	NH <sub>4</sub> Cl
			9.5	34.2	"
			4.2	40.7	"
			0.0	46.5	"

(\*) Blitz and Marcus, 1911

(\*) Blitz and Marcus, 1911

The specific volumes and heat capacities of solutions of Magnesium Chloride and ammonium nitrate in water are given by Rutakov, 1948.

#### THE SYSTEM MAGNESIUM CHLORIDE - SODIUM CHLORIDE - WATER

The eutectic of the system  $\text{MgCl}_2 + \text{NaCl} + \text{H}_2\text{O}$  is at  $-35^\circ$ , 1.56% NaCl, 22.71%  $\text{MgCl}_2$  with solid phases: Ice +  $\text{NaCl} \cdot 2\text{H}_2\text{O}$  +  $\text{MgCl}_2 \cdot 12\text{H}_2\text{O}$ . The invariant solution in equilibrium with  $\text{MgCl}_2 \cdot 12\text{H}_2\text{O}$  +  $\text{NaCl} \cdot 2\text{H}_2\text{O}$  + NaCl ( $-26^\circ$ ) contains 1.81% NaCl and 23.35%  $\text{MgCl}_2$ . (Luzhnaja and Vereshchchina, 1946) Careful cryoscopic determinations are given by Mun and Daner, 1957.

Data for the system  $\text{MgCl}_2 - \text{NaCl} - \text{H}_2\text{O}$  up to  $200^\circ$  are given by d'Ans and Sypiana, 1942.

Cl

Results at $0^\circ$			Results at $15^\circ$		
(Kournakov & Zemcuznyj, 1919, 1924)			(Keitel, 1923)		
Mols. per 1000 mols. $\text{H}_2\text{O}$		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{MgCl}_2$	$\text{Na}_2\text{Cl}_2$		$\text{MgCl}_2$	NaCl	
99.8	0.0	$\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$	35.10	0.0	$\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$
98.0	1.7	" + NaCl	23.84	3.68	NaCl
75.0	3.2	NaCl	15.80	10.07	"
49.1	12.8	"	7.60	18.95	"
38.0	20.0	"			
18.95	37.0	"			
0.0	54.9	"			

Results at $25^\circ$			
(Kournakov and Zemcuznyj, 1919, 1924)		(Keitel, 1923)	(Takegami, 1921)
Mols. per 1000 mols. $\text{K}_2\text{O}$		Gms. per 100 gms. sat. sol.	
$\text{MgCl}_2$	$\text{Na}_2\text{Cl}_2$	$\text{MgCl}_2$	NaCl
104.9	0.0	35.60	0.0
--	--	--	--
102.5	2.45	35.00	0.97
95.0	3.0	30.87	1.39
79.2	4.1	24.28	4.01
58.5	9.0	9.68	16.38
48.4	14.5	8.01	17.74
40.6	19.5	--	--
26.7	29.6	--	--
16.0	40.0	--	--
0.0	55.5	--	--

(Cont.)



# Mg MAGNESIUM

## THE SYSTEM MAGNESIUM CHLORIDE - SODIUM CHLORIDE - WATER—Cont.

(Results of Keitel, 1923 at the following degrees)

Cl	Results at 55°		Results at 83°		Results at 105°		Solid Phase in each case	
	Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.			
	MgCl <sub>2</sub>	NaCl	MgCl <sub>2</sub>	NaCl	MgCl <sub>2</sub>	NaCl		
	37.55	0.0	39.81	0.0	43.47	0.0		MgCl <sub>2</sub> ·6H <sub>2</sub> O
	37.51	0.28	38.80	0.40	42.93	0.09		" + NaCl
	34.49	0.97	34.89	0.74	31.01	2.61	NaCl	
	30.80	1.65	30.86	2.28	24.68	7.22	"	
	25.05	4.32	22.51	7.65	0.0	28.35	"	
	23.59	5.01	15.37	12.90			"	
	16.18	10.74	7.83	20.81			"	
	8.29	18.34	0.0	27.60			"	
	7.37	19.30					"	
	0.0	27.01					"	

## THE SYSTEM MgCl<sub>2</sub> - NaCl - CaCl<sub>2</sub> - H<sub>2</sub>O BELOW 30°

(Lushnaja and Verehtetina, 1946)

The authors studied the system at low temperatures by observing the temperature of initial crystallization upon cooling. They present data at constant ratios of CaCl<sub>2</sub>:MgCl<sub>2</sub> with varying amounts of NaCl present. The following 3 phase equilibria were extracted from the tables.

Temp.°	Gms. per 100 gms. sat. sol.			Solid Phase
	CaCl <sub>2</sub>	MgCl <sub>2</sub>	NaCl	
-21.5	3.50	3.50	16.0	Ice + NaCl·2H <sub>2</sub> O
-22.5	4.80	1.60	17.00	"
-24.3	3.05	6.15	13.90	"
-26.5	3.43	10.29	8.6	"
-26.5	7.20	7.20	9.0	"
-27.0	11.49	3.81	9.20	"
-39.0	5.84	17.54	1.72	"
-44.0	12.30	12.30	2.00	"
-52.0	20.96	6.98	1.66	"
- 0.5	3.95	3.95	18.5	NaCl·2H <sub>2</sub> O + NaCl
- 1.2	2.45	7.35	16.0	"
- 1.3	3.52	1.84	19.10	"
- 6.5	12.70	4.23	10.40	"
- 6.5	3.97	11.93	9.3	"
- 8.0	7.90	7.90	10.2	"
-19.5	13.85	13.85	2.40	"
-23.8	6.75	20.25	2.05	"
-25.0	14.65	14.65	1.60	"
-27.5	22.28	7.42	1.70	"
-38.3	5.69	17.09	0.32	Ice + MgCl <sub>2</sub> ·12H <sub>2</sub> O
-42.5	12.18	12.18	1.38	"
-17.5	8.28	24.86	0.56	MgCl <sub>2</sub> ·12H <sub>2</sub> O + NaCl·2H <sub>2</sub> O
-27.0	14.82	14.82	0.65	"
-30.0	13.15	13.15	1.42	"
-35	0.0	22.71	1.56	Ice + MgCl <sub>2</sub> ·12H <sub>2</sub> O+NaCl·2H <sub>2</sub> O
-26	0.0	23.35	1.81	MgCl <sub>2</sub> ·12H <sub>2</sub> O+NaCl·2H <sub>2</sub> O+NaCl

The Quaternary Eutectic is about -58° with a ratio of about 17:83 MgCl<sub>2</sub>:CaCl<sub>2</sub> in solution.

For a discussion and calculation of the crystallization area of NaCl in this system see Mun and Yarym-Agaev, 1957.

Results for the systems  $\text{MgCl}_2 + \text{NaCl} + \text{Na}_2\text{SO}_4 + \text{NaNO}_3 + \text{H}_2\text{O}$  ( $10^\circ$ ,  $50^\circ$ ) and  $\text{MgCl}_2 + \text{NaCl} + \text{Na}_2\text{SO}_4 + \text{NaNO}_3 + \text{Mg}(\text{NO}_3)_2 + \text{H}_2\text{O}$  ( $50^\circ$ ) are given by Leinbach and Pfeiffenberger, 1929, 1930.

THE SYSTEM  $\text{MgCl}_2 - \text{RbCl} - \text{KCl} - \text{H}_2\text{O}$  AT  $25^\circ$   
(D'Ans and Busch, 1937)

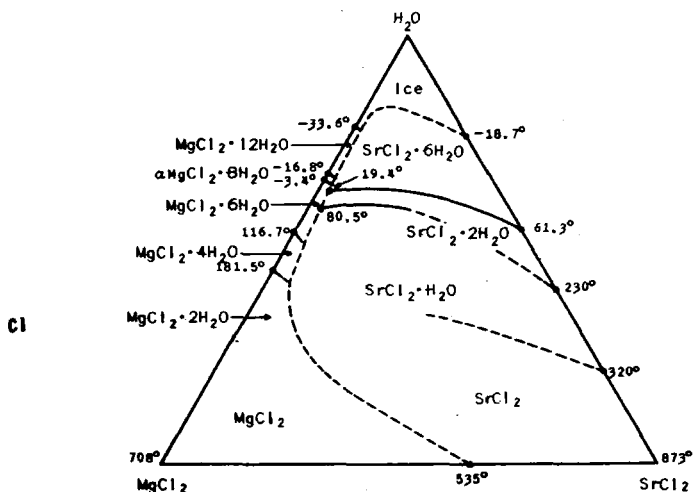
Gm. Mols. per 1000 gms. $\text{H}_2\text{O}$			Mols. Rb per 100 mols. Rb + K in:		Solid Phase	Cl
$\text{MgCl}_2$	$\text{Rb}_2\text{Cl}_2$	$\text{K}_2\text{Cl}_2$	sat. sol.	Solid Phase		
104.0	trace	0.0	--	--	$\text{MgCl}_2 \cdot 6\text{H}_2\text{O} + 1.1.6$	
49.2	24.8	0.0	--	--	1.1.6	
(31.0)	(38.0)	1.3	100	--	" + $\text{RbCl}$	
32.2	36.7	0.0	--	--	"	
(72.0)	00.0	(5.5)	0.0	--	$\text{KCl} + \text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$	
57.3	6.2	7.9	44.0	--	$(\text{K}, \text{Rb})\text{Cl} + (\text{K}, \text{Rb})\text{Cl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$	
50.2	12.9	10.2	55.7	--	"	
44.3	29.7	7.2	81.5	--	"	
41.5	33.3	5.7	85.0	--	"	
68.7	0.4	7.0	4.8	0.0	$(\text{K}, \text{Rb})\text{Cl}$	
72.3	0.6	5.9	9.7	17.2	$(\text{K}, \text{Rb})\text{Cl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$	
46.5	19.7	8.8	69.2	86.0	"	
34.0	32.8	8.5	79.3	54.1	$(\text{K}, \text{Rb})\text{Cl}$	
45.0	27.4	3.5	89.0	95.4	$(\text{K}, \text{Rb})\text{Cl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$	
50.3	18.0	9.4	65.7	83.4	"	
48.7	18.2	6.8	72.3	86.5	"	
46.6	19.0	6.3	75.1	90.2	"	
49.3	21.9	4.0	86.3	91.6	"	

1.1.6 =  $\text{MgCl}_2 \cdot \text{RbCl} \cdot 6\text{H}_2\text{O}$  (Rubidium Carnallite)

THE SYSTEM MAGNESIUM CHLORIDE - STRONTIUM CHLORIDE - WATER  
(Assarsson and Balder, 1954a)

There are no double salts in the system between  $18^\circ$  and  $100^\circ$ . The transition  $\text{SrCl}_2 \cdot 6\text{H}_2\text{O} \rightarrow \text{SrCl}_2 \cdot 2\text{H}_2\text{O}$  occurs at  $19.4^\circ$ , in solution containing 1.3%  $\text{SrCl}_2$  and 34.7%  $\text{MgCl}_2$ . The transition  $\text{SrCl}_2 \cdot 2\text{H}_2\text{O} \rightarrow \text{SrCl}_2 \cdot \text{H}_2\text{O}$  occurs at  $80.5^\circ$ , with 1.7%  $\text{SrCl}_2$  and 39.1%  $\text{MgCl}_2$  in solution. The authors present the following diagram:

# Mg MAGNESIUM



THE SYSTEM  $\text{MgCl}_2 + \text{Na}_2\text{S}_2\text{O}_3 \rightleftharpoons \text{MgS}_2\text{O}_3 + 2\text{NaCl} (+\text{H}_2\text{O})$  AT 25°  
(Silberman and Ivanov, 1946)

Saturated Solution Wt. %				Solid Phase
$\text{MgS}_2\text{O}_3$	$\text{Na}_2\text{S}_2\text{O}_3$	$\text{MgCl}_2$	$\text{NaCl}$	
—	32.98	—	9.86	$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O} + \text{NaCl}$
—	—	35.80	0.21	$\text{MgCl}_2 \cdot 6\text{H}_2\text{O} + \text{NaCl}$
3.10	—	33.68	—	$\text{MgCl}_2 \cdot 6\text{H}_2\text{O} + \text{MgS}_2\text{O}_3 \cdot 6\text{H}_2\text{O}$
19.18	25.48	—	—	$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O} + \text{MgS}_2\text{O}_3 \cdot 6\text{H}_2\text{O}$
15.25	22.13	—	6.45	$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O} + \text{NaCl}$
18.56	20.49	—	5.64	$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O} + \text{NaCl} + \text{MgS}_2\text{O}_3 \cdot 6\text{H}_2\text{O}$
23.05	9.14	—	8.67	$\text{MgS}_2\text{O}_3 \cdot 6\text{H}_2\text{O} + \text{NaCl}$
19.63	—	8.34	6.38	"
17.88	—	10.56	5.36	"
10.15	—	20.40	1.99	"
3.17	—	33.40	0.36	$\text{MgS}_2\text{O}_3 \cdot 6\text{H}_2\text{O} + \text{MgCl}_2 \cdot 6\text{H}_2\text{O} + \text{NaCl}$

SOLUBILITY OF MAGNESIUM CHLORIDE IN AQUEOUS SOLUTIONS  
OF POTASSIUM PERMANGANATE AT 25°  
(Hertz and Hiebenthal, 1929)

Gm. Mola. per liter sat. sol.

1/5-KMnO <sub>4</sub>	1/2MgCl <sub>2</sub>
0.0	9.56
0.10	9.46
+ 0.16	9.52

SOLUBILITY OF MAGNESIUM CHLORIDE IN ALCOHOLS  
(Lloyd, Brown, Glynn, Bonncl and Jones, 1928)

In Methanol			In Ethanol		
t°	Gms. MgCl <sub>2</sub> per 100 gms. CH <sub>3</sub> OH	Solid Phase	t°	Gms. MgCl <sub>2</sub> per 100 gms. C <sub>2</sub> H <sub>5</sub> OH	Solid Phase
0	15.5	MgCl <sub>2</sub> ·6CH <sub>3</sub> OH	0	3.61	MgCl <sub>2</sub> ·6C <sub>2</sub> H <sub>5</sub> OH
10	15.7	"	10	4.34	"
20	10.0	"	20	5.60	"
30	16.7	"	30	7.40	"
40	17.8	"	40	10.00	"
50	19.0	"	50	12.80	"
60	20.4	"	60	15.89	"
			65	17.20	"
			70	18.63	"

Cl

THE SYSTEM MAGNESIUM CHLORIDE - DIOXANE - WATER AT 25°  
(Weickel and Lynch, 1950)

Solutions saturated with MgCl <sub>2</sub> ·6H <sub>2</sub> O·(C <sub>2</sub> H <sub>4</sub> ) <sub>2</sub> O <sub>2</sub> Wt. %		Region of two immiscible liquids			
		Lighter layer wt. %		Heavier layer wt. %	
MgCl <sub>2</sub>	(C <sub>2</sub> H <sub>4</sub> ) <sub>2</sub> O <sub>2</sub>	MgCl <sub>2</sub>	(C <sub>2</sub> H <sub>4</sub> ) <sub>2</sub> O <sub>2</sub>	MgCl <sub>2</sub>	(C <sub>2</sub> H <sub>4</sub> ) <sub>2</sub> O <sub>2</sub>
35.33	0.33*	0.00	95.96	15.09	35.52
34.98	0.42	0.01	94.45	12.69	38.70
34.03	0.07	0.04	92.92	10.00	42.80
31.79	0.26	0.12	90.34	7.50	48.72
28.65	1.55	0.28	86.32	5.18	54.58
23.25	10.55	0.66	82.19	3.64	61.53
19.91	18.76				
16.91	27.74				

\*Also saturated with MgCl<sub>2</sub>·6H<sub>2</sub>O.

SOLUBILITY OF MAGNESIUM CHLORIDE IN VARIOUS SOLVENTS

Solvent	t°	Solubility	Author
Furfural	25	0.04 gms. MgCl <sub>2</sub> /100 gas. sat. sol.	(1)
Anhyd. Hydrazine	Room 2	gms. MgCl <sub>2</sub> /100 cc. solvent	(2)
0.043 wt. % BrC <sub>2</sub> H <sub>4</sub> Br solution in water	35	21.57 gms. MgCl <sub>2</sub> /100 gas. sat. sol.	(3)
Selenium tetrachloride (SeCl <sub>4</sub> )	25	4.96 gms. MgCl <sub>2</sub> /100 gas. sat. sol.	(4)
Equal volumes ethyl ether +H <sub>2</sub> O, saturated with HCl	0	0.0122 gms. MgCl <sub>2</sub> /100 cc. solvent	(5)

- (1) Tribble, 1941
- (2) Welsh and Broderson, 1915
- (3) Drushinin and Shostakovskiy, 1942
- (4) Wise, 1923
- (5) Fischer and Seidel, 1941

## Mg MAGNESIUM

Melting points are given for the following:

MgCl <sub>2</sub> + NaCl	(Klemm and Weiss, 1940; Scholich, 1920; Menge, 1911; Klemm, 1948; Beyersdorfer and Oryschkewitsch, 1948; Speranskaya, 1938)
MgCl <sub>2</sub> + MgSO <sub>4</sub>	(Speranskaya, 1938; Janecke, 1912)
MgCl <sub>2</sub> + Na <sub>2</sub> SO <sub>4</sub> = MgSO <sub>4</sub> + NaCl	(Speranskaya, 1938)
MgCl <sub>2</sub> + K <sub>2</sub> SO <sub>4</sub> = MgSO <sub>4</sub> + KCl	( " " )
MgCl <sub>2</sub> + KCl	(Berersdorfer and Oryschkewitsch, 1948; Scholich, 1920; Klemm, 1948)
MgCl <sub>2</sub> + RbCl	(Berersdorfer and Oryschkewitsch, 1948; Klemm, 1948; Markov and Panchenko, 1954)
MgCl <sub>2</sub> + KCl + NaCl	(Scholich, 1920)
MgCl <sub>2</sub> + MnCl <sub>2</sub>	(Sandonnini, 1912, 1914)
MgCl <sub>2</sub> + PbCl <sub>2</sub>	(Menge, 1911)
MgCl <sub>2</sub> + SnCl <sub>2</sub>	(Menge, 1911)
MgCl <sub>2</sub> + SrCl <sub>2</sub>	(Sandonnini, 1912, 1914)
MgCl <sub>2</sub> + TiCl <sub>4</sub>	(Korring, 1914)
MgCl <sub>2</sub> + ZnCl <sub>2</sub>	(Menge, 1911)
MgCl <sub>2</sub> + NbCl <sub>5</sub>	(Korshunov and Sil'vestrova, 1956)
MgCl <sub>2</sub> + ZrCl <sub>4</sub>	( " " " " )

## ClO MAGNESIUM CHLORATE Mg(ClO<sub>3</sub>)<sub>2</sub>

### SOLUBILITY IN WATER

(Meusser, 1902)

t°	Gms. Mg(ClO <sub>3</sub> ) <sub>2</sub> per 100 Gms. Solution	Mols. Mg(ClO <sub>3</sub> ) <sub>2</sub> per 100 Mols. H <sub>2</sub> O	Solid Phase
-18	51.64	10.05	Mg(ClO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O
0	53.27	10.73	"
18	56.50	12.22	"
29	60.23	14.25	"
35	63.65	16.48	"
42	63.82	16.60	Mg(ClO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
65.5	69.12	20.08	"
39.5	65.37	17.76	Mg(ClO <sub>3</sub> ) <sub>2</sub> ·2H <sub>2</sub> O
61.0	69.46	21.40	"
68	70.69	22.69	"
93	(73.71)	(26.38)	"

Sp. Gr. of saturated sol. at +18° = 1.564.

MAGNESIUM PERCHLORATE  $\text{Mg}(\text{ClO}_4)_2$ 

ClO

SOLUBILITY IN WATER  
(Lilich and Dzburinskii, 1956)[Solid Phase  $\text{Mg}(\text{ClO}_4)_2 \cdot 6\text{H}_2\text{O}$ ]

t°	$\text{Mg}(\text{ClO}_4)_2$ per 100 gms. $\text{H}_2\text{O}$		t°	$\text{Mg}(\text{ClO}_4)_2$ per 100 gms. $\text{H}_2\text{O}$	
	Moles	Grams		Moles	Grams
0	0.410	91.5	30	0.457	102.0
5	0.420	93.7	35	0.468	104.5
10	0.426	95.0	40	0.472	105.2
15	0.434	96.8	45	0.479	107.0
20	0.444	99.1	50	0.489	109.1
25	0.448	100.0			
	(0.450)	(100.4) <sup>a</sup>			
	(0.447)	(99.6) <sup>b</sup>			

<sup>a</sup>Sidgwick and Lewis, 1926<sup>b</sup>Willard and Smith, 1926; density 1.4720.

Data for freezing points of dilute  $\text{Mg}(\text{ClO}_4)_2$  solutions are given  
by Nicholson and Felsing, 1950.

SOLUBILITY OF MAGNESIUM PERCHLORATE IN ORGANIC SOLVENTS AT 25°  
(Willard and Smith, 1926)Anhydrous  $\text{Mg}(\text{ClO}_4)_2$  was used throughout.

Solvent	d. of solvent	d. of sat. sol.	Gms. $\text{Mg}(\text{ClO}_4)_2$ per 100 gms. sat. sol.
Methyl alcohol	0.78705	1.1057	34.14
Ethyl alcohol	0.78515	0.9518	19.33
nPropyl alcohol	0.7989	1.1926	42.33
nButyl alcohol	0.8059	1.1399	39.16
isoButyl alcohol	0.7981	1.0609	31.27
Acetone	0.7864	1.9798	30.015
Ethyl acetate	0.89457	1.3057	41.49
Ethyl ether	0.7081	0.7101	0.29
	--	--	(0.0643)*
	--	--	(0.0588-15°)*
			(0.0437- 0°)*

\*Rowley and Seiler, 1940.

MAGNESIUM Hexa Antipyrine PERCHLORATE  $[\text{Mg}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6](\text{ClO}_4)_2$ 

ClO

100 gms. sat. solution of Magnesium Hexa Antipyrine Perchlorate in  
Water contain 7.69 gms.  $[\text{Mg}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6](\text{ClO}_4)_2$  at 20°. (Wilke, Dorfurf  
and Schliephake, 1929.)

## Mg MAGNESIUM

### CrO MAGNESIUM CHROMATE $\text{MgCrO}_4$

#### SOLUBILITY OF MAGNESIUM CHROMATE IN WATER (Hill, Soth, and Ricci, 1940a)

Each result is the mean of a determination in which equilibrium was approached from supersaturation, and one in which it was approached from undersaturation. A very finely divided solid phase was produced at 75° upon long stirring, but its composition was not determined, and the pentahydrate may be metastable at this temperature.

t°	Gms. $\text{MgCrO}_4$ per 100 gms. Sat. Sol.	Solid Phase	t°	Gms. $\text{MgCrO}_4$ per 100 gms. sat. sol.	Solid Phase
0	32.06	$\text{MgCrO}_4 \cdot 7\text{H}_2\text{O}$	25	35.39	$\text{MgCrO}_4 \cdot 5\text{H}_2\text{O}$
10	33.87	"	35	35.81	"
15	34.78	"	50	36.82	"
e17.2	35.15	$\text{MgCrO}_4 \cdot 7\text{H}_2\text{O} + \text{MgCrO}_4 \cdot 5\text{H}_2\text{O}$	60	37.68	"
*10	34.94	$\text{MgCrO}_4 \cdot 5\text{H}_2\text{O}$	75	39.96	"
*15	35.20	"			

e = extrapolated

\* = Metastable

#### THE SYSTEM MAGNESIUM CHROMATE - AMMONIUM CHROMATE - WATER AT 25° (Hill, Soth, and Ricci, 1940)

At 25°, 100 gms. of a saturated solution of the double salt in water contain 11.50 gms.  $\text{MgCrO}_4 \cdot (\text{NH}_4)_2\text{CrO}_4$  (Density = 1.088).

Gms. per 100 gms. Sat. Sol.		Solid Phase
$\text{MgCrO}_4$	$(\text{NH}_4)_2\text{CrO}_4$	
0.0	27.02	$(\text{NH}_4)_2\text{CrO}_4$
0.36	27.02	" + 1:1:6
0.53	22.81	1:1:6
1.25	14.02	"
4.62	6.64	"
6.52	5.31	"
11.71	3.39	"
19.21	1.95	"
28.81	0.85	"
35.20	0.41	" + $\text{MgCrO}_4 \cdot 5\text{H}_2\text{O}$
35.39	0.0	$\text{MgCrO}_4 \cdot 5\text{H}_2\text{O}$

1:1:6 =  $\text{MgCrO}_4 \cdot (\text{NH}_4)_2\text{CrO}_4 \cdot 6\text{H}_2\text{O}$

THE SYSTEMS MAGNESIUM AMMONIUM CHROMATE - MAGNESIUM AMMONIUM SELENATE -  
WATER AND MAGNESIUM AMMONIUM CHROMATE - MAGNESIUM AMMONIUM SULFATE -  
WATER AT 25°  
(Hill, Soth, and Ricci, 1940)

The salts form continuous, hexahydrated solid solutions. Each determination was made in duplicate, and equilibrium was approached from two directions.

$\text{Mg}(\text{NH}_4)_2(\text{CrO}_4)_2\text{-Mg}(\text{NH}_4)_2(\text{SeO}_4)_2\text{-H}_2\text{O}$				$\text{Mg}(\text{NH}_4)_2(\text{CrO}_4)_2\text{-Mg}(\text{NH}_4)_2(\text{SO}_4)_2\text{-H}_2\text{O}$			
Sat. Sol. Wt. %		Solid Wt. %		Sat. Sol. Wt. %		Solid Wt. %	
A	B	A	B	A	C	A	C
11.50	0.0	73.00	0.0	11.50	0.0	73.00	0.0
8.43	6.07	61.43	12.23	8.83	4.75	61.33	11.20
5.63	11.85	45.73	28.70	6.60	8.61	45.95	25.78
3.40	16.59	29.31	45.80	5.08	10.89	33.85	37.42
2.04	19.37	17.68	57.94	3.05	13.44	17.27	53.40
1.09	21.28	9.24	66.78	1.77	14.96	8.90	61.39
0.0	23.31	0.0	76.21	0.0	16.58	0.0	70.02

A =  $\text{Mg}(\text{NH}_4)_2(\text{CrO}_4)_2$

B =  $\text{Mg}(\text{NH}_4)_2(\text{SeO}_4)_2$

C =  $\text{Mg}(\text{NH}_4)_2(\text{SO}_4)_2$

MAGNESIUM POTASSIUM CHROMATE  $\text{MgCrO}_4\cdot\text{K}_2\text{CrO}_4\cdot 2\text{H}_2\text{O}$

100 grams  $\text{H}_2\text{O}$  dissolve 28.2 grams at 20°, and 34.3 grams at 60°.

(Schweitzer)

MAGNESIUM DICHROMATE  $\text{MgCr}_2\text{O}_7$

CrO

SOLUBILITY IN WATER  
(Costa and Hartford, 1957)

The transition between the hexa- and penta-hydrates is not discernable in the solubility curve. It was found to be  $48.5 \pm 0.5^\circ$  by analysis of the solid phases at each temperature. The heat of transition is about 0.20 kcal/mole.

t°	Gms. $\text{MgCr}_2\text{O}_7$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{MgCr}_2\text{O}_7$ per 100 gms. sat. sol.	Solid Phase
25	56.98	$\text{MgCr}_2\text{O}_7\cdot 5\text{H}_2\text{O}$	51.6	61.72	$\text{MgCr}_2\text{O}_7\cdot 5\text{H}_2\text{O}$
30.3	58.52	$\text{MgCr}_2\text{O}_7\cdot 6\text{H}_2\text{O}$	52.0	61.72	"
39.4	59.75	"	53.5	61.82	"
42.2	60.23	"	53.6	61.92	"
44.2	60.53	"	54.0	61.96	"
45.9	60.68	"	55.2	62.32	"
47.5	61.03	"	55.7	62.40	"
47.8	61.08	"	56.4	62.54	"
48.0	61.01	"	57.8	62.60	"
48.2	61.05	"	60.2	62.85	"
48.5	—	+ $\text{MgCr}_2\text{O}_7\cdot 5\text{H}_2\text{O}$	70.0	64.39	"
49.4	61.35	$\text{MgCr}_2\text{O}_7\cdot 5\text{H}_2\text{O}$	78.6	66.53	"
49.8	61.40	"	80.0	66.51	"
50.4	61.44	"	81.7	67.21	"
51.0	61.57	"	89.4	—	+ $\text{MgCr}_2\text{O}_7\cdot \text{H}_2\text{O}$

\*Hartford, 1956; density 1.712

\*metastable



**Mg MAGNESIUM****SOLUBILITY IN ALCOHOL**

Approximately 200 gms.  $\text{MgCrO}_4 \cdot 5\text{H}_2\text{O}$  dissolve in one liter of saturated solution in alcohol at  $25^\circ$  (decomposes). Above  $89.4^\circ$   $\text{MgCr}_2\text{O}_7 \cdot \text{H}_2\text{O}$  is the stable phase.

(Hartford, 1946)

**F MAGNESIUM FLUORIDE  $\text{MgF}_2$** **SOLUBILITY OF MAGNESIUM FLUORIDE IN WATER**

t°	Gms. $\text{MgF}_2$ per liter sat. sol.		Authority
18	0.076	(conductivity method)	(Kohlrausch, 1905)
27	0.084	( " " )	( " 1908)
25	0.130	(analytical method)	(Carter, 1928)

**SOLUBILITY OF MAGNESIUM FLUORIDE IN AQUEOUS SOLUTIONS  
OF HYDROCHLORIC ACID**  
(Tananew and Tchrelschwill, 1936)

Normality of Aq. HCl	Gm. Mols. $\text{MgF}_2$ dissolved per liter	pH of sat. sol.
0.01	0.0036	1.94
0.10	0.0086	1.15
1.00	0.0428	0.25

Melting points have been determined in the following systems:

$\text{MgF}_2 + \text{NaF}$	(Bergman and Dergunov, 1941, 1945; Grube, 1927; Jaisle, 1926; Dergunov and Bergman, 1948)
$\text{MgF}_2 + \text{RbF}$	(Remy and Seeman, 1940; Dergunov and Bergman, 1948)
$\text{MgF}_2 + \text{LiF}$	(Haven, 1950)
$\text{MgF}_2 + \text{MgO} + \text{SiO}_2$	(Ershova and Ol'shanskii, 1957)
$\text{MgF}_2 + \text{Al}_2\text{O}_3 + \text{SiO}_2$	(Ershova, 1957)

**BF MAGNESIUM Hexa Antipyrine FLUOBORATE  $[\text{Mg}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6](\text{BF}_4)_2$** 

100 cc. sat. solution of Magnesium Hexa antipyrine fluoborate in water contain 6.6 gms.  $[\text{Mg}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6](\text{BF}_4)_2$  at  $20^\circ$ .  
(Wilke, Dorfart and Mureck, 1929)

MAGNESIUM FLUOSILICATE  $\text{MgSiF}_6$ 

(See also page 542)

SiF

## SOLUBILITY IN WATER

The results of Simpson and Glocker, 1953 are higher than those of Yatlov and Pinaevskaya, 1938. The more recent determinations were made by matching the density with that of a solution of known concentration.

Y. and P., 1938			S. and G., 1953		
t°	Gms. $\text{MgSiF}_6$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{MgSiF}_6$ per 100 gms. sat. sol.	Solid Phase
- 0.9	5.0	Ice	1.7	21.11	$\text{MgSiF}_6 \cdot 6\text{H}_2\text{O}$
- 2.2	10.0	"	10	22.63	"
- 3.8	15.0	"	18.3	24.07	"
- 6.0	19.5	" + $\text{MgSiF}_6 \cdot 6\text{H}_2\text{O}$	26.7	25.30	"
0	20.85	$\text{MgSiF}_6 \cdot 6\text{H}_2\text{O}$	35	26.41	"
+20	23.53	"	43.3	27.48	"
	23.00(*)	"	51.7	28.45	"
40	25.86	"	60	29.39	"
50	28.54	"	68.3	30.20	"
57	28.66	"			
60	30.74	"			

(\*) Worthington and Haring, 1931; density = 1.2399.

SOLUBILITY OF MAGNESIUM FLUOSILICATE IN AQUEOUS  
FLUOSILICIC ACID SOLUTIONS AT 20°  
(Jatlov and Pinaevskaja, 1936)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{H}_2\text{SiF}_6$	$\text{MgSiF}_6$		$\text{H}_2\text{SiF}_6$	$\text{MgSiF}_6$	
0.0	23.53	$\text{MgSiF}_6 \cdot 6\text{H}_2\text{O}$	15.28	8.68	$\text{MgSiF}_6 \cdot 6\text{H}_2\text{O}$
0.97	23.07	"	28.82	2.94	"
1.96	21.84	"	38.30	1.68	"
7.53	16.68	"	46.18	0.20	"

MAGNESIUM Ortho GERMANATE  $\text{Mg}_2\text{GeO}_4$ 

GeO

SOLUBILITY IN WATER AND AQUEOUS SOLUTIONS AT 26°  
(Muller, 1922)

Solvent	Gms. $\text{Mg}_2\text{GeO}_4$ per 100 cc. sat. sol.
Water	0.0016
3 vols. $\text{H}_2\text{O}$ + 2 vols. $\text{NH}_4\text{OH}$	0.002
Aq. 10% $(\text{NH}_4)_2\text{SO}_4$ + excess $\text{NH}_4\text{OH}$	0.013

## Mg MAGNESIUM

### I MAGNESIUM IODIDE $\text{MgI}_2$

#### SOLUBILITY IN WATER (Menschutkin, 1905, 1907)

The salt was prepared by the action of water upon magnesium iodide dietherate by which the octahydrate and not the hexahydrate is formed. The crystals of this hydrate melt at  $43.6^\circ$ . The solubility determinations were made by the synthetic method.

t°	Gms. per 100 Gms. Sat. Solution		Solid Phase
	$\text{MgI}_2 \cdot 6\text{H}_2\text{O}$	= $\text{MgI}_2$	
0	76.0	54.7	$\text{MgI}_2 \cdot 8\text{H}_2\text{O}$
18	--	59.7*	"
20	81.0	58.3	"
40	88.0	63.4	"
43.5 tr. pt.	90.8	65.4	" + $\text{MgI}_2 \cdot 6\text{H}_2\text{O}$
43	89.8	64.7	$\text{MgI}_2 \cdot 6\text{H}_2\text{O}$
80	90.3	65.0	"
120	90.9	65.4	"
160	91.7	66.0	"
200	93.4	67.2	"
215	94.3	67.9	"

\*Mylius and Funk,  $d = 1.909$

### I MAGNESIUM IODIDE DIETHERATE $\text{MgI}_2 \cdot 2(\text{C}_2\text{H}_5)_2\text{O}$

This compound was studied in detail by B. N. Menschutkin. (Monograph in the Russian Language entitled "On Etherates and Other Molecular Combinations of Magnesium Bromide and Iodide," St. Petersburg, 1907, pp. 267 + XLVIII. Also published in "Memoirs of the St. Petersburg Polytechnic Institute," vols. 1-7, 1904-07 and in condensed form in vols. 49-67 of the Zeit. anorg. Chem., 1906-09.)

Preparation of Material. The dietherate of magnesium iodide,  $\text{MgI}_2 \cdot 2(\text{C}_2\text{H}_5)_2\text{O}$  was prepared by the very gradual addition of iodine to a mixture of magnesium and dry ether. The reaction is not so violent as that which takes place during the preparation of the magnesium bromide dietherate. Two liquid layers are present at the end of the reaction and by slight cooling beautiful white needle-like crystals separate from the lower one. The growth of these crystals is also accompanied, as in the case of the magnesium bromide compound, by an evolution of either droplets. Magnesium iodide dietherate is very hygroscopic, it is less stable than magnesium bromide dietherate, and becomes yellowish even after several hours, and brown after a day, owing probably to separation of iodine. As in the case of the magnesium bromide compound it reacts with very many organic compounds as alcohols, acids, ketones, etc., with liberation of ether and formation of addition products. These latter constitute the material used for the solubility studies.

Explanation of Results. As is seen from the following table, the solubility increases much more rapidly with temperature than in the case of magnesium bromide dietherate, especially in the vicinity of the melting point of  $\text{MgI}_2 \cdot 2(\text{C}_2\text{H}_5)_2\text{O}$  under its ethereal solution, which is at

23.6°. At this temperature there appears two layers, the lower one of which may be considered as a solution of ether in dietherate, and the upper one as a solution of the lower layer in ether. By increase of temperature a point is reached, at which both layers are miscible in all proportions (critical point). In the case of magnesium bromide dietherate no such critical point could be obtained. Both layers may be cooled below 23.6°, but only to about +15° since here spontaneous crystallization of the dietherate almost always occurs, and the temperature rises to 23.6°. The great tendency to crystallize is probably due to the difference between the composition of the lower layer and of the saturated solution of the dietherate. The determinations in the vicinity of the critical point were quite difficult to make on account of the considerable opalescence which occurred and also the formation of a white substance, the nature of which was not ascertained. The critical concentration, as determined by means of the law of straight averages of Caillietet and Mathias, was approximately 40.3 percent  $\text{MgI}_2 \cdot 2(\text{C}_2\text{H}_5)_2\text{O}$ ; the temperature, 38.5°. At concentrations of  $\text{MgI}_2 \cdot 2\text{C}_4\text{H}_{10}\text{O}$  greater than 54 percent, a single liquid is again formed and the solubility curve can be followed up to the melting point of the dietherate at 51°.

The more recent work of Stewart and Ubbelohde, 1949 is in excellent agreement with Menschutkin's. S. and U. used nitrogen atmospheres, and kept the mixtures in the dark to prevent photodecomposition.

#### SOLUBILITY OF MAGNESIUM IODIDE DIETHERATE IN ETHER

(Solid Phase  $\text{MgI}_2 \cdot 2(\text{C}_2\text{H}_5)_2\text{O}$  throughout)

<u>Menschutkin</u>		<u>Stewart and Ubbelohde</u>	
t°	Gms. $\text{MgI}_2$ per 100 gms. sat. sol.	t°	Gms. $\text{MgI}_2$ per 100 gms. sat. sol.
5.4	1.45	0.0	1.21
11.8	2.43	4.0	1.35
15.6	3.46	8.0	1.75
18.1	5.40	11.0	2.25
20.4	7.55	12.6	2.58
22.2	11.28	14.4	3.22
23.6	14.40	16.6	4.02
	*	18.5	5.23
	35.5	20.0	6.78
25	47.6		
30	54.0		
35	57.0		
40	58.6		
45	61.2		
51.5 m. pt.	65.2		

\*Between these two concentrations of  $\text{MgI}_2 \cdot 2(\text{C}_2\text{H}_5)_2\text{O}$  two liquid layers separate (see below).

# Mg MAGNESIUM

At 23.6° the saturated solution separates into two liquid layers which have the following composition at different temperatures. (Menschutkin)

	Gms. per 100 Gms. Solution					
t°	Lower Layer		Upper Layer			
	MgI <sub>2</sub> ·2(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O =	MgI <sub>2</sub>	MgI <sub>2</sub> ·2(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O =	MgI <sub>2</sub>		
15	54.4	35.5	20.5	13.4		unstable
20	54.4	35.5	21.5	14.1		"
25	54.4	35.5	22.5	14.7		stable
30	54.4	35.5	23.5	15.4		"
35	54.1	35.3	26.0	17.0		"
36	53.5	34.9	27.0	17.7		"
37	52.2	34.2	28.5	18.7		"
38	50.5	33.1	32.0	21.0		"
38.5*	40.3	26.3	40.3	26.3		

\*crit. temp.

For data in the system  $\text{MgI}_2 - (\text{C}_2\text{H}_5)_2\text{O} - \text{CH}_3\text{MgI}$  see Stewart and Ubbelohde, 1949.

## MAGNESIUM IODIDE ALCOHOLATES and ANILINATE

SOLUBILITY OF EACH IN THE RESPECTIVE ALCOHOLS OR ANILINE (Menschutkin, 1907)

$\text{MgI}_2 \cdot 6\text{CH}_3\text{OH}$ in Methyl Alcohol		$\text{MgI}_2 \cdot 6\text{C}_2\text{H}_5\text{OH}$ in Ethyl Alcohol		$\text{MgI}_2 \cdot 6\text{C}_6\text{H}_5\text{NH}_2$ in Aniline		$\text{MgI}_2 \cdot 6(\text{CH}_3)_2\text{CHOH}$ in Dimethyl Carbinol	
Gms. $\text{MgI}_2 \cdot 6\text{CH}_3\text{OH}$ per 100 Gms.		Gms. $\text{MgI}_2 \cdot 6\text{C}_2\text{H}_5\text{OH}$ per 100 Gms.		Gms. $\text{MgI}_2 \cdot 6\text{C}_6\text{H}_5\text{NH}_2$ per 100 Gms.		Gms. $\text{MgI}_2 \cdot 6(\text{CH}_3)_2\text{CHOH}$ per 100 Gms.	
t°	Sat. Sol.	t°	Sat. Sol.	t°	Sat. Sol.	t°	Sat. Sol.
0	49.6	0	21.9	0	3.3	10	57.1
20	52.6	20	33.2	60	3.9	30	60.0
40	55.3	40	44.4	100	5.0	50	63.3
60	58.8	60	55.3	130	8.5	70	67.0
80	60.6	80	65.5	150	17.5	90	71.2
100	63.3	100	74.7	170	38.0	110	76.2
120	66.2	120	82.7	180	52.0	120	79.4
140	69.5	130	87.2	188†	64.5	130	84.8
160	73.2	140	93.3	200	65.9*	136	91.7
180	77.1	143	96.0	210	67.2*	138†	100
200	81.5	146.5†	100	230	69.8*		

\*Solid Phase,  $\text{MgI}_2 \cdot 4\text{C}_6\text{H}_5\text{NH}_2$

†m. pt.

†tr. pt.

## MAGNESIUM IODIDE COMPOUNDS with CARBONYL COMPOUNDS

SOLUBILITY OF MAGNESIUM IODIDE COMPOUNDS WITH BENZALDEHYDE,  
ACETONE, ACETAL, AND ACETIC ACID IN EACH OF THESE LIQUIDS  
(Menschutkin)

Because of the great hygroscopicity, etc., the solubility determinations are not strictly accurate in all cases.

<u>MgI<sub>2</sub>·6C<sub>6</sub>H<sub>5</sub>COH</u> <u>in Benzaldehyde</u>		<u>MgI<sub>2</sub>·6CH<sub>3</sub>COCH<sub>3</sub></u> <u>in Acetone</u>	
t°	Gms. MgI <sub>2</sub> ·6C <sub>6</sub> H <sub>5</sub> COH per 100 Gms. Sat. Sol.	t°	Gms. MgI <sub>2</sub> ·6CH <sub>3</sub> COCH <sub>3</sub> per 100 Gms. Sat. Sol.
0	3.2	0	4.9
20	3.8	20	5.95*
40	5.3	30	6.7
60	7.7	50	8.3
80	11.0	60	10.2
100	18.5	70	15.2
110	26.5	80	28.6
120	40.0	85	40.0
125	53.0	90	59.2
130	74.5	95	80.0
136	94.2	100	92.5
139 m. pt.	100	105	98.5
		106.5 m. pt.	

\*Altaba, 1951

<u>MgI<sub>2</sub>·2CH<sub>3</sub>CH(OC<sub>2</sub>H<sub>5</sub>)<sub>2</sub></u> <u>in Acetal</u>		<u>MgI<sub>2</sub>·6CH<sub>3</sub>COOH</u> <u>in Acetic Acid</u>	
t°	Gms. MgI <sub>2</sub> ·2CH <sub>3</sub> CH(OC <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> per 100 Gms. Sat. Sol.	t°	Gms. MgI <sub>2</sub> ·6CH <sub>3</sub> COOH per 100 Gms. Sat. Sol.
20	0.15	20	0.6
60	0.45	40	2.0
77	0.60	60	5.0
(Between these two concentrations the mixture separates into two liquid layers.)		70	9.5
		80	18.5
		95	42.0
77	92.0	105	54.5
79	93.7	115	65.0
81	95.5	125	73.8
83	97.3	135	85
86 m. pt.	100	140	94
		142 m. pt.	100

# Mg MAGNESIUM

## SOLUBILITY OF MAGNESIUM IODIDE COMPOUNDS WITH FORMIC AND ACETIC ACID ESTERS IN THE RESPECTIVE ESTERS (Menschutkin)

### MgI<sub>2</sub>·6HCOOC<sub>2</sub>H<sub>5</sub> in Ethyl Formate

t°	Gms. MgI <sub>2</sub> ·6HCOOC <sub>2</sub> H <sub>5</sub> per 100 Gms. Sat. Sol.
0	15.1
10	17.4
20	20.5
30	25.0
40	31.8
50	44
60	68
70.5 m. pt.	100

### MgI<sub>2</sub>·6CH<sub>3</sub>COOCH<sub>3</sub> in Methyl Acetate

t°	Gms. MgI <sub>2</sub> ·6CH <sub>3</sub> COOCH <sub>3</sub> per 100 Gms. Sat. Sol.
0	0.4
60	0.75
90	0.9
100	1.8
103	2.4
(Two layers here.)	
103	74.2
110	81.7
120	98
121 m. pt.	100

### MgI<sub>2</sub>·6CH<sub>3</sub>COOC<sub>2</sub>H<sub>5</sub> in Ethyl Acetate

t°	Gms. MgI <sub>2</sub> ·6CH <sub>3</sub> COOC <sub>2</sub> H <sub>5</sub> per 100 Gms. Sat. Sol.
0	3.2
20	4.8
40	8.6
50	13.7
55	21.5
60	38.0
65	63.5
70	90.5
75	92.7
78.5 m. pt.	100

### MgI<sub>2</sub>·6CH<sub>3</sub>COOC<sub>3</sub>H<sub>7</sub> in Propyl Acetate

t°	Gms. MgI <sub>2</sub> ·6CH <sub>3</sub> COOC <sub>3</sub> H <sub>7</sub> per 100 Gms. Sat. Sol.
0	4.1
20	5.4
30	6.5
35	7.8
40	19.0
45	46.0
50	72.5
55	88.2
60	96
65 m. pt.	100

### MgI<sub>2</sub>·6CH<sub>3</sub>COO(Iso)C<sub>4</sub>H<sub>9</sub> in Isobutyl Acetate

t°	Gms. MgI <sub>2</sub> ·6CH <sub>3</sub> COO(Iso)C <sub>4</sub> H <sub>9</sub> per 100 Gms. Sat. Sol.
0	10.5
20	13.6
40	17.6
60	24.9
70	33.7
80	52
85	89
87.5 m. pt.	100

### MgI<sub>2</sub>·6CH<sub>3</sub>COO(iso)C<sub>5</sub>H<sub>11</sub> in Isocamyl Acetate

t°	Gms. MgI <sub>2</sub> ·6CH <sub>3</sub> COO(iso)C <sub>5</sub> H <sub>11</sub> per 100 Gms. Sat. Sol.
0	7.7
20	11.5
40	20.9
45	25.5
50	33.2
55	47.8
57.5	63
60 m. pt.	• 100

SOLUBILITY OF MAGNESIUM IODIDE COMPOUNDS WITH ACETONITRILE,  
ACETAMIDE AND URETHAN IN THESE LIQUIDS  
(Menschutkin)

<u>MgI<sub>2</sub>·6CH<sub>3</sub>CN</u> <u>in Acetonitrile</u>		<u>MgI<sub>2</sub>·6CH<sub>3</sub>CONH<sub>2</sub></u> <u>in Acetamide</u>		Solid Phase
t°	Gms. MgI <sub>2</sub> ·6CH <sub>3</sub> CN per 100 Gms. Sat. Sol.	t°	Gms. MgI <sub>2</sub> ·6CH <sub>3</sub> CONH <sub>2</sub> per 100 Gms. Sat. Sol.	
0	37.2	82 m.pt. of acetamide		
30	49.8	70	28.0	CH <sub>3</sub> CONH <sub>2</sub>
50	58.2	58	46.7	"
70	67.9	49*	56.5	" + MgI <sub>2</sub> ·6CH <sub>3</sub> CONH <sub>2</sub>
75	71.7	80	63.4	MgI <sub>2</sub> ·6CH <sub>3</sub> CONH <sub>2</sub>
80	76.5	130	76.0	"
85	83.0	160	85.5	"
89	91.3	170	90.8	"
		177†	100	"
*Eutec.	†m. pt.			

MgI<sub>2</sub>·6NH<sub>3</sub>COOC<sub>2</sub>H<sub>5</sub> in Urethan

t°	Gms. MgI <sub>2</sub> ·6NH <sub>3</sub> COOC <sub>2</sub> H <sub>5</sub> per 100 Gms. Sat. Sol.	Solid Phase
49 m. pt. of urethan		
45	27.5	NH <sub>3</sub> COOC <sub>2</sub> H <sub>5</sub>
39	45.0	"
32*	51.8	" + MgI <sub>2</sub> ·NH <sub>3</sub> COOC <sub>2</sub> H <sub>5</sub>
40	55.0	MgI <sub>2</sub> ·NH <sub>3</sub> COOC <sub>2</sub> H <sub>5</sub>
60	64.7	"
80	78.8	"
86	92.5	"
87†	100	"
*Eutec.	†m. pt.	

100 gms. sat. solution of Magnesium Iodide in Liquid Ammonia contain 0.156 gm. MgI<sub>2</sub> at 0°.

(Linhard and Stephan, 1933, 1934)

Melting points in the systems MgI<sub>2</sub> + KI and MgI<sub>2</sub> + NaI are given by Beyersdorfer and Oryschkewitsch (1948) and by Klemm (1948).

**MAGNESIUM IODOMERCURATE MgI<sub>2</sub>·2HgI<sub>2</sub>·7H<sub>2</sub>O**

The sat. solution in water at 17.8° has the composition MgI<sub>2</sub>·1.29HgI<sub>2</sub>·11.06 H<sub>2</sub>O and Sp. Gr. 2.92.

(Duboin, 1906)



# Mg MAGNESIUM

## 10 MAGNESIUM IODATE $\text{Mg}(\text{IO}_3)_2$

### SOLUBILITY OF MAGNESIUM IODATE IN WATER (Hill and Moskowitz, 1931)

The previous determinations of Mylius and Funk, 1897, 1900, are shown to be incomplete.

t°	d. of sat. sol.	Gms. $\text{Mg}(\text{IO}_3)_2$ per 100 gms. sat. sol.	Solid Phase
- 0.36	1.026	3.18	Ice + Mg10
- 5.0	1.034	4.39	Mg10
10.0	1.049	5.87	"
15.0	1.073	7.79*	"
13.3 tr. pt.	--	--	" + Mg4
5.0	1.047	6.09*	Mg4
10.0	1.060	6.68*	Mg4
15.0	1.065	7.29	"
25	1.075	8.55	"
35	1.086	9.83	"
40	1.090	10.51	"
50	1.115	12.05	"
57.5	--	13.1	" + $\text{Mg}(\text{IO}_3)_2$
70	--	15.7*	"
90	--	19.6*	"
60	---	13.2	$\text{Mg}(\text{IO}_3)_2$
70	--	13.3	"
80	--	13.4	"
90	--	13.5	"

\*Metastable; Mg10 =  $\text{Mg}(\text{IO}_3)_2 \cdot 10\text{H}_2\text{O}$ ; Mg4 =  $\text{Mg}(\text{IO}_3)_2 \cdot 4\text{H}_2\text{O}$ .

### THE SYSTEM MAGNESIUM IODATE - IODIC ACID - WATER AT 25° (Ricci and Freedman, 1952a)

High densities and viscosities made sampling difficult, and the invariant point (or points) was not determined.

Gms. per 100 gms. sat. sol.		Density	Solid Phase	Gms. per 100 gms. sat. sol.		Density	Solid Phase
$\text{Mg}(\text{IO}_3)_2$	$\text{HIO}_3$			$\text{Mg}(\text{IO}_3)_2$	$\text{HIO}_3$		
8.55	0.0	1.079	M	24.92	45.17	--	M
11.04	10.04	1.217	M	24.81	47.71	--	M
12.68	13.99	1.301	M	11.21	66.85	--	A
16.93	21.38	1.456	M	6.69	70.37	2.57	A
21.03	29.61	1.695	M	3.22	72.71	2.55	A
24.28	36.63	1.978	M	0.0	75.32	2.49	A

M =  $\text{Mg}(\text{IO}_3)_2 \cdot 4\text{H}_2\text{O}$

A =  $\text{HIO}_3$

THE SYSTEM MAGNESIUM IODATE - MAGNESIUM NITRATE - WATER  
(Hill and Moskowitz, 1931)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	Mg(NO <sub>3</sub> ) <sub>2</sub>	Mg(IO <sub>3</sub> ) <sub>2</sub>			Mg(NO <sub>3</sub> ) <sub>2</sub>	Mg(IO <sub>3</sub> ) <sub>2</sub>	
Results at 5°				Results at 25° (Cont.)			
1.034	0.0	4.39	Mg10	1.202	18.48	5.14	Mg4
1.053	2.49	3.93	"	1.261	25.81	4.20	"
1.076	5.45	3.92	"	1.325	33.50	3.25	"
1.105	8.86	4.03	"	1.398	41.00	2.46	" + Mg6
1.149	13.10	4.26	"	1.380	41.60	0.90	Mg6
1.184	17.0	4.55	" + Mg4	1.378	42.03	0.0	"
1.197	18.52	4.44	Mg4	Results at 50°			
1.244	24.08	3.95	"				
1.333	34.21	2.82	"	1.115	0.0	12.05	Mg4
1.368	38.10	2.39	" + Mg6	1.141	7.29	9.00	"
1.352	39.02	0.46	Mg6	1.186	15.17	7.31	"
1.347	39.25	0.0	"	1.253	24.35	5.58	"
Results at 25°				1.321	32.15	4.36	"
				1.368	38.82	3.57	"
1.075	0.0	8.55	Mg4	--	44.41	3.13	" + Mg6
1.089	3.49	7.35	"	--	45.27	1.52	Mg6
1.116	7.31	6.66	"	--	46.09	0.0	"
1.171	14.60	5.66	"	--			

Mg4 = Mg(IO<sub>3</sub>)<sub>2</sub>·4H<sub>2</sub>O; Mg6 = Mg(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O; Mg10 = Mg(IO<sub>3</sub>)<sub>2</sub>·10H<sub>2</sub>O

THE SYSTEM MAGNESIUM IODATE - SODIUM IODATE - WATER  
(Hill and Ricci, 1931)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	NaIO <sub>3</sub>	Mg(IO <sub>3</sub> ) <sub>2</sub>			NaIO <sub>3</sub>	Mg(IO <sub>3</sub> ) <sub>2</sub>	
Results at 5°				Results at 25° (Cont.)			
1.038	0.0	4.37	Mg10	1.119	7.77	4.76	NaIO <sub>2</sub> ·H <sub>2</sub> O
1.047	1.45	3.74	"	1.102	7.94	2.99	"
1.055	2.53	3.33	" + Na5	1.081	8.30	1.18	"
1.043	2.68	2.19	Na5	1.076	8.57	0.00	"
1.028	3.28	0.0	"	Results at 50°			
Results at 25°				--	0.0	11.97	Mg4
1.078	0.0	8.54	Mg4	--	4.59	9.95	"
1.091	2.80	7.24	"	--	8.94	8.41	"
1.113	6.16	6.05	"	--	11.97	7.67	" + NaIO <sub>3</sub> ·H <sub>2</sub> O
1.125	7.49	5.86	" + NaIO <sub>3</sub> ·H <sub>2</sub> O	--	12.42	4.93	NaIO <sub>3</sub> ·H <sub>2</sub> O
1.128	7.66	5.73*	"	--	13.05	3.73	"
1.139	8.79	5.57*	" + NaIO <sub>3</sub>	--	13.26	3.05	"
1.134	8.74	5.42*	NaIO <sub>3</sub>	--	13.27	2.64	"
1.121	7.52	5.40	NaIO <sub>3</sub> ·H <sub>2</sub> O	--	13.54	1.55	"
1.122	7.50	5.33	"	--	13.49	0.00	"

Mg4 = Mg(IO<sub>3</sub>)<sub>2</sub>·4H<sub>2</sub>O; Mg10 = Mg(IO<sub>3</sub>)<sub>2</sub>·10H<sub>2</sub>O; Na5 = NaIO<sub>3</sub>·5H<sub>2</sub>O

# Mg MAGNESIUM

## MoO MAGNESIUM MOLYBDATE $\text{MgMoO}_4$

### SOLUBILITY OF MAGNESIUM MOLYBDATE IN WATER (Ricci and Linke, 1951)

t°	Gms. $\text{MgMoO}_4$ per 100 gms. Sat. Sol.	Density	Solid Phase	t°	Gms. $\text{MgMoO}_4$ per 100 gms. Sat. Sol.	Density	Solid Phase
-0.45	3.94	--	Ice	45	17.74	1.178	5
-0.75	6.28	--	"	50	18.40	1.180	5
-1.25	9.38	--	"	55	19.00	1.185	5
-1.67	11.55*	1.111	Ice+7	58	19.48	1.184	5
5	12.94	1.127	7	59	19.55	1.192	5
7	13.50	1.135	7	62 <sup>m</sup>	19.90	1.195	5
10	14.31	1.143	7	60.8	19.85*	1.192	5 + 2
11	14.61	1.145	7	60 <sup>m</sup>	19.96	1.196	2
12.7	15.15*	1.151	7 + 5	63	19.12	1.182	2
5 <sup>m</sup>	14.43	1.143	5	64	18.83	1.177	2
10 <sup>m</sup>	14.85	1.147	5	71	16.51	1.149	2
15	15.26	1.151	5	72	16.13	1.147	2
20	15.59	1.150	5	75	15.30	1.141	2
25	15.90	1.159	5	80	13.70	1.121	2
30	16.29	1.161	5	85	12.09	1.096	2
36	16.89	1.160	5	90	10.78	1.087	2
43	17.63	1.160	5	95	9.38	1.072	2

<sup>m</sup> = metastable; 7 =  $\text{MgMoO}_4 \cdot 7\text{H}_2\text{O}$ ; 5 =  $\text{MgMoO}_4 \cdot 5\text{H}_2\text{O}$ ; 2 =  $\text{MgMoO}_4 \cdot 2\text{H}_2\text{O}$ ;  
\* = Extrapolated.

### THE SYSTEM MAGNESIUM MOLYBDATE - MAGNESIUM CHLORIDE - WATER AT 25° (Ricci and Linke, 1951)

Gms. per 100 gms. Sat. Sol.		Density	Solid Phase	Gms. per 100 gms. Sat. Sol.		Density	Solid Phase
$\text{MgMoO}_4$	$\text{MgCl}_2$			$\text{MgMoO}_4$	$\text{MgCl}_2$		
15.90	0.0	1.159	M5	0.58	26.83	1.235	Mg + M2
12.84	2.03	1.143	M5	.63	27.52	1.234	M2
10.07	4.29	1.128	M5	.52	28.03	--	M2
7.14	7.54	1.131	M5	.39	29.29	1.258	M2
4.06	11.58	1.141	M5	.31	30.37	--	M2
2.75	15.36	1.156	M5	.30	31.25	1.278	M2
1.55	19.30	1.179	M5	.26	32.29	1.293	M2
0.91	24.20	1.216	M5	.12	33.34	1.279	M2
.83	24.25	--	M5	.10	34.53	1.312	M2
.78	25.63	1.231	M5	.15	35.53	1.324	M2+ Cl6
.67	26.34	1.229	M5	0.0	35.71	1.323	Cl6

M5 =  $\text{MgMoO}_4 \cdot 5\text{H}_2\text{O}$

M2 =  $\text{MgMoO}_4 \cdot 2\text{H}_2\text{O}$

Cl6 =  $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$

THE SYSTEM MAGNESIUM MOLYBDATE - MAGNESIUM SULFATE - WATER AT 25°  
(Ricci and Linke, 1951)

Gms. per 100 gms. sat. sol.		Density	Solid Phase	Gms. per 100 gms. sat. sol.		Density	Solid Phase
MgMoO <sub>4</sub>	MgSO <sub>4</sub>			MgMoO <sub>4</sub>	MgSO <sub>4</sub>		
15.90	0.0	1.159	M	6.42	20.72	1.292	M
14.70	2.91	1.176	M	5.06	23.76	1.313	M + S
13.28	6.06	1.198	M	4.51	24.02	1.305	S
12.08	8.79	1.218	M	3.70	24.65	1.296	S
10.76	11.54	1.230	M	3.20	24.78	1.295	S
9.20	14.64	1.254	M	2.26	25.33	1.291	S
7.63	18.03	1.271	M	0.0	26.67	1.278	S

M = MgMoO<sub>4</sub>·5H<sub>2</sub>OS = MgSO<sub>4</sub>·7H<sub>2</sub>O

MoO

THE SYSTEM MAGNESIUM MOLYBDATE - SODIUM MOLYBDATE - WATER AT 25°  
(Ricci and Linke, 1951)

Gms. per 100 gms. sat. sol.		Density	Solid Phase	Gms. per 100 gms. sat. sol.		Density	Solid Phase
MgMoO <sub>4</sub>	Na <sub>2</sub> MoO <sub>4</sub>			MgMoO <sub>4</sub>	Na <sub>2</sub> MoO <sub>4</sub>		
15.90	0.0	1.159	M	9.27	17.27	1.271	M + D
13.71	4.84	1.177	M	8.57	17.91	1.272	D
12.09	9.14	1.210	M	7.34	19.15	1.267	D
11.22	11.38	1.220	M	6.94	19.85	1.273	D
11.00	12.10	1.230	M	4.23	23.56	1.285	D
10.69	12.99	1.238	M	1.62	29.30	1.321	D
10.39	13.92	1.248	M	1.57	29.44	1.322	D
10.17	14.68	1.252	M	0.48	34.74	1.373	D
10.03	14.86	1.250	M	.39	35.79	1.387	D
9.84	15.29	1.255	M	.23	37.41	1.401	D
9.44	16.45	1.268	M	.10	38.26	1.419	D
9.26	17.18	1.270	M	.11	39.31	1.429	D + N
8.87 <sup>m</sup>	18.45	1.282	M	0.0	39.38	1.432	N

m = metastable;

M = MgMoO<sub>4</sub>·5H<sub>2</sub>O;N = Na<sub>2</sub>MoO<sub>4</sub>·2H<sub>2</sub>O;D = MgMoO<sub>4</sub>·Na<sub>2</sub>MoO<sub>4</sub>·2H<sub>2</sub>O

# Mg MAGNESIUM

MoO THE SYSTEM  $\text{MgMoO}_4 + \text{Na}_2\text{SO}_4 \rightleftharpoons \text{MgSO}_4 + \text{Na}_2\text{MoO}_4 (+\text{H}_2\text{O})$  at 25°  
(Ricei and Linke, 1951)

Data are also given for quaternary solutions saturated with two solid phases.

Moles per mole of Dissolved Salts					Density	Solid Phase
$\text{MgMoO}_4$	$\text{MgSO}_4$	$\text{Na}_2\text{SO}_4$	$\text{Na}_2\text{MoO}_4$	$\text{H}_2\text{O}$		
			1.0000	17.60	1.432	A
		.3394	.6606	14.67	1.446	A + B
		1.0000		28.70	1.201	B
	.4937	.5063		13.87	1.345	B + F
	.5000	.5000		13.9	1.345	F
	.6766	.3234		13.83	1.349	F + C
	1.0000			18.37	1.278	C
.1222	.8778			17.57	1.313	C + D
1.0000				54.10	1.159	D
.3750			.6250	30.39	1.271	D + E
.0031			.9969	17.56	1.429	E + A
.0037		.3363	.6600	14.69	1.442	A + B + E
.1793	.2529	.5678		15.26	1.358	B + D + E
.1133	.3781	.5086		13.74	1.376	B + D + F
.0759	.6164	.3077		13.63	1.375	C + D + F

A =  $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$   
 B =  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$   
 C =  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$   
 D =  $\text{MgMoO}_4 \cdot 5\text{H}_2\text{O}$   
 E =  $\text{MgMoO}_4 \cdot \text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$   
 F =  $\text{MgSO}_4 \cdot \text{Na}_2\text{SO}_4 \cdot 4\text{H}_2\text{O}$

# NO MAGNESIUM NITRITE $\text{Mg}(\text{NO}_2)_2$

## SOLUBILITY OF MAGNESIUM NITRITE IN WATER (Bureau, 1936, 1937)

t°	Gms. $\text{Mg}(\text{NO}_2)_2$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{Mg}(\text{NO}_2)_2$ per 100 gms. sat. sol.	Solid Phase
- 3.25	7.04	Ice	- 1.65	31.75	Mg9
-14.03	17.25	"	-10.5 tr.pt.	38.6	" + Mg6
-21.15†	23.2	" + Mg9	16.35	40.9	Mg6
-16.15	24.4	Mg9	25.65	47.0	"
-12.15	26.6	"	29.5 tr.pt.	52.0*	" + Mg3
- 2.15	30.25	"			

†Mg3 =  $\text{Mg}(\text{NO}_2)_2 \cdot 3\text{H}_2\text{O}$ ; Mg6 =  $\text{Mg}(\text{NO}_2)_2 \cdot 6\text{H}_2\text{O}$ ; Mg9 =  $\text{Mg}(\text{NO}_2)_2 \cdot 9\text{H}_2\text{O}$ .

\*At temperatures above the tr. pt. 29.5°, hydrolysis of the salt occurs with rapid decomposition of the solution.

MAGNESIUM NITRATE  $\text{Mg}(\text{NO}_3)_2$ 

NO

SOLUBILITY OF MAGNESIUM NITRATE IN WATER  
(Sievverts and Petzold, 1932; Ewing, Brander, Slichter and  
Griesinger, 1933)

The closely agreeing results of the above investigators made by the freezing-point and direct solubility methods, were plotted and the following values taken from the average curve.

It may be noted that several individual determinations (at  $0^\circ$ ,  $25^\circ$ ) are higher than those listed below. See for example, Urazov and Shevtsova, 1957; Ewing and Klinger, 1935; DiCapua, 1929, etc. in the pages following.

t°	Density	Sat. Sol. Wt. %	Solid Phase	t°	Density	Sat. Sol. Wt. %	Solid Phase
		$\text{Mg}(\text{NO}_3)_2$				$\text{Mg}(\text{NO}_3)_2$	
- 5.0	1.092	12.0	Ice	85	1.484	53.3	Mg6
-10.0	1.150	18.5	"	88	1.515	55.5	"
-15.0	1.202	22.7	"	89.5†	--	58.0	"
-20	1.238	26.5	"	88	--	60.0	"
-25	1.268	29.5	"	85	--	61.5	"
-30	1.295	31.5	"	80	--	63.2	"
-34.1	--	33.4 <sup>m</sup>	"	70	--	65.5	"
-31.6	1.302	32.3	" + Mg9	60	--	66.3	"
-30	--	32.5	Mg9	55.6*	--	67.4	" + Mg2
-25	--	33.7	"	52.5	--	68.0 <sup>m</sup>	"
-20	--	35.2	"	40.5	--	69.0 <sup>m</sup>	"
-15*	--	37.0	" + Mg6	60	--	67.5	Mg2
-33	--	35.5 <sup>m</sup>	Mg6	70	--	68.5	"
-23	--	36.5 <sup>m</sup>	"	80	--	69.5	"
- 8	--	37.5	"	100	--	71.7	"
+ 1.0	1.365	38.5	"	120	--	75.4	"
15	1.379	40.4	"	125	--	77.0	"
25	1.388	42.1	"	129†	--	80.0	"
35	1.399	43.2	"	127.7*	--	81.8	" + $\text{Mg}(\text{NO}_3)_2$
40	1.405	44.1	"	130	--	82.0	$\text{Mg}(\text{NO}_3)_2$
50	1.422	45.8	"	140	--	82.4	"
60	1.445	47.7	"	160	--	83.8	"
75	1.454	50.3	"	186	--	84.6	"
80	1.468	51.5	"				

$\text{Mg2} = \text{Mg}(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O}$ ;  $\text{Mg6} = \text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ ;  $\text{Mg9} = \text{Mg}(\text{NO}_3)_2 \cdot 9\text{H}_2\text{O}$ .

<sup>m</sup> = Metastable.

† = tr. pt.

\* = m. pt.

# Mg MAGNESIUM

## SOLUBILITY OF MAGNESIUM NITRATE IN AQUEOUS SOLUTIONS OF NITRIC ACID AT 25° (Ewing and Klinger, 1933)

Results for this system at 20° and for concentrations of HNO<sub>3</sub> up to 59.38 percent are given by Malquori, 1928.

	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	HNO <sub>3</sub>	Mg(NO <sub>3</sub> ) <sub>2</sub>		HNO <sub>3</sub>	Mg(NO <sub>3</sub> ) <sub>2</sub>		HNO <sub>3</sub>	Mg(NO <sub>3</sub> ) <sub>2</sub>	
NO	0.0	42.5	Mg6	56.7	16.5	Mg6	68.5	19.0	Mg2
	12.6	33.2	"	54.6	20.2	"	77.0	13.0	"
	18.5	28.6	"	40.9	34.3	"	84.4	9.4	"
	28.1	22.1	"	39.6	36.0	"	89.7	6.2	"
	36.7	17.1	"	41.0	36.7	Mg2	91.0	4.7	Mg(NO <sub>3</sub> ) <sub>2</sub>
	45.4	13.2	"	54.8	27.6	"	93.9	3.8	"
	55.4	11.5	"	58.4	25.2	"	99.6	0.2	"

Mg6 = Mg(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O; Mg2 = Mg(NO<sub>3</sub>)<sub>2</sub>·2H<sub>2</sub>O.

## THE SYSTEM MAGNESIUM NITRATE - MAGNESIUM SULFATE - WATER

MN6 = Mg(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O;

MS7 = MgSO<sub>4</sub>·7H<sub>2</sub>O

At 0°  
(Benrath and Benrath, 1930)

At 25°  
(Benrath, 1928, 1929)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	MgSO <sub>4</sub>	Mg(NO <sub>3</sub> ) <sub>2</sub>			MgSO <sub>4</sub>	Mg(NO <sub>3</sub> ) <sub>2</sub>	
1.368	0.0	38.58	MN6	1.397	0.0	42.89	MN6
1.368	0.99	37.65	"	1.396	0.99	41.10	"
1.368	1.38	37.03 <sup>1</sup>	" + MS7	1.399	1.77	40.65	"
1.369	1.48	36.99	" "	1.401	2.28	40.05	"
1.370	1.56	37.04	" "	1.403	2.85	39.79	" + MS7
1.372	1.62	36.80 <sup>2</sup>	" "	1.345	3.90	33.55	MS7
1.290	2.52	28.69	MS7	1.316	5.50	28.49	"
1.230	6.41	17.82	MS7	1.277	10.00	19.06	"
1.216	10.83	10.83	"	1.271	15.90	11.25	"
1.214	11.98	9.17	"	1.271	16.36	10.71	"
1.222	16.58	3.94	"	1.280	20.03	6.68	"
1.224	17.98	2.73	"	1.304	26.68	0.0	"
1.234	19.70	1.09	"				
1.236	20.82	0.0	"				

<sup>1</sup>The solid phase contained 11.99 gm. MgSO<sub>4</sub> + 42.5 gm. Mg(NO<sub>3</sub>)<sub>2</sub> per 100 gms. moist solid.

<sup>2</sup>The solid phase contained 8.36 gm. MgSO<sub>4</sub> + 46.99 gm. Mg(NO<sub>3</sub>)<sub>2</sub> per 100 gms. moist solid.

Previous results at 25°, differing slightly from the above, are given by Jackman and Browne, 1922.

Additional determinations for the system  $\text{Mg}(\text{NO}_3)_2 + \text{MgSO}_4 + \text{H}_2\text{O}$  at 25°, 35°, 41°, 50° and 60° are given by Schroder, 1929; Results at 74.6° by Schroder, 1929a, 1929b; Results at 15°, 50° and 97° by Benrath, 1928, 1929; and Results at 99.5° by Benrath and Benrath, 1930.

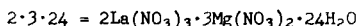
The above named investigators also give very complete data for equilibrium in the reciprocal salt pair,



at the several temperatures indicated above.

THE SYSTEM MAGNESIUM NITRATE - LANTHANUM NITRATE - WATER AT 25°  
(Urazov and Shevtsova, 1957)

NO



Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{La}(\text{NO}_3)_3$	$\text{Mg}(\text{NO}_3)_2$		$\text{La}(\text{NO}_3)_3$	$\text{Mg}(\text{NO}_3)_2$	
67.17	0.00	$\text{La}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$	26.68	25.00	2·3·24
62.00	4.28	Solid Solution	23.15	27.47	"
59.83	5.20	2·3·24	12.61	34.00	"
52.42	10.04	"	10.16	36.37	"
45.00	14.23	"	5.10	40.00	"
41.05	16.82	"	3.03	42.40	"
35.86	18.91	"	3.00	42.52	" + Solid soln.
33.50	20.70	"	0.00	44.73	Solid Solution
31.00	22.54	"	0.00	45.74	$\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$

THE SYSTEM MAGNESIUM NITRATE - MANGANESE NITRATE - WATER AT 20°  
(DiCapua, 1929)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Mn}(\text{NO}_3)_2$	$\text{Mg}(\text{NO}_3)_2$		$\text{Mn}(\text{NO}_3)_2$	$\text{Mg}(\text{NO}_3)_2$	
0.0	43.68	$\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$	27.40	29.0	$\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$
2.88	41.25	"	28.36	27.78	"
7.15	38.00	"	29.15	26.50	" + $\text{Mn}(\text{NO}_3)_2 \cdot 5\text{H}_2\text{O} (?)$
9.90	37.15	"	32.0	24.35	$\text{Mn}(\text{NO}_3)_2 \cdot 5\text{H}_2\text{O}$
12.41	35.40	"	39.92	16.17	"
18.85	31.60	"	44.30	10.05	"
31.30	20.60	"	49.76	6.15	"
26.25	29.92	"	56.81	0.0	"

MAGNESIUM AMMONIUM NITRATE  $\text{Mg}(\text{NO}_3)_2 \cdot 2\text{NH}_4\text{NO}_3$

NO

100 gms.  $\text{H}_2\text{O}$  dissolve 10 gms.  $\text{Mg}(\text{NO}_3)_2 \cdot 2\text{NH}_4\text{NO}_3$  at 12.5°. (Foucroy)



# Mg MAGNESIUM )

## THE SYSTEM MAGNESIUM NITRATE - SODIUM NITRATE - WATER (Jackman and Browne, 1922; Benrath, 1928, 1929; Sieverts and Muller, 1930)

### Results at 25°

The results of the above named investigators were plotted and the following values read from the average curve.

Gms. per 100 gms. sat. solution		Solid Phase	Gms. per 100 gms. sat. solution		Solid Phase
Mg(NO <sub>3</sub> ) <sub>2</sub>	NaNO <sub>3</sub>		Mg(NO <sub>3</sub> ) <sub>2</sub>	NaNO <sub>3</sub>	
42.5 <sup>1</sup>	0.0	Mg(NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O	32.0	12.5	NaNO <sub>3</sub>
41.2	2.0	"	24.0	20.0	"
40.2	4.0	"	16.0	28.8	"
39.4	6.0	"	8.0	38.5	"
38.6	8.0	"	4.0	43.2	"
38.2	9.0	" + NaNO <sub>3</sub>	0.0	48.0	"

### Invariant Points at several temperatures.

t°	d. of sat. sol.	Gms. per 100 gms. sat. solution		Solid Phase
		Mg(NO <sub>3</sub> ) <sub>2</sub>	NaNO <sub>3</sub>	
0	--	35.17	6.59 (5)	Mg(NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O + NaNO <sub>3</sub>
15	1.412	36.62	8.43 (1)	"
"	1.414	36.5	7.7 (2)	"
25	--	38.25	9.22 (3)	"
"	--	38.01	7.72 (5)	"
"	1.441	37.99	9.28 (1)	"
"	1.427	37.8	8.2 (2)	"
50	1.488	42.40	7.92 (1)	"
"	1.463	41.8	8.9 (2)	"
75	1.521	47.9	8.6 (4)	"
"	1.721	66.4	5.5 (4)	Mg(NO <sub>3</sub> ) <sub>2</sub> ·2H <sub>2</sub> O + NaNO <sub>3</sub>
110	--	69.4	10.2 (4)	"

(1) Benrath, 1928, 1929;

(4) Sieverts and Muller, 1931;

(2) Sieverts and Muller, 1930;

(5) Schroder, 1930.

(3) Jackman and Browne, 1922;

## NO MAGNESIUM NEODYMIUM NITRATE 3Mg(NO<sub>3</sub>)<sub>2</sub>·2Nd(NO<sub>3</sub>)<sub>3</sub>·24H<sub>2</sub>O

### SOLUBILITY IN WATER (Friend, 1930)

t°	Gms. 3Mg(NO <sub>3</sub> ) <sub>2</sub> ·2Nd(NO <sub>3</sub> ) <sub>3</sub> ·24H <sub>2</sub> O per 100 gms. sat. sol.		t°	Gms. 3Mg(NO <sub>3</sub> ) <sub>2</sub> ·2Nd(NO <sub>3</sub> ) <sub>3</sub> ·24H <sub>2</sub> O per 100 gms. sat. sol.	
0.4	60.42		48.8	72.50	
0.6	60.84		65.4	77.64	
4.4	61.92		75.6	81.07	
14.2	64.0		87.0	84.35	
17.0	63.81		90.6	86.89	
27.2	67.28		109.0 m. pt.	100.00	
40.6	70.72				

SOLUBILITY IN AQUEOUS  $\text{HNO}_3$  AND  $\text{Mg}(\text{NO}_3)_2$   
(Friend, 1930)

Aqueous Solvent	t°	Gms. $3\text{Mg}(\text{NO}_3)_2 \cdot 2\text{Nd}(\text{NO}_3)_3 \cdot 24\text{H}_2\text{O}$ per 100 gms. sat. sol.
1.0 Normal $\text{HNO}_3$	0.6	57.21
"	14.4 d = 1.499	60.25
"	24.2	63.06
"	77.2	78.26
2.2 Normal $\text{HNO}_3$	15.2	54.49
"	50.2	63.14
5.2 Normal $\text{HNO}_3$	14.8	42.01
"	24.8	45.84
"	74.0	64.40
11.25 Normal $\text{HNO}_3$	14.8 d = 1.357	5.64
"	49.0	30.98
"	78.0	62.47
0.7 Normal $\text{Mg}(\text{NO}_3)_2$	24.8	59.23
1.77 " "	24.4	50.31
saturated "	24.2	2.92

## MAGNESIUM NITRATE ALCOHOLATES

NO

SOLUBILITY OF MAGNESIUM NITRATE IN METHYL AND ETHYL ALCOHOLS  
(Lloyd, Brown, Glynwyn, Bonnell and Jones, 1928)

Results for $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{CH}_3\text{OH}$			Results for $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{C}_2\text{H}_5\text{OH}$		
t°	Gms. $\text{Mg}(\text{NO}_3)_2$ per 100 gms. $\text{CH}_3\text{OH}$	Solid Phase	t°	Gms. $\text{Mg}(\text{NO}_3)_2$ per 100 gms. $\text{C}_2\text{H}_5\text{OH}$	Solid Phase
10	15.7	$\text{Mg}(\text{NO}_3)_2 \cdot 6\text{CH}_3\text{OH}$	0	1.47	$\text{Mg}(\text{NO}_3)_2 \cdot 6\text{C}_2\text{H}_5\text{OH}$
20	17.3	"	20	3.07	"
30	20.9	"	30	5.39	"
40	23.3	"	40	10.86	"
50	26.9	"	50	16.53	"
60	35.0	"	60	24.23	"
			70	34.02	$\text{Mg}(\text{NO}_3)_2$
			80	32.63	"

100 gms. of a saturated solution in furfural contain 0.03 gms.  
 $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ .

(Trimble, 1941)

Melting points in the system  $\text{Mg}(\text{NO}_3)_2 + \text{NaNO}_3$  are given by Janecke,  
1942.

## Mg MAGNESIUM

### NBO MAGNESIUM NIOBATES $Mg(NbO_3)_2$ (meta)

For the metavanadate at 20°,  $K_{sp} = 2.3 \times 10^{-17}$ , as determined with radio tracers.

(Lapitakii and Pchelkin, 1956)

### O MAGNESIUM OXIDE $MgO$

### OH MAGNESIUM HYDROXIDE $Mg(OH)_2$

#### SOLUBILITY IN WATER

According to Gjalbaek, 1925, magnesium hydroxide exists in two well defined modifications of which the more easily soluble is the labil form and the more difficultly soluble is the stable form. The labil form is obtained by precipitating magnesium salts with bases, by hydration of magnesium oxide and by replacement between metallic magnesium and water. The stable magnesium hydroxide is formed from the labil. The change (recrystallization) goes quickly at high magnesium concentrations and slower at lower concentrations.

The following comparative results are reported. Temp. 18°.

Method	Minimum Solubility (stable)	Maximum Solubility (labil)
Direct solubility determination	$2.2 \times 10^{-4}$	$6.5 \times 10^{-4}$
$Mg^{++} + 2NH_4OH \rightleftharpoons Mg(OH)_2 + NH_4^+$	$1.9 \times 10^{-4}$	$5.5 \times 10^{-4}$
Conductivity method	$(1.35 \times 10^{-4})$	$4.6 \times 10^{-4}$
Electrometric method	$1.6 \times 10^{-4}$	$7.0 \times 10^{-4}$

A further comparison of the solubilities of naturally occurring and freshly precipitated  $Mg(OH)_2$  was made by Quatarol and Belfiori, 1941. Aging decreases the solubility of the precipitate.

For P-T equilibrium data in the system  $MgO - H_2O$  see Roy and Roy, 1957.

Results at Several Temperatures.

The data of various authors is in only fair agreement, see above. Travers and Nouvel, 1929 (TN) used crystalline  $\text{Mg}(\text{OH})_2$  and the determinations were made in a copper flask or copper lined autoclave at higher pressures. The dissolved magnesia was determined by the electrometric method (hydrogen electrode) and also by direct titration using phenol red as indicator and operating in an atmosphere free of  $\text{CO}_2$ . Remy and Kuhlmann, 1924 (RK) prepared a saturated solution by agitating freshly ignited  $\text{MgO}$  with conductivity water for 4 hours, taking great care to exclude  $\text{CO}_2$ . Conductimetric analyses were made. Oka, 1940 (O) made potentiometric titrations. Other data are by Busch, 1927 (B), Makarov and Vol'nov, 1954 (MV), Whitby, 1933 (W), Gjalbaek, 1925 (G), Kohbranch (K), Nasanen, 1941 (N), Feitknecht and Studer, 1949 (FS).

$t^\circ$	Moles $\text{Mg}(\text{OH})_2$		Author	$t^\circ$	Moles $\text{Mg}(\text{OH})_2$		Author
	per liter	sat. sol.			per liter	sat. sol.	
0	0.00005		MV	45	0.000150		TN
18	0.000168		TN	70-75	0.000118		TN
	0.00035 - 40		RK	100	0.000072		TN
	0.0002		K	110	0.000074		TN
25	0.00011		O	142	0.000042		TN
	0.000197		N, FS	150	0.000037		TN
	0.00046		W	158	0.000031		TN
	0.000214		B	178	0.000090		TN
35	0.000169		TN				

## SOLUBILITY OF MAGNESIUM HYDROXIDE IN SALT SOLUTIONS

In aq.  $\text{NH}_3$  +  $\text{NH}_4\text{Cl}$  at  $18^\circ$ 

(Fredholm, 1934)

Paraffined flasks were used and  $\text{CO}_2$  carefully excluded. In order to approach equilibrium from both sides a part of the mixtures were prepared by adding  $\text{NH}_3$  and  $\text{NH}_4\text{Cl}$  to aqueous  $\text{MgCl}_2$  solutions and the others (last three in table) by adding an excess of carefully prepared  $\text{Mg}(\text{OH})_2$  to  $\text{NH}_4\text{Cl}$  solutions. The solutions were shaken from 2 to 8 days. The clear saturated solutions were analyzed for  $\text{Mg}$ ,  $\text{NH}_3$ , and  $\text{NH}_4^+$ .

Gm. Mols. per liter			Gm. Mols. per liter		
$\text{NH}_3$	$\text{NH}_4^+$	Mg	$\text{NH}_3$	$\text{NH}_4$	Mg
0.0637	0.0409	0.0317	0.0357	0.0167	0.0175
0.0369	0.0228	0.0338	0.1024	0.0952	0.0512
0.0308	0.0220	0.0410	0.0577	0.0411	0.0289
0.0760	0.0285	0.0120	0.0391	0.0201	0.0196

In aq.  $\text{NaOH}$  +  $\text{NaCl}$  at room temperature

(Maigret, 1905)

Gms. $\text{MgO}$ per Liter Solution with Added:		
Gms. $\text{NaCl}$ per Liter	0.8 g. $\text{NaOH}$ per Liter	4.0 g. $\text{NaOH}$ per Liter
125	0.07	0.03
140	0.045	—
160	none	none

# Mg MAGNESIUM

## SOLUBILITY OF MAGNESIUM HYDROXIDE IN SALT SOLUTIONS--Cont.

### In aq. $\text{MgCl}_2$ at $30^\circ$

(Lukens, 1932)

Magnesium oxide dissolves in aqueous  $\text{MgCl}_2$  solutions with subsequent precipitation of a compound of the composition  $5\text{MgO} \cdot \text{MgCl}_2 \cdot x\text{H}_2\text{O}$ . The rate of the reaction is influenced by the previous heat treatment of the  $\text{MgO}$  and the temperature at which the reaction occurs. The compound initially precipitated is transformed by continued contact with  $\text{MgCl}_2$  solutions of Sp. Gr. above 1.16, to a new compound,  $5\text{MgO} \cdot \text{MgCl}_2 \cdot y\text{H}_2\text{O}$ , containing a different amount of water. The water content,  $x$  and  $y$ , of these compounds could not be determined.

O

OH In previous studies of this system at  $25^\circ$  and at  $50^\circ$  by Maeda and Yarmane, 1928, the authors reported the composition of the compound formed to be,  $3\text{MgO} \cdot \text{MgCl}_2 \cdot 12\text{H}_2\text{O}$ .

d'Ans and Katz, 1941 showed that the solubility of  $\text{Mg}(\text{OH})_2$  increases with increasing  $\text{MgCl}_2$  in solution.

### In aq. $\text{MgSO}_4$

(Kiessewetter, 1953)

Various concentrations of  $\text{MgSO}_4$  were used, and factors such as stirring time, flocculation, rate of dissolving, etc. were considered.

### In aq. $\text{NaCl}$ , $\text{Na}_2\text{SO}_4$ at high temperature

(Travers and Nouvel, 1929)

The presence of  $\text{NaCl}$  and of  $\text{Na}_2\text{SO}_4$  increase the solubility. Thus in an aqueous solution of 1.0 gm.  $\text{Na}_2\text{SO}_4$  per 100 cc, the solubility of the  $\text{Mg}(\text{OH})_2$  is 0.000238 gm. mols. per liter at  $110^\circ$  and 0.000142 gm. mols. at  $160^\circ$ .

### In aq. potassium salts at $25^\circ$

Whitby, 1933, gives results for the solubility of  $\text{Mg}(\text{OH})_2$  in aqueous solutions of  $\text{KOH}$ ,  $\text{KCl}$ ,  $\text{KBr}$ ,  $\text{KI}$  and  $\text{K}_2\text{SO}_4$  at  $25^\circ$ .

## THE SYSTEM MAGNESIUM HYDROXIDE - HYDROGEN PEROXIDE - WATER

(Makarov and Vol'nov, 1954)

Sat. Sol. wt. %		Solid Phase	At $0^\circ$		Solid Phase
MgO	1/2 $\text{O}_2$		MgO	1/2 $\text{O}_2$	
0.002	—	$\text{Mg}(\text{OH})_2$	0.14	27.83	$\text{MgO}_2 \cdot \text{H}_2\text{O}$
0.05	0.43	" + $\text{MgO}_2 \cdot \text{H}_2\text{O}$	0.13	28.45	"
0.02	0.62	$\text{MgO}_2 \cdot \text{H}_2\text{O}$	0.10	33.61	$\text{MgO}_2 \cdot \frac{1}{2}\text{H}_2\text{O}$
—	6.02	"	0.04	38.99	"
0.01	6.37	"	—	43.35	"
0.02	9.04	"	—	44.45	"
0.03	15.47	"	—	45.06	"
0.10	16.02	"	—	45.25	"

## THE SYSTEM MAGNESIUM HYDROXIDE - HYDROGEN PEROXIDE - WATER--Cont.

At 20°

Sat. Sol.		Sat. Sol.	
Wt. %		Wt. %	
1/2 O <sub>2</sub>	Solid Phase	1/2 O <sub>2</sub>	Solid Phase
0.55	Mg(OH) <sub>2</sub>	16.04	MgO·1/2 H <sub>2</sub> O
12.90	MgO·1/2 H <sub>2</sub> O	17.40	"
13.10	"	20.73	"
14.10	"	25.03	MgO <sub>2</sub>
14.10	"	28.61	"
14.90	"	33.73	"

O  
OH
 SOLUBILITY OF MAGNESIUM HYDROXIDE IN ALCOHOL - WATER  
 MIXTURES AT 25°  
 (Jankovic, 1958)

In aq. Methanol			In aq. Ethanol		
Mole % H <sub>2</sub> O in solvent	Density	Mg. Mg(OH) <sub>2</sub> per 100 gms. sat. sol.	Mole % H <sub>2</sub> O in Solvent	Density	Mg. Mg(OH) <sub>2</sub> per 100 gms. sat. sol.
95.2	0.9877	2.1	96.8	0.9905	1.5
90.0	0.9751	1.4	91.6	0.9709	0.6
83.3	0.9596	0.7	86.6	0.9573	0.2
76.5	0.9415	0.3	81.6	0.9415	0.0
58.4	0.8998	0.0			

The solubility of MgO in molten cryolite was studied by Hayakawa and Kido, 1951.

For data on the solubility of MgO and H<sub>2</sub>O in molten carnallite see Vil'nyanskii and Bakina, 1956.

For results in fused chlorides and sulfates of Li, Na, K see Voskresenskaya and Kashochev, 1956.

## Mg MAGNESIUM

## PO MAGNESIUM PHOSPHATE

THE SYSTEM  $MgO - P_2O_5 - H_2O$   
(Belopol'skii, Shpunt and Shulgina, 1950, 1955;  
Shpunt, Belopol'skii and Shulgina, 1951)

Earlier data at 25° were given by Cameron and Bell, 1907.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
MgO	P <sub>2</sub> O <sub>5</sub>	Solid Phase	MgO	P <sub>2</sub> O <sub>5</sub>	Solid Phase
<u>Results at 0°</u>			<u>Results at 25°--Cont.</u>		
1.9	6.3	MgHPO <sub>4</sub> ·3H <sub>2</sub> O	0.9	63.3	Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>
4.6	16.5	"	0.7	64.0	"
8.0	29.5	" + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O	0.5	65.6	"
4.4	49.6	Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O	0.04	68.8	"
3.9	52.5	"	0.04	70.0	"
4.1	53.2	"	<u>Results at 50°</u>		
3.1	58.4	" + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>	0.4	1.3	MgHPO <sub>4</sub> ·3H <sub>2</sub> O
2.2	59.7	Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>	1.6	6.0	"
0.4	62.6	"	2.6	9.3	"
0.4	64.8	"	4.6	16.8	"
<u>Results at 10°</u>			7.0	27.2	"
1.8	6.2	MgHPO <sub>4</sub> ·3H <sub>2</sub> O	8.9	37.3	" + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
4.7	16.8	"	8.3	39.6	Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
8.2	31.0	" + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O	7.2	41.8	" + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O
4.4	50.5	Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O	5.0	53.4	Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O
3.9	54.5	"	3.9	57.5	" + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>
3.4	57.5	"	2.2	62.7	Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>
3.2	58.9	" + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>	1.5	63.7	"
0.4	62.0	Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>	<u>Results at 58°</u>		
0.3	63.8	"	0.4	1.3	MgHPO <sub>4</sub> ·3H <sub>2</sub> O
<u>Results at 25°</u>			1.6	6.0	"
2.0	6.5	MgHPO <sub>4</sub> ·3H <sub>2</sub> O	2.6	9.3	"
4.1	14.4	"	4.6	16.8	"
7.6	29.5	"	7.0	27.2	"
8.3	33.1	" + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O	9.5	38.5	" + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O
7.6	33.6	Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O	6.3	50.0	Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O
7.2	35.3	"	5.1	55.0	"
6.3	38.0	"	4.5	58.0	" + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>
5.7	41.5	"	3.3	60.0	Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>
5.3	43.1	"	2.1	63.0	"
4.6	48.6	"	<u>Results at 80°</u>		
4.6	47.6	"	0.5	1.5	MgHPO <sub>4</sub> ·3H <sub>2</sub> O
4.6	48.5	"	0.8	3.0	"
4.4	52.8	"	2.2	6.8	"
4.6	53.3	" + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O	3.1	10.6	"
3.9	54.7	Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O	4.0	13.8	"
3.7	55.6	"	4.9	18.5	"
3.8	57.2	"	6.1	23.5	"
3.6	57.4	"	6.8	26.1	"
3.2	59.6	" + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>			

(Cont.)

THE SYSTEM MgO - P<sub>2</sub>O<sub>5</sub> - H<sub>2</sub>O--Cont.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
MgO	P <sub>2</sub> O <sub>5</sub>		MgO	P <sub>2</sub> O <sub>5</sub>	
<u>Results at 80°--Cont.</u>			<u>Results at 130°</u>		
8.0	31.3	MgHPO <sub>4</sub> ·3H <sub>2</sub> O	0.8	3.0	MgHPO <sub>4</sub> ·3H <sub>2</sub> O
8.9	35.6	"	3.1	10.6	"
9.6	39.4	"	4.9	18.5	"
11.0	44.8	" + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O	6.8	26.1	"
10.7	44.5	Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O	8.0	31.3	"
8.8	47.1	"	9.6	39.4	"
8.2	48.0	"	12.7	54.0	" + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O
7.8	49.6	"			+ Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>
6.5	53.8	"	6.2	60.0	Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>
6.4	54.9	"	4.1	63.0	"
6.0	55.5	" + Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>			
5.0	58.3	Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>			
4.0	60.8	"			
2.9	61.8	"			
1.9	64.4	"			

SOLUBILITY OF MAGNESIUM MONOHYDROGEN PHOSPHATE, MgHPO<sub>4</sub>

t°	ksp	Author
22	6.5 x 10 <sup>-5</sup>	Greenwald, 1955
38	3.5 x 10 <sup>-5</sup>	Tabor and Hastings, 1943
38	1.0 x 10 <sup>-5</sup>	Holt, Pierce and Kajdi, 1954

SOLUBILITY OF TRI-MAGNESIUM PHOSPHATE, Mg<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>

At 38° the K<sub>sp</sub>, extrapolated to zero ionic strength is [Mg<sup>++</sup>]<sup>3</sup>[PO<sub>4</sub><sup>=</sup>]<sup>2</sup> = 2 x 10<sup>-27</sup>.

(Holt, Pierce and Kajdi, 1954)



# Mg MAGNESIUM

## PO MAGNESIUM AMMONIUM PHOSPHATE $MgNH_4PO_4 \cdot 6H_2O$

### SOLUBILITY IN AQUEOUS SALT SOLUTIONS AT 25° (Uncles and Smith, 1946)

All data are reported as mg. of magnesium per liter of solution. In pure water 13.6 mg. of magnesium were found dissolved in a liter of saturated solution at 25°. See also tables following.

Salt Solution	Normality of Salt Solution					
	0.05	0.10	0.20	0.30	0.40	0.50
$(NH_4)_2C_2O_4$	38.8	57.0	89.5	121.0	152.0	180.0
$(NH_4)_2C_2O_4$ in 0.01N $NH_4OH$	22.5	—	64.5	—	112.0	—
$(NH_4)_2C_2O_4$ in 0.10N $NH_4OH$	8.76	—	27.1	—	47.7	—
$(NH_4)_2C_2O_4$ in 1.00N $NH_4OH$	2.63	—	8.32	—	14.4	—
$Na_2C_2O_4$	43.5	68.5	106.0	138.0	166.0	191.0
$Na_2C_2O_4$ in 0.01N $NH_4OH$	22.1	—	60.5	—	109.0	—
$Na_2C_2O_4$ in 0.10N $NH_4OH$	6.57	—	21.3	—	39.4	—
$Na_2C_2O_4$ in 1.00N $NH_4OH$	2.40	—	7.00	—	11.9	—
$(NH_4)_2MoO_4$	340.0	493.0	730.0	—	—	—
$(NH_4)_2MoO_4$ in 0.05N $NH_4OH$	—	—	404.0	—	—	—
$(NH_4)_2MoO_4$ in 0.20N $NH_4OH$	—	—	2.5	—	—	—
KCl	—	18.8	—	—	—	26.4
KNO <sub>3</sub>	—	17.9	—	—	—	24.6
K <sub>2</sub> SO <sub>4</sub>	—	21.9	—	—	—	34.2
CaCl <sub>2</sub>	—	296	—	—	—	499
CaCl <sub>2</sub> in 0.1N $NH_4OH$	—	131	—	—	—	311
CaCl <sub>2</sub> in 1.0N $NH_4OH$	—	18.3	—	—	—	26.9
CaCl <sub>2</sub> in 2.0N $NH_4OH$	—	6.6	—	—	—	12.1
BeCl <sub>2</sub>	—	125	—	—	—	184
BeCl <sub>2</sub> in 0.1N $NH_4OH$	—	70	—	—	—	140
BeCl <sub>2</sub> in 1.0N $NH_4OH$	—	15.3	—	—	—	26.0

	Normality of Salt Solution					
	0.001	0.005	0.010	0.025	0.050	0.075
$NH_4OH$	9.60	3.42	1.39	—	0.70	—
$(NH_4)_2HPO_4$	12.7	8.10	4.68	2.29	1.26	1.12
$Na_2HPO_4$	13.1	9.93	8.95	—	8.14	—

	Normality of Salt Solution							
	0.10	0.25	0.50	0.75	1.00	1.50	2.00	5.00
$NH_4OH$	0.53	—	0.44	—	0.55	—	—	0.70
$(NH_4)_2HPO_4$	1.00	—	0.76	—	0.50	—	—	0.80
$NH_4Cl$	19.1	25.9	38.0	46.0	53.0	61.5	67.0	79.0
$NH_4Cl$ in 0.01N $NH_4OH$	7.24	—	16.5	—	22.0	—	30.0	—
$NH_4Cl$ in 0.10N $NH_4OH$	2.11	—	5.53	—	7.46	—	9.30	—
$NH_4Cl$ in 1.00N $NH_4OH$	1.20	—	2.96	—	4.20	—	5.60	—
$NH_4NO_3$	19.3	24.6	35.0	42.0	46.5	52.0	54.0	56.5
$NH_4NO_3$ in 0.01N $NH_4OH$	6.80	—	14.4	—	19.1	—	26.0	—
$NH_4NO_3$ in 0.10N $NH_4OH$	1.71	—	4.50	—	5.90	—	7.65	—
$NH_4NO_3$ in 1.00N $NH_4OH$	1.22	—	2.80	—	4.00	—	5.30	—
$(NH_4)_2SO_4$	24.1	35.8	52.2	64.0	73.0	87.0	97.5	119.0
$(NH_4)_2SO_4$ in 0.01N $NH_4OH$	9.24	—	22.7	—	35.0	—	56.0	—
$(NH_4)_2SO_4$ in 0.10N $NH_4OH$	3.07	—	8.85	—	13.8	—	21.0	—
$(NH_4)_2SO_4$ in 1.00N $NH_4OH$	1.25	—	3.70	—	5.90	—	10.0	—
NaCl	22.3	27.2	32.0	35.0	37.0	39.4	40.2	39.6
NaCl in 0.01N $NH_4OH$	6.30	—	11.7	—	15.1	—	16.6	—
NaCl in 0.10N $NH_4OH$	1.75	—	3.78	—	4.76	—	5.66	—
NaNO <sub>3</sub>	20.0	25.4	30.5	33.4	35.0	37.4	38.2	37.0
NaNO <sub>3</sub> in 0.01N $NH_4OH$	6.00	—	11.4	—	13.8	—	14.7	—
NaNO <sub>3</sub> in 0.10N $NH_4OH$	2.70	—	6.35	—	8.86	—	12.7	—
$Na_2SO_4$	25.0	32.0	38.6	42.8	46.0	51.0	54.0	—
$Na_2SO_4$ in 0.01N $NH_4OH$	8.53	—	19.6	—	27.4	—	34.5	—
$Na_2SO_4$ in 0.10N $NH_4OH$	2.70	—	6.35	—	8.86	—	12.7	—
$Na_2SO_4$ in 1.00N $NH_4OH$	0.80	—	2.40	—	3.64	—	4.80	—

## SOLUBILITY OF MAGNESIUM AMMONIUM PHOSPHATE IN VARIOUS SALT SOLUTIONS

(See also previous tables)

(Results of Wenger, 1911)

Gms.  $\text{NH}_4\text{MgPO}_4$  per 100 Gms. Solvent in:

t°	Water	Gms. $\text{NH}_4\text{MgPO}_4$ per 100 Gms. Solvent in:				
		Aq. 5% $\text{NH}_4\text{NO}_3$	Aq. 5% $\text{NH}_4\text{Cl}$	Mixture of 1 Pt. $\text{NH}_3$ (d = 0.96) + 4 Pts. $\text{H}_2\text{O}$	Aq. 5% $\text{NH}_4\text{Cl}$ + 4 $\text{NH}_3$ per 100	Aq. 10% $\text{NH}_4\text{Cl}$ + 4 $\text{NH}_3$ per 100
0	0.023	0.110	0.060	0.0087	--	--
20	0.052	0.046	0.105	0.0098	0.0165	0.0541
30	--	0.054	0.113	--	--	--
40	0.036	0.064	0.071	0.0136	--	--
50	0.030	0.072	0.093	0.0153	--	--
60	0.040	0.085	0.173	0.0174	0.0274	0.0731
70	0.016	0.083	0.124	0.0178	--	--
80	0.019	0.101	0.191	0.0145	--	--

(Results of Maljaroff and Matakiewitsch, 1934)

An excess of  $\text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}$ , made from  $\text{MgCl}_2$ , was shaken at room temperature with each of the salt solutions and from time to time the content of phosphate was determined. Equilibrium was reached after a short (?) time. The content of magnesium ammonium phosphate was determined by titration with 0.1 N  $\text{HCl}$  using methyl orange as indicator.

Conc. of Aq. Salt solution in		Gms. $\text{MgNH}_4\text{PO}_4$ per liter sat. solution in aqueous:				
gms. per 100 cc.	$\text{NaCl}$	$\text{NH}_4\text{NO}_3$	$\text{Na}_2\text{SO}_4$	$\text{NH}_4\text{Cl}$	$(\text{NH}_4)_2\text{SO}_4$	$(\text{NH}_4)_2\text{C}_2\text{O}_4$
0.625	0.1067	--	0.1272	0.1092	--	0.1505
1.25	0.1191	0.1186	0.1512	0.1355	0.1415	0.3208
2.50	0.1459	0.1376	0.1774	0.1882	0.1876	0.4688
5.00	0.1552	0.1668	0.1894	0.2205	0.2493	0.7690
7.50	--	0.1919	--	0.2515	--	--
10.00	0.1625	0.2042	0.2482	0.2725	0.3535	--

Other results for the solubility of  $\text{MgNH}_4\text{PO}_4$  in aq.  $\text{NH}_4\text{Cl}$ ,  $\text{MgCl}_2$  and  $(\text{NH}_4)_2\text{HPO}_4$  solutions at 25° are given by Bube, 1910. For results in 50%  $\text{ZnSO}_4$  solutions see Neiman, Miller and Fedoseeva, 1950.

MAGNESIUM HYPOPHOSPHATE  $\text{Mg}_2\text{P}_2\text{O}_6 \cdot 12\text{H}_2\text{O}$ 

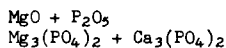
PO

One liter of water dissolves 0.066 gm. hypophosphate. (Salzer, 1886)

One liter of water dissolves 5 gms. magnesium hydrogen hypophosphate,  $\text{MgH}_2\text{P}_2\text{O}_6 \cdot 4\text{H}_2\text{O}$ .

(Salzer)

Melting point data are given for:



Berak, 1958  
Ando, 1958

## Mg MAGNESIUM

### 50 MAGNESIUM SULFITE $\text{MgSO}_3$

#### SOLUBILITY OF MAGNESIUM SULFITE IN WATER (Hagisawa, 1934)

Gms. $\text{MgSO}_3$ per 100 gms.			Gms. $\text{MgSO}_3$ per 100 gms.		
t°	sat. sol.	Solid Phase	t°	sat. sol.	Solid Phase
0	0.338	$\text{MgSO}_3 \cdot 6\text{H}_2\text{O}$	65	0.720	$\text{MgSO}_3 \cdot 3\text{H}_2\text{O}$
15	0.497	"	75	0.664	"
25	0.646	"	85	0.623	"
35	0.846	"	98	0.615	"
40 tr.pt.	--	" + $\text{MgSO}_3 \cdot 3\text{H}_2\text{O}$	45	1.116*	$\text{MgSO}_3 \cdot 6\text{H}_2\text{O}$
42	0.937	$\text{MgSO}_3 \cdot 3\text{H}_2\text{O}$	55	1.465*	"
46	0.897	"	57.5	1.688*	"
50	0.844	"	62.5	1.950*	"
55	0.817	"	38	1.034*	$\text{MgSO}_3 \cdot 3\text{H}_2\text{O}$

\*Metastable

### 51 MAGNESIUM SULFATE $\text{MgSO}_4$

#### SOLUBILITY OF MAGNESIUM SULFATE IN WATER

This system is complicated by the great range of temperature over which the hexa and penta (?) hydrates exist in metastable equilibrium. Of the large number of determinations which have been made, those of de Coppet, 1872 (ice curve); Cottrell et.al., 1901 (Eutectic); Kupper, 1927; Schroder, 1929; Ting and McCabe, 1934; Robson, 1927; Froehlich, 1929; and Smith, Rinse and Lowe-Kooymans, 1928 were plotted and the following values read from the average curve.

Gms. $\text{MgSO}_4$ per 100 gms.			Gms. $\text{MgSO}_4$ per 100 gms.		
t°	sat. sol.	Solid Phase	t°	sat. sol.	Solid Phase
-2.5	12.0	Ice	69*	37.1	$\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$ + $\text{MgSO}_4 \cdot \text{H}_2\text{O}$
-3.5†	17.0 (?)	" + $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	70	37.3**	$\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$
-4.0†	19.0**	" + $\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$	80*	39.3**	" + $\text{MgSO}_4 \cdot 5(\text{or } 4?)\text{H}_2\text{O}$
0	18.0 (?)	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	85	40.2**	$\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$
0	20.5**	$\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$	90	41.2**	"
10	22.0 (?)	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	95	42.0**	"
10	23.6**	$\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$	100	42.9**	"
20	25.2	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	85	39.3**	$\text{MgSO}_4 \cdot 5(\text{or } 4?)\text{H}_2\text{O}$
20	28.3**	$\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$	90	39.6**	"
25	26.7	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	95	40.0**	"
25	27.6**	$\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$	100	40.5**	"
30	28.0	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	80	35.8	$\text{MgSO}_4 \cdot \text{H}_2\text{O}$
30	28.8**	$\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$	90	34.6	"
35	29.3	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	100	33.5	"
35	30.0**	$\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$	120	30.0	"
40	30.8	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	140	24.0	"
40	31.2**	$\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$	160	13.0	"
45	32.3	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	170	8.0	"
48*	33.0	" + $\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$	180	5.0	"
50	33.4	$\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$	190	2.5	"
55	34.3	"	200	1.5	"
60	35.3	"	220	0.8	"
65	36.3	"	240	0.5	"

\*tr. pt.

\*\*metastable

†eutec.

Results of Benrath, 1941 above 100°, differing from those above:

t°	Gms. MgSO <sub>4</sub> per 100 gms. Sat. Sol.	t°	Gms. MgSO <sub>4</sub> per 100 gms. Sat. Sol.	t°	Gms. MgSO <sub>4</sub> per 100 gms. Sat. Sol.
125	45	210	30	210	15
165	40	212	25	210	5
182	35	210	20		

SOLUBILITY OF MAGNESIUM SULFATE IN AQUEOUS SOLUTIONS  
OF SULFURIC ACID AT 12.6°  
(Montemartini and Losana, 1928)

50

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	H <sub>2</sub> SO <sub>4</sub>	MgSO <sub>4</sub>			H <sub>2</sub> SO <sub>4</sub>	MgSO <sub>4</sub>	
1.2666	0.0	24.33	MgSO <sub>4</sub> ·7H <sub>2</sub> O	1.4390	33.74	15.16	1·1·3
1.2729	8.64	19.25	"	1.4431	40.94	11.12	" + 1·3
1.2861	15.78	16.05	"	1.4906	53.01	4.25	1·3
1.3267	24.28	12.23	" + MgSO <sub>4</sub> ·H <sub>2</sub> O	1.5688	59.10	1.50	" + 1·1·3
1.3440	27.20	8.68	MgSO <sub>4</sub> ·H <sub>2</sub> O	1.6553	66.49	0.38	1·3
1.3592	28.95	11.92	" + 1·1·3	1.7780	82.31	0.21	"
1.3641	29.81	12.37	1·1·3	1.8455	98.56	0.14	"

1·1·3 = MgSO<sub>4</sub>·H<sub>2</sub>SO<sub>4</sub>·3H<sub>2</sub>O; 1·3 = MgSO<sub>4</sub>·3H<sub>2</sub>SO<sub>4</sub>

Results for this system at 0°, 19° and 35.5° are given by Arditti, 1933, in the form of a diagram but without the numerical values. The author reported the solid phases to be MgSO<sub>4</sub>·7H<sub>2</sub>O, MgSO<sub>4</sub>·H<sub>2</sub>SO<sub>4</sub>·3H<sub>2</sub>O, MgSO<sub>4</sub>·H<sub>2</sub>SO<sub>4</sub>, 3MgSO<sub>4</sub>·2H<sub>2</sub>SO<sub>4</sub> and 3MgSO<sub>4</sub>·H<sub>2</sub>SO<sub>4</sub>.

Batuner, 1938 found that 100 gms. of a saturated solution, containing 50 gms. of H<sub>2</sub>SO<sub>4</sub>, contained 4.25 gms. MgSO<sub>4</sub> at 35°, 45°, 55°, and 65°. The solid phase was MgSO<sub>4</sub>·H<sub>2</sub>O.

Polytherms from 10 to 90°, and the 65° isotherm of the system MgSO<sub>4</sub> - H<sub>2</sub>BO<sub>3</sub> - H<sub>2</sub>O were determined by Manole - Bezhan and Sokolovskii, 1951.

THE SYSTEM MAGNESIUM SULFATE - MAGNESIUM HYDROXIDE - WATER  
Results of Delyon, 1936

Aqueous solutions of MgSO<sub>4</sub> containing more than 500 gms. per liter dissolve MgO with formation of the oxy sulfate, MgSO<sub>4</sub>·3MgO·11H<sub>2</sub>O. The author studied the influence of the mode of preparation of the MgO, the concentration of MgSO<sub>4</sub> and the temperature upon this reaction. The results show the amount of MgO dissolved under given conditions. For example it was found that one liter of an aqueous solution containing 500 gms. MgSO<sub>4</sub>, dissolves 4.2 gms. MgO at 60°.

## Mg MAGNESIUM

Results of Sugi and Nakayama, 1958 at 100°

Read from a diagram drawn by the authors:

Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
MgSO <sub>4</sub>	Mg(OH) <sub>2</sub>	
10	0.006	MgSO <sub>4</sub> ·5Mg(OH) <sub>2</sub> ·3H <sub>2</sub> O
20	0.014	"
30	0.025	"
40	0.039	"
49.5	0.056	MgSO <sub>4</sub> ·5Mg(OH) <sub>2</sub> ·3H <sub>2</sub> O + Kieserite
50.5	0.030	Kieserite
50.0	0.0	"

SO

THE SYSTEM MAGNESIUM SULFATE - MAGNESIUM CHLORIDE - WATER  
(See also p. 483, this volume)Results at 75°

(Luk'yanova, Sokol and Sokolova, 1956)

Sat. sol. wt. %		Solid Phase	Sat. sol. wt. %		Solid Phase
MgSO <sub>4</sub>	MgCl <sub>2</sub>		MgSO <sub>4</sub>	MgCl <sub>2</sub>	
38.0	0.0 *	MgSO <sub>4</sub> ·6H <sub>2</sub> O	10.19	19.39	MgSO <sub>4</sub> ·H <sub>2</sub> O
37.75	0.60*	"	8.71	21.31	"
36.08	2.06*	" + MgSO <sub>4</sub> ·4H <sub>2</sub> O	3.10	28.56	"
35.89	2.58*	MgSO <sub>4</sub> ·4H <sub>2</sub> O	0.89	33.15	"
34.24	3.29*	"	0.79	36.34	"
31.10	4.92*	"	0.40	38.86	" + MgCl <sub>2</sub> ·6H <sub>2</sub> O
29.92	6.17*	"	0.30	38.82	" + "
27.85	7.86*	"	0.0	39.10	MgCl <sub>2</sub> ·6H <sub>2</sub> O
25.48	10.37*	"	28.48	4.80	MgSO <sub>4</sub> ·H <sub>2</sub> O
23.76	11.20*	"	27.0	6.16	"
17.94	13.92	MgSO <sub>4</sub> ·H <sub>2</sub> O	33.15	2.60	"
			23.0	9.46	"

\*metastable

Results at several temperatures

Froehlich, 1929 determined the solubility of magnesium sulfate in solutions containing (initially) 50, 100 and 300 gms. MgCl<sub>2</sub> per liter. The following values were read from a plot of the authors data.

t° in each case	(50 gms. MgCl <sub>2</sub> per liter)		(100 gms. MgCl <sub>2</sub> per liter)		(300 gms. MgCl <sub>2</sub> per liter)	
	Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
	MgSO <sub>4</sub>	MgCl <sub>2</sub>	MgSO <sub>4</sub>	MgCl <sub>2</sub>	MgSO <sub>4</sub>	MgCl <sub>2</sub>
20	21.0	3.8	14.0	8.5	5.0	24.0
40	25.5	3.7	21.0	8.0	10.0	22.2
60	30.5	3.6	26.5	7.7	13.0	21.3
80	34.0	3.5	30.5	7.4	14.5	21.2
100	36.0	3.4	30.5	7.1	7.5	23.0
120	30.0	3.4	23.0	7.1	3.8	24.0
140	20.0	3.5	15.5	7.5	3.0	24.0
160	12.0	3.6	8.2	8.2	2.5	23.3
180	5.0	3.7	2.5	10.0	--	--

## THE SYSTEM MAGNESIUM SULFATE - CALCIUM SULFATE - WATER

(See also Vol. I, p. 673,4)

Results at 35°  
(Novikova, 1957)

Solubilities of  $\text{CaSO}_4$  were determined by precipitation with alcohol and by radioactive tracers. The alcohol method gave higher results, probably due to coprecipitation. The  $\text{CaSO}_4$  solubility curve is S-shaped. Results by the tracer method are given below.

Sat. Sol. wt. %		Solid Phase	Sat. Sol. wt. %		Solid Phase
$\text{CaSO}_4$	$\text{MgSO}_4$		$\text{CaSO}_4$	$\text{MgSO}_4$	
0.211	0.0	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	0.104	14.379	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
0.125	1.453	"	0.0520	22.216	"
0.134	2.761	"	0.0398	24.314	"
0.149	4.855	"	0.0181	29.418	" + $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
0.143	7.167	"	0.0	29.403	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
0.136	10.262	"			

Results at 55°  
(Bodaleva and Lepeshkov, 1956)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{CaSO}_4$	$\text{MgSO}_4$		$\text{CaSO}_4$	$\text{MgSO}_4$	
0.212	0.0	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	0.070	20.64	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
0.183	0.52	"	0.036	22.50	"
0.166	0.98	"	0.020	34.70	" + $\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$
0.173	2.10	"	0.0	34.94	$\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$
0.179	3.89	"	0.161	0.0	$\text{CaSO}_4$
0.186	6.35	"	0.133	1.07	"
0.199	9.61	"	0.153	2.38	"
0.200	10.41	"	0.165	5.72	"
0.115	17.00	"	0.160	9.85	"
0.089	18.78	"	0.082	17.10	"

## THE SYSTEM MAGNESIUM SULFATE - MANGANESE SULFATE - WATER

(Benrath and Blankenstein, 1934)

The authors also give results for the temperatures 17.5°, 27°, 37°, 45°, and 70° as well as the composition of the solid phases and the values calculated to the Janecke x-m method of expressing equilibrium.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
MnSO <sub>4</sub>	MgSO <sub>4</sub>		MnSO <sub>4</sub>	MgSO <sub>4</sub>	
Results at 0°					
3.56	18.19	MgSO <sub>4</sub> ·7H <sub>2</sub> O	23.1	8.37	M.C.Mg <sup>7</sup> + Mn <sup>7</sup>
6.17	17.68	"	25.91	6.91	MnSO <sub>4</sub> ·7H <sub>2</sub> O
10.66	14.61	"	29.25	3.97	"
14.21	12.77	"	32.0	1.88	"
17.83	11.0	"			

(Cont.)

**Mg**    **MAGNESIUM**

THE SYSTEM MAGNESIUM SULFATE - MANGANESE SULFATE - WATER--Cont.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
MnSO <sub>4</sub>	MgSO <sub>4</sub>	Solid Phase	MnSO <sub>4</sub>	MgSO <sub>4</sub>	Solid Phase
<u>Results at 23°</u>			<u>Results at 50°--Cont.</u>		
1.10	25.4	MgSO <sub>4</sub> ·7H <sub>2</sub> O	13.04	24.8	M.C.Mn1 + Mg6
1.83	25.3	"	13.33	24.4	MnSO <sub>4</sub> ·H <sub>2</sub> O
8.65	21.16	"	16.00	21.2	"
14.27	17.86	"	19.30	17.08	"
20.4	14.50	"	26.00	10.46	"
26.3	11.88	"	30.70	6.00	"
28.1	10.36	"	33.8	2.36	"
28.5	9.36	M.C. Mg7 + Mn5			
		M.C. Mg6 + Mn5			
30.0	8.43	MnSO <sub>4</sub> ·5H <sub>2</sub> O			
33.7	5.00	"	0.30	34.8	M.C.Mg1 + MnI
35.2	3.06	"	1.64	33.6	"
37.7	1.04	"	3.41	31.3	"
			5.72	29.5	"
			7.55	27.2	"
			10.55	23.5	"
			13.68	20.4	"
			17.86	13.45	"
			20.1	9.43	"
			25.9	2.39	"
<u>Results at 50°</u>					
2.24	32.0	MgSO <sub>4</sub> ·6H <sub>2</sub> O			
3.15	31.3	"			
8.43	27.6	"			
12.40	25.5	"			

Mg7 = MgSO<sub>4</sub>·7H<sub>2</sub>O;                      Mg6 = MgSO<sub>4</sub>·6H<sub>2</sub>O;                      Mg1 = MgSO<sub>4</sub>·H<sub>2</sub>O;  
 Mn7 = MnSO<sub>4</sub>·7H<sub>2</sub>O;                      Mn5 = MnSO<sub>4</sub>·5H<sub>2</sub>O;                      Mn1 = MnSO<sub>4</sub>·H<sub>2</sub>O.  
 M.C. = Mixed crystals

THE SYSTEM MAGNESIUM SULFATE - AMMONIUM SULFATE - WATER  
(Weston, 1922 (30°, 60°); Benrath and Thiemann, 1932)

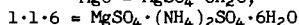
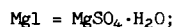
Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{MgSO}_4$	$(\text{NH}_4)_2\text{SO}_4$	Solid Phase	$\text{MgSO}_4$	$(\text{NH}_4)_2\text{SO}_4$	Solid Phase
<u>At 0°</u>			<u>At 30° (W.)</u>		
42.77	2.31	$\text{Mg}7 + 1 \cdot 1 \cdot 6$	27.60	2.98	$1 \cdot 1 \cdot 6$
			16.53	6.31	"
			7.30	10.55	"
			1.25	26.15	"
			0.30	41.20	"
			0.00	43.60	" + $(\text{NH}_4)_2\text{SO}_4$
<u>At 25°</u>			<u>At 45°</u>		
26.44	2.29	$\text{Mg}7 + 1 \cdot 1 \cdot 6$			
22.55	3.02	$1 \cdot 1 \cdot 6$			
12.0	5.96	"			
8.43	7.83	"			
3.02	15.0	"	31.22	3.0	" + $\text{Mg}7$
1.3	23.32	"			
0.56	31.94	"			
0.0	43.22	"	31.45	2.96	" + $\text{Mg}7 + \text{Mg}6$
<u>At 49.6°</u>					
$\text{Mg}7 = \text{MgSO}_4 \cdot 7\text{H}_2\text{O};$			$\text{Mg}6 = \text{MgSO}_4 \cdot 6\text{H}_2\text{O};$		
$1 \cdot 1 \cdot 6 = \text{MgSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$			$\text{Mg}1 = \text{MgSO}_4 \cdot \text{H}_2\text{O};$		

(Cont.)

## THE SYSTEM MAGNESIUM SULFATE - AMMONIUM SULFATE - WATER--Cont.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
MgSO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Solid Phase	MgSO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Solid Phase
<u>At 46.2°</u>			<u>At 65°</u>		
31.69	2.89	1·1·6 + Mg6	0.73	46.04	1·1·6 + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
<u>At 50°</u>			<u>At 67.5°</u>		
32.13	3.0	" + "	36.7	3.38	" + Mg6 + Mg1
<u>At 60°(W.)</u>			<u>At 75°</u>		
			1.74	46.43	" + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
31.10	3.98	1·1·6	<u>At 96°</u>		
26.85	5.85	"			
15.04	11.91	"	34.14	5.17	" + Mg1
11.92	14.27	"	29.33	10.87	" + "
4.68	26.77	"	27.14	12.28	1·1·6
0.0	46.8	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	24.26	14.21	"
<u>At 62.4°</u>			17.35	19.08	"
			17.19	21.36	"
34.64	3.27	1·1·6 + Mg6	14.27	24.94	"
			8.12	36.35	"
			4.75	46.73	" + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>

SO

SOLUBILITY OF AMMONIUM MAGNESIUM SULFATE IN WATER  
(Porlezza, 1914)

t°	Gms. per 100 Gms.		Solid Phase
	Sat. Sol.	Water	
- 0.34	1.01	1.02	Ice
- 0.80	2.98	3.07	"
- 1.23	4.92	5.17	"
- 1.60	6.56	7.02	"
- 2.02	8.34	9.10	"
- 2.34 Eutec.	--	--	" + (NH <sub>4</sub> ) <sub>2</sub> Mg(SO <sub>4</sub> ) <sub>2</sub> ·6H <sub>2</sub> O
0	10.58	11.83	(NH <sub>4</sub> ) <sub>2</sub> MgSO <sub>4</sub> ·6H <sub>2</sub> O
10	12.75	14.61	"
20	15.23	17.96	"
25	16.45	19.69	"
	16.61	19.94*	"
30	17.84	21.71	"
40	20.51	25.86	"
50	23.18	30.17	"
60	26.02	35.17	"
80	32.58	48.32	"
100	39.66	65.72	"

\*Hill, Durham, and Ricci, 1940; d. = 1.090.



THE SYSTEM MAGNESIUM SULFATE - SODIUM SULFATE - WATER.

The system has been studied by several authors with reasonable agreement among the data. In addition to the results given below, Zdanovskii (1949) reviews the results of the Institute of Salt Science (USSR) from 0° to 35°. For other data see Roozeboom, 1887, 1888; D'Ans, 1915; Pel'sh, 1953; Levina, 1938a; and Blasdale and Robson, 1938. The latter authors give a diagram composed of the isotherms constructed from their own and other results. From this the composition of any stable solution in equilibrium with one or more solid phases can be found for any temperature between 0° and 210°.

A similar presentation of all available determinations upon this system, up to 1929, calculated to both the weight percent and gram mole basis, is given by Froelisch, 1929.

The results in parentheses (0°, 25°) are by Kournakow and Zemcuznyj, 1919, 1924.

AG = Archibald and Gale, 1924

T = Takegami, 1921

Ta = Takegami, 1921a, 1922

S = Schroder, 1929

B = Benrath, 1928

\* = Metastable

$$\text{Mg8} = \text{MgSO}_4 \cdot 8\text{H}_2\text{O}; \quad \text{Mg7} = \text{MgSO}_4 \cdot 7\text{H}_2\text{O}; \quad \text{Mg6} = \text{MgSO}_4 \cdot 6\text{H}_2\text{O}; \quad \text{Mg1} = \text{MgSO}_4 \cdot \text{H}_2\text{O};$$
$$\text{Na}_{10} = \text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}; \quad 1.1.4 = \text{Astrakanite, } \text{MgSO}_4 \cdot \text{Na}_2\text{SO}_4 \cdot 4\text{H}_2\text{O};$$
$$1.1 = \text{MgSO}_4 \cdot \text{Na}_2\text{SO}_4; \quad 1.3 = \text{Vanthoffite, MgSO}_4 \cdot 3\text{Na}_2\text{SO}_4;$$

2.2.5 = Loweite,  $2\text{MgSO}_4 \cdot 2\text{Na}_2\text{SO}_4 \cdot 5\text{H}_2\text{O}$

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
Density	MgSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>		Density	MgSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	
<u>At 0° (AG)</u>				<u>At 15° (B)--Cont.</u>			
--	(20.63)	0.0	Mg7	--	8.09	9.90	Na10
--	20.0	0.0	Mg12	1.185	3.63	10.07	"
--	20.0	4.3	Mg12(?)	1.132	1.21	10.92	"
--	20.0	4.63	Mg7 + Na10	1.105	0.0	11.72	"
--	(19.66)	(3.92)	" + "				
--	11.25	4.69	Na10		<u>At 18.7° (AG)</u>		
--	9.65	4.89	"	--	25.7	0.5	Mg7
				--	24.4	3.4	"
				--	20.60	11.48	"
--	20.9	7.46	Mg7 + Na10	--	20.57	11.80	" + Na10
--	19.4	7.4	Na10	--	15.70	12.30	Na10
--	0.75	8.3	"	--	11.30	13.50	"
				--	8.92	13.90	"
				--	1.48	14.68	"
<u>At 15° (B)</u>				<u>At 25° (AG)</u>			
1.204	25.13	0.0	Mg7		(28.04)	0.00	Mg7
--	24.92	0.26	"	--	22.6	10.8	"
1.291	24.75	0.75	"	--	19.8	16.9*	" + Na10
1.292	24.33	1.68	"	--	21.15	13.0	" + 1.1-4
1.286	23.81	3.97	"	--	(19.86)	(14.54)	" + "
1.301	22.29	7.88	"	--	16.6	17.8	Na10 + "
--	21.59	10.93	"	--	(15.88)	(18.52)	" + "
1.319	20.88	11.72	" + Na10	--	0.25	21.2	"
1.271	13.89	9.92	Na10	--	0.0	(21.87)	"

(Cont.)

## THE SYSTEM MAGNESIUM SULFATE - SODIUM SULFATE - WATER--Cont.

AG = Archibald and Gale, 1924

T = Takegami, 1921

Ta = Takegami, 1921a, 1922

S = Schroder, 1929

B = Benrath, 1928

\* = Metastable

Mg8 =  $\text{MgSO}_4 \cdot 8\text{H}_2\text{O}$ ; Mg7 =  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ ; Mg6 =  $\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$ ; Mg1 =  $\text{MgSO}_4 \cdot \text{H}_2\text{O}$ ; $\text{Na}_{10}$  =  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ ; 1.1.4 = Astrakanite,  $\text{MgSO}_4 \cdot \text{Na}_2\text{SO}_4 \cdot 4\text{H}_2\text{O}$ ;1.1 =  $\text{MgSO}_4 \cdot \text{Na}_2\text{SO}_4$ ; 1.3 = Vanthoffite,  $\text{MgSO}_4 \cdot 3\text{Na}_2\text{SO}_4$ ;2.2.5 = Loweite,  $2\text{MgSO}_4 \cdot 2\text{Na}_2\text{SO}_4 \cdot 5\text{H}_2\text{O}$ 

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase	SO
Density	MgSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>		Density	MgSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>		
At 25° (B)				At 30° (Ta)--Cont.				
1.304	26.68	0.0	Mg7	--	22.89	11.80	Mg8	
1.320	25.66	2.42	"	--	23.00	12.49	" + Mg7	
1.364	23.53	7.96	"	--	22.33	13.71	Mg7	
1.389	21.53	12.47	" + 1.1.4	--	21.92	14.47	"	
1.383	18.33	15.70	1.1.4					
1.384	15.90	18.47	" + Na10					
1.320	10.89	18.87	Na10					
1.276	6.00	20.42	"	--	24.55	8.75	Mg7	
1.251	3.73	20.79	"	--	24.5	9.27	"	
1.210	0.0	21.75	"	--	23.25	12.35	" + 1.1.4	
				--	15.8	18.6	" + "	
				--	12.3	23.25	Na10 + 1.1.4	
				--	6.48	26.08	" + "	
At 25° (T)								
--	26.68	0.00	Mg7					
--	23.77	6.69	"					
--	20.06	10.80	"					
--	19.84	26.54	"	--	28.0	8.5	Mg7 + 1.1.4	
--	21.60	12.45	" + 1.1.4	--	25.1	9.6	1.1.4	
--	19.46	14.13	1.1.4	--	24.1	10.8	"	
--	18.28	15.89	"	--	20.95	13.8	"	
--	16.31	18.22	"	--	15.35	19.15	"	
--	16.14	18.16	"	--	13.15	22.80	"	
--	14.14	20.50	"	--	12.2	23.2	" + Na	
--	15.63	18.63	" + Na10	--	11.6	24.5	Na	
--	17.67	18.16	Na10	--	11.0	24.7	"	
--	10.93	19.17	"	--	3.61	30.7	"	
--	10.78	18.85	"	--	2.54	30.70	"	
--	3.34	20.88	"					
--	0.00	21.54	"					
At 25° (Ta)								
--	26.68	0.00	Mg8	--	32.8	2.51	Mg6	
--	25.48	2.73	"	--	31.3	5.7	" + 1.1.4	
--	25.94	3.54	"	--	30.45	6.15	1.1.4	
--	24.49	5.29	"	--	27.8	9.75	"	
--	23.49	7.50	"	--	18.2	16.0	"	
--	22.32	10.10	"	--	16.0	18.3	"	
--	21.27	12.76	"	--	14.1	21.8	"	
				--	13.7	23.8	" + 1.3	
				--	12.7	25.0	" + Na <sub>2</sub> SO <sub>4</sub>	
				--	9.65	26.85	"	
				--	2.6	30.0	"	
At 30° (Ta)								
--	29.00	0.00	Mg8					
--	26.35	3.96	"					
--	24.35	8.43	"					

(Cont.)

## Mg MAGNESIUM

## THE SYSTEM MAGNESIUM SULFATE - SODIUM SULFATE - WATER--Cont.

AG = Archibald and Gale, 1924

S = Schroder, 1929

T = Takegami, 1921

B = Benrath, 1928

Ta = Takegami, 1921a, 1922

\* = Metastable

Mg8 =  $\text{MgSO}_4 \cdot 8\text{H}_2\text{O}$ ; Mg7 =  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ ; Mg6 =  $\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$ ; Mg1 =  $\text{MgSO}_4 \cdot \text{H}_2\text{O}$ ;Na<sub>10</sub> =  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ ; 1.1.4 = Astrakanite,  $\text{MgSO}_4 \cdot \text{Na}_2\text{SO}_4 \cdot 4\text{H}_2\text{O}$ ;1.1 =  $\text{MgSO}_4 \cdot \text{Na}_2\text{SO}_4$ ; 1.3 = Vanthoffite,  $\text{MgSO}_4 \cdot 3\text{Na}_2\text{SO}_4$ ;2.2.5 = Loweite,  $2\text{MgSO}_4 \cdot 2\text{Na}_2\text{SO}_4 \cdot 5\text{H}_2\text{O}$ 

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Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
Density	MgSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>		Density	MgSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	
At 50° (B)				At 60° (S)--Cont.			
1.401	33.50	0.0	Mg6	1.3642	11.70	23.33	1.3 + Na <sub>2</sub> SO <sub>4</sub>
1.410	32.50	1.96	"	1.3635	11.34	23.68	1.3
1.426	31.60	3.95	"	1.3695	12.69	22.59	Na <sub>2</sub> SO <sub>4</sub>
1.428	31.32	4.74	" + 1.1.4	1.3419	8.35	25.43	"
1.414	27.49	7.55	1.1.4	1.3215	4.96	27.59	"
1.380	20.16	13.86	"	1.2908	0.0	20.70	"
1.374	15.75	18.62	"	At 80° (AG)			
1.381	11.98	23.25	" + Na <sub>2</sub> SO <sub>4</sub>	---	38.4	2.8	Mg1
1.364	9.80	24.77	Na <sub>2</sub> SO <sub>4</sub>	---	36.3	4.9	2.2.5
1.329	3.52	29.42	"	---	33.25	6.35	"
1.310	0.0	31.70	"	---	24.06	12.6	"
At 60° (AG)				---	18.1	17.85	"
---	34.5	1.92	Mg6	---	16.4	19.7	"
---	33.8	3.55	"	---	15.4	21.4	"
---	33.8	4.6	" + 1.1.4	---	14.7	22.0	"
---	30.0	6.5	"	---	14.55	22.3	" + 1.3
---	23.1	12.0	"	---	14.2	22.25	1.3
---	18.2	15.8	"	---	13.85	22.55	"
---	14.0	21.8	"	---	4.29	28.1	" (?) + Na <sub>2</sub> SO <sub>4</sub>
---	9.9	24.85	Na <sub>2</sub> SO <sub>4</sub>	---	0.0	30.4	Na <sub>2</sub> SO <sub>4</sub>
---	6.05	27.85	"	At 90° (B)			
				1.400	35.60	0.0	Mg1
At 67° (S)				1.401	33.89	2.01	"
1.4114	35.33	0.0	MgSO <sub>4</sub> · 6H <sub>2</sub> O	1.422	32.20	5.55	" + 1.1
1.4182	34.86	1.04	"	1.367	27.95	7.28	1.1
1.4365	33.86	3.55	"	1.308	18.28	14.83	"
1.4377	33.70	3.98	" + 2.2.5	1.328	14.40	19.15	" + 1.3
1.4212	30.92	5.48	2.2.5	1.308	12.42	21.01	1.3
1.4092	29.06	6.90	"	1.298	8.74	24.20	"
1.4045	28.15	7.75	" + 1.1.4	1.284	5.88	26.90	" + Na <sub>2</sub> SO <sub>4</sub>
1.3926	25.44	9.84	2.2.5	1.280	4.91	27.49	Na <sub>2</sub> SO <sub>4</sub>
1.3725	16.18	19.34	"	---	2.47	28.50	"
1.4120	29.49	6.80	1.1.4	1.237	0.0	29.85	"
1.4035	27.89	7.80	"	At 100° (AG)			
1.3982	26.81	8.53	"	42.5	0.0*	Mg6	
1.3868	24.31	10.57	"	40.6	0.0	Mg1	
1.3829	23.53	11.20	"	32.0	6.07	2.2.5	
1.3795	22.86	11.82	"	31.1	6.5	"	
1.3729	20.48	13.90	"	23.2	12.55	"	
1.3728	19.94	14.46	"	16.9	19.4	" (?) + 1.3	
1.3706	19.08	15.37	"	13.75	20.6	1.3	
1.3651	14.19	20.65	"	13.7	20.5	"	
1.3687	12.34	22.89	" + Na <sub>2</sub> SO <sub>4</sub>	0.0	29.8	Na <sub>2</sub> SO <sub>4</sub>	
1.3697	13.82	21.40	1.3				
1.3651	13.12	21.91	" + 1.1.4				
1.3634	12.35	22.64	1.3				

For data for the system  $\text{MgSO}_4 + 2\text{NaCl} \rightleftharpoons \text{MgCl}_2 + \text{Na}_2\text{SO}_4 (+\text{H}_2\text{O})$  see Faiziev, 1954 (25°) and Solov'eva, 1956 (65°). Solov'eva found the new double salt  $9\text{Na}_2\text{SO}_4 \cdot \text{MgSO}_4$ .

A large number of determinations in the system  $\text{MgSO}_4 + 2\text{NaNO}_3 \rightleftharpoons \text{Mg}(\text{NO}_3)_2 + \text{Na}_2\text{SO}_4 (+\text{H}_2\text{O})$  are given by Benrath, 1928 and Schroder, 1930a.

THE SYSTEM  $\text{MgSO}_4 + 2\text{NaHCO}_3 \rightleftharpoons \text{Mg}(\text{HCO}_3)_2 + \text{Na}_2\text{SO}_4 (+\text{H}_2\text{O})$  AT 25°  
(Nikol'skaya and Mozhkina, 1956)

The pressure  $\text{CO}_2$  was 1 atm. The authors review the earlier literature data.

Density	Cms. per 100 gms. sat. sol.				Solid Phase
	$\text{Mg}(\text{HCO}_3)_2$	$\text{MgSO}_4$	$\text{NaHCO}_3$	$\text{Na}_2\text{SO}_4$	
1.0252	2.417	--	0.790	--	$\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$
1.0719	0.656	--	9.836	--	" + $\text{NaHCO}_3$
1.3154	1.950	26.75	--	--	" + $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
--	--	--	--	--(1)	" + "
1.0259	2.924	--	--	0.526	$\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$
1.0521	3.646	--	--	2.870	"
1.0876	3.947	--	--	6.553	"
1.1196	3.778	--	--	9.960	"
1.1517	2.890	--	--	13.723	"
1.2395	2.186	--	--	22.970	" + $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
1.2446	1.523	--	1.594	22.753	" + " + $\text{NaHCO}_3$
1.3848	1.316	14.825	--	19.921	" + " + $\text{Na}_2\text{SO}_4$ + $\text{MgSO}_4 \cdot 4\text{H}_2\text{O}$
1.3900	1.172	21.735	--	12.422	" + $\text{Na}_2\text{SO}_4$ + $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ + $\text{MgSO}_4 \cdot 4\text{H}_2\text{O}$
--	--	21.9	--	12.49	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O} + \text{Na}_2\text{SO}_4 + \text{MgSO}_4 \cdot 4\text{H}_2\text{O}$
--	--	16.263	--	18.731	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O} + \text{Na}_2\text{SO}_4 + \text{MgSO}_4 \cdot 4\text{H}_2\text{O}$
1.2297	--	--	4.045	20.775	$\text{NaHCO}_3$ + $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$

(1) Gloss

#### THE SYSTEM MAGNESIUM SULFATE - NICKEL SULFATE - WATER

Continuous solid solutions are formed between 0° and 100°. According to Benrath and Neumann, 1939, the solid phases have the following composition:

t°	
Below 29.1	Continuous Solid Solution $(\text{Mg}, \text{Ni})\text{SO}_4 \cdot 7\text{H}_2\text{O}$
29.1 to 44	Solid Solutions $(\text{Mg}, \text{Ni})\text{SO}_4 \cdot 7\text{H}_2\text{O}$ and $(\text{Mg}, \text{Ni} \cdot \alpha)\text{SO}_4 \cdot 6\text{H}_2\text{O}$
44 to 48	Solid Solutions $(\text{Mg}, \text{Ni})\text{SO}_4 \cdot 7\text{H}_2\text{O}$ , $(\text{Mg}, \text{Ni} \cdot \beta)\text{SO}_4 \cdot 6\text{H}_2\text{O}$ , and $(\text{Mg}, \text{Ni} \cdot \alpha)\text{SO}_4 \cdot 6\text{H}_2\text{O}$
48 to 60.3	Solid Solutions $(\text{Mg}, \text{Ni} \cdot \beta)\text{SO}_4 \cdot 6\text{H}_2\text{O}$ and $(\text{Mg}, \text{Ni} \cdot \alpha)\text{SO}_4 \cdot 6\text{H}_2\text{O}$
60.3 to 68	Continuous Solid Solution $(\text{Mg}, \text{Ni} \cdot \beta)\text{SO}_4 \cdot 6\text{H}_2\text{O}$
68 to 84.8	Solid Solutions $(\text{Mg}, \text{Ni})\text{SO}_4 \cdot \text{H}_2\text{O}$ and $(\text{Mg}, \text{Ni} \cdot \beta)\text{SO}_4 \cdot 6\text{H}_2\text{O}$
84.8 to 100	Continuous Solid Solution $(\text{Mg}, \text{Ni})\text{SO}_4 \cdot \text{H}_2\text{O}$

# Mg MAGNESIUM

Results of Gorshtein and Silvantereva, 1953 at 20°



Solid Phase = Heptahydrated Solid Solutions

Sat. Sol. Wt. %		Wet Residue Wt. %		Sat. Sol. Wt. %		Wet Residue Wt. %	
Mg7	Ni7	Mg7	Ni7	Mg7	Ni7	Mg7	Ni7
0.0	49.20	--	--	26.27	24.89	43.43	52.99
1.20	47.60	1.53	91.38	39.85	11.17	67.44	24.31
2.31	47.10	3.01	88.25	48.59	4.11	86.68	8.95
4.62	45.02	6.37	87.27	47.70	1.94	85.52	4.08
8.60	40.92	12.27	81.82	50.17	1.19	83.20	2.31
15.44	35.49	23.07	69.93	51.37	0.0	--	--

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THE SYSTEM MAGNESIUM SULFATE - THALLIUM SULFATE - WATER  
(Benrath, 1931)

t°	Gms. per 100 gms. sat. sol.		Solid Phase	t°	Gms. per 100 gms. sat. sol.		Solid Phase
	Tl <sub>2</sub> SO <sub>4</sub>	MgSO <sub>4</sub>			Tl <sub>2</sub> SO <sub>4</sub>	MgSO <sub>4</sub>	
0	2.39	22.37	Mg7 + 1.1.6	40.5	10.98	15.13	Tl <sub>2</sub> SO <sub>4</sub>
"	3.02	12.66	1.1.6	"	8.36	3.77	"
"	3.76	7.42	" + Tl <sub>2</sub> SO <sub>4</sub>	"	7.74	1.92	"
17.6	3.36	24.64	Mg7 + 1.1.6	64.5	4.70	35.08	Mg6
"	4.88	17.52	1.1.6	"	6.47	34.53	" + 1.1.6
"	5.75	13.76	"	"	12.22	26.98	1.1.6
"	6.40	12.0	" + Tl <sub>2</sub> SO <sub>4</sub>	"	15.20	22.65	" + Tl <sub>2</sub> SO <sub>4</sub>
40.5	2.59	31.0	Mg7	"	15.91	18.40	Tl <sub>2</sub> SO <sub>4</sub>
"	5.06	30.05	" + 1.1.6	"	12.52	4.67	"
"	6.86	25.12	1.1.6	100	9.41	30.34	MgSO <sub>4</sub> ·H <sub>2</sub> O
"	9.42	19.66	"	"	24.7	25.4	" + Tl <sub>2</sub> SO <sub>4</sub>
"	10.78	15.62	" + Tl <sub>2</sub> SO <sub>4</sub>	"	23.65	18.55	Tl <sub>2</sub> SO <sub>4</sub>

1.1.6 = MgSO<sub>4</sub>·Tl<sub>2</sub>SO<sub>4</sub>·6H<sub>2</sub>O; Mg6 = MgSO<sub>4</sub>·6H<sub>2</sub>O; Mg7 = MgSO<sub>4</sub>·7H<sub>2</sub>O

SOLUBILITY OF MAGNESIUM SULFATE IN AQUEOUS METHANOL SOLUTIONS AT 25°  
(Jankovic, 1958)

[Solid Phase MgSO<sub>4</sub>·7H<sub>2</sub>O]

Mole % CH <sub>3</sub> OH in Solvent	Density	Wt. % MgSO <sub>4</sub> in Sat. Sol.	Mole % CH <sub>3</sub> OH in Solvent	Density	Wt. % MgSO <sub>4</sub> in Sat. Sol.
4.8	1.182	18.898	29.6	0.881	0.0510
8.9	1.080	11.752	46.5	0.868	0.0220
10.4	1.060	9.482	55.9	0.849	0.0068
11.9	1.025	7.802	67.6	0.831	0.0020
17.2	0.977	2.311	75.0	0.820	0.0009
26.3	0.921	0.465	88.7	0.801	0.0002
32.1	0.901	0.1707			

## SOLUBILITY OF MAGNESIUM SULFATE IN AQUEOUS ETHANOL SOLUTIONS

(Solid Phase  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ )Results at 25°(Tarassenkow  
and Katz, 1937)

(Jankovic, 1958)

Gms. per 100 gms. sat. sol.		Mole % $\text{C}_2\text{H}_5\text{OH}$ in Solvent	Density	Wt. % $\text{MgSO}_4$ in Sat. Sol.
$\text{C}_2\text{H}_5\text{OH}$	$\text{MgSO}_4$			
0.0	26.70	5.0	1.2644	23.344
13.20	15.09	7.9	1.2220	21.001
28.70	4.84	9.9	1.1900	19.448
39.72	1.07	13.7	1.1301	16.420
63.54	0.04	18.5	1.0779	12.708
71.61	0.02	21.3	1.0515	10.148
		24.0	1.0215	8.008
		29.6	0.9746	4.811
		32.6	0.9593	3.655
		40.4	0.9164	1.642
		46.7	0.9008	1.058
		54.1	0.8750	0.615
		63.4	0.8555	0.403
		79.7	0.8255	0.272

80

Results at 50°

(Tarassenkow and Katz, 1937)

Solid Phase  $\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$ Two liquid layers are formed  
between 3 and 65 wt. %  $\text{C}_2\text{H}_5\text{OH}$ 

(Nikol'skaya, 1946)

Gms. per 100 gms. sat. sol.				Gms. per 100 gms. sat. sol.			
Upper Layer		Lower Layer		Upper Layer		Upper Layer	
$\text{C}_2\text{H}_5\text{OH}$	$\text{MgSO}_4$	$\text{C}_2\text{H}_5\text{OH}$	$\text{MgSO}_4$	$\text{C}_2\text{H}_5\text{OH}$	$\text{MgSO}_4$	$\text{C}_2\text{H}_5\text{OH}$	$\text{MgSO}_4$
No separation		0.0	33.44	16.00	15.08	27.90	7.68
"	"	2.69	32.12	9.91	21.30	37.93	3.15
"	"	3.10	31.10	5.93	27.40	51.00	0.67
60.38	0.32	4.10	30.74	4.28	30.50	58.94	0.26
50.75	1.02	6.10	26.78				
41.76	1.94	7.64	23.85				
39.11	2.99	10.41	21.17				
34.12	5.11	11.69	19.16				
32.26	5.61	13.95	16.74				
64.79	0.15	No separation					

Similar data at 75° are given  
by Nikol'skaya.

# Mg MAGNESIUM

## SOLUBILITY OF MAGNESIUM SULFATE IN AQUEOUS SOLUTIONS OF ISO PROPYL ALCOHOL AT 25° (Ginnings and Chen, 1931)

The results locate the binodal curve of the system, including a tie line, \*, which shows the composition of two liquid layers in contact with each other, and the plait point, PP, at which the two liquid layers become homogeneous.

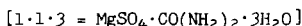
	Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
	Iso C <sub>3</sub> H <sub>7</sub> OH	MgSO <sub>4</sub>	Iso C <sub>3</sub> H <sub>7</sub> OH	MgSO <sub>4</sub>
50	39.30	1.43*	12.10	11.80
	32.80	2.77	9.40	14.00
	28.40	4.20	7.10	16.40
	23.70	5.90	5.00	19.40
	21.4	7.3 PP	3.00	22.50*

The composition of the homogeneous mixture, Plait point, PP, of the system MgSO<sub>4</sub> + Tertiary Butyl Alcohol + H<sub>2</sub>O at 25° was found by Ginnings, Herring and Webb, 1933 to be 3.3 percent MgSO<sub>4</sub> + 27.2 percent ter. (CH<sub>3</sub>)<sub>3</sub>COH + 69.5 percent H<sub>2</sub>O. The original results for the remaining points on the binodal curve are not given but only the values of constants calculated from empirical equations.

The binodal curve of the system MgSO<sub>4</sub> + Allyl Alcohol + H<sub>2</sub>O at 25° has been determined by Ginnings and Dees, 1935; and that for the system MgSO<sub>4</sub> + Pyridine + H<sub>2</sub>O at 25° has been determined by Ginnings, Webb and Hinohara, 1933. The authors do not give their experimental results but only the values of a series of arbitrary constants calculated from them by means of empirical equations. The results showed that allyl alcohol is more difficult to salt out than iso propyl or normal propyl alcohol.

## THE SYSTEM MAGNESIUM SULFATE - UREA - WATER (Salaimankulov, Druzhinin and Bergman, 1957 (0, 30, 45°); Whittaker, Lundstrom and Shimp, 1936 (30°); Salaimankulov and Bergman, 1957 (eutec. to +20°))

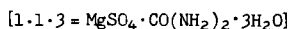
Salaimankulov and Bergman present a polythermal diagram for the system from the eutectic to +20°.



t°	Gms. per 100 gms. sat. sol.		Solid Phase
	CO(NH <sub>2</sub> ) <sub>2</sub>	MgSO <sub>4</sub>	
(Data by S. & B.)			
(-11.1°)	32.9	0.0	CO(NH <sub>2</sub> ) <sub>2</sub> + Ice
(- 3.6°)	0.0	20.6	MgSO <sub>4</sub> · 12H <sub>2</sub> O + Ice
(+ 1.8°)	0.0	21.4	" + MgSO <sub>4</sub> · 7H <sub>2</sub> O
(-19°)	26.5	18.0	" + Ice + CO(NH <sub>2</sub> ) <sub>2</sub>
(-12°)	30.5	19.0	" + MgSO <sub>4</sub> · 7H <sub>2</sub> O + CO(NH <sub>2</sub> ) <sub>2</sub>

(Cont.)

## THE SYSTEM MAGNESIUM SULFATE - UREA - WATER--Cont.



Density	Gms. per 100 gms. sat. sol.		Solid Phase
	CO(NH <sub>2</sub> ) <sub>2</sub>	MgSO <sub>4</sub>	
	Results at 0° (SDB)		
1.2459	--	21.31	MgSO <sub>4</sub> ·12H <sub>2</sub> O
1.2646	2.68	21.73	MgSO <sub>4</sub> ·7H <sub>2</sub> O
1.2688	7.98	21.65	"
1.2783	10.57	21.19	"
1.2983	15.45	21.23	"
1.3022	19.32	21.32	"
1.3215	20.69	21.29	"
1.3408	27.40	21.78	"
1.3455	28.34	21.65	"
1.3529	30.04	21.47	"
1.3648	31.48	21.75	"
1.3779	35.41	21.99	"
1.3896	37.54	21.61	" + CO(NH <sub>2</sub> ) <sub>2</sub>
1.3790	37.91	21.06	CO(NH <sub>2</sub> ) <sub>2</sub>
1.3620	37.64	19.88	"
1.3424	37.57	18.16	"
1.3333	37.95	17.84	"
1.3145	38.28	16.25	"
1.2918	39.13	14.57	"
1.2548	39.28	11.56	"
1.2129	40.56	7.68	"
1.1757	40.56	4.50	"
1.1234	40.34	--	"

30

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
CO(NH <sub>2</sub> ) <sub>2</sub>	MgSO <sub>4</sub>	Solid Phase	CO(NH <sub>2</sub> ) <sub>2</sub>	MgSO <sub>4</sub>	Solid Phase
Results at 30° (WLS)			Results at 45° (SDB)		
0.0	28.42	MgSO <sub>4</sub> ·7H <sub>2</sub> O	--	32.23	MgSO <sub>4</sub> ·7H <sub>2</sub> O
4.13	28.16	"	9.65	31.19	"
11.15	28.00	"	18.29	29.35	"
20.80	28.32	" + 1.1.3	18.63	29.20	" + 1.1.3
(22.10)	(27.50)(SDB)	" + "	19.02	29.20	1.1.3
22.84	28.19	1.1.3	26.00	27.10	"
27.36	25.96	"	35.21	25.43	"
32.57	25.16	"	42.41	24.60	"
36.66	23.84	"	50.30	22.01	"
43.00	21.64	"	56.39	21.40	"
46.04	21.14	"	57.18	21.38	" + CO(NH <sub>2</sub> ) <sub>2</sub>
50.35	20.79	"	57.96	21.00	CO(NH <sub>3</sub> ) <sub>2</sub>
53.09	20.96	" + CO(NH <sub>2</sub> ) <sub>2</sub>	58.65	17.60	"
(53.00)	(21.50)(SDB)	" + "	59.41	13.95	"
53.39	21.08	CO(NH <sub>2</sub> ) <sub>2</sub>	60.01	12.02	"
52.15	17.63	"	60.98	10.00	"
52.93	14.18	"	62.00	8.60	"
54.79	9.21	"	62.45	5.81	"
55.42	4.47	"	63.20	4.45	"
57.00	0.0	"	65.53	--	"



# Mg MAGNESIUM

## THE SYSTEM MAGNESIUM SULFATE - URETHAN - WATER AT 25° (Palitzsch, 1928, 1929)

Gm. Mols. per 1000 gms. H <sub>2</sub> O		Solid Phase
MgSO <sub>4</sub>	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>	
3.029	0.0	MgSO <sub>4</sub> ·7H <sub>2</sub> O
0.0	35.69	Upper liquid layer
2.854	0.3704	Lower liquid layer
0.0	53.09	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>

Data for the system magnesium sulfate, phenol, and water are given by Timmermans, 1907.

SO

## Solubility of Magnesium Sulfate in Various Solvents

Solvent	t°	Saturating Phase	Solubility	Author
			Gms. per 100 Gms. CH <sub>3</sub> OH	
Methanol	15	MgSO <sub>4</sub> · $\frac{1}{2}$ CH <sub>3</sub> OH	0.276	(1)
	25	"	0.224	"
	35	"	0.180	"
	45	"	0.153	"
	55	"	0.123	"
Ethanol			Gms. per 100 Gms. C <sub>2</sub> H <sub>5</sub> OH	
	15	MgSO <sub>4</sub>	0.025	"
	35	"	0.020	"
	55	"	0.016	"
95% Formic acid Pure Glycerol (d <sub>4</sub> <sup>25</sup> = 1.246) Aq. 46.5 Wt. Percent Cane Sugar Solution			Gms. per 100 gms. sat. sol.	
	19	—	0.34	(2)
	25	—	20.8	(3)
	31.25	—	14.0	(4)

(1) Gibson, Driscoll and Jones, 1929

(2) Aschan, 1933

(3) Schnellbach and Rosin, 1929

(4) Kohler, 1897

Melting points are given for:

MgSO <sub>4</sub> + Rb <sub>2</sub> SO <sub>4</sub>	Flyushchev and Markovskaya, 1954
MgSO <sub>4</sub> + RbCl	Bergman and Golubeva, 1953
MgSO <sub>4</sub> + K <sub>2</sub> SO <sub>4</sub>	Ginsberg, 1906; Nacken, 1907a; Grahmman, 1913
MgSO <sub>4</sub> + Na <sub>2</sub> SO <sub>4</sub>	Nacken, 1907b; Sperenskaya, 1938
MgSO <sub>4</sub> + H <sub>2</sub> SO <sub>4</sub>	Kendall and Davidson, 1921

MAGNESIUM THIOSULFATE  $\text{MgS}_2\text{O}_3$ 

SO

SOLUBILITY OF MAGNESIUM THIOSULFATE IN WATER  
(Silberman and Ivanov, 1946)

The salt begins to decompose  $\text{MgS}_2\text{O}_3 \rightleftharpoons \text{S} + \text{MgSO}_3$  at about  $70^\circ$ .

$t^\circ$	Gms. $\text{MgS}_2\text{O}_3$ per 100 gms. Sat. Sol.	Solid Phase
0	30.69	$\text{MgS}_2\text{O}_3 \cdot 6\text{H}_2\text{O}$
10.5	31.97	"
28	34.51	"
36.5	35.48	"
43.5	36.10	"
46.5	36.64	"
54	37.62	"
61.25	38.91	"
73.25	41.18	"
75.75	41.45 (+0.25 gms. $\text{MgS}_2\text{O}_3$ )	"
80.75	42.80 (+0.18 gms. " )	"
85.25	44.81 (+0.35 gms. " )	"
86.75	45.0 (+0.30 gms. " )	"

Data are also given for the system  $\text{MgS}_2\text{O}_3 + 2\text{NaCl} \rightleftharpoons \text{Na}_2\text{S}_2\text{O}_3 + \text{MgCl}_2$  in water at  $25^\circ$ .

MAGNESIUM DITHIONATE  $\text{MgS}_2\text{O}_6 \cdot \text{H}_2\text{O}$ SOLUBILITY OF MAGNESIUM DITHIONATE IN WATER  
(de Baat, 1926)

$t^\circ$	$0^\circ$	$12^\circ$	$20^\circ$	$30^\circ$
Gms. $\text{MgS}_2\text{O}_6$ per 100 gms. sat. sol.	31.94	33.30	33.91	35.24

MAGNESIUM SULFAMATE  $\text{Mg}(\text{H}_2\text{NSO}_3)_2$ 

SO

SOLUBILITY OF MAGNESIUM SULFAMATE IN WATER  
(King and Hooper, 1941)

Equilibrium was attained from both under saturation and super saturation.

$t^\circ$	Gms. $\text{Mg}(\text{H}_2\text{NSO}_3)_2$ per 100 gms. $\text{H}_2\text{O}$	Solid Phase	$t^\circ$	Gms. $\text{Mg}(\text{H}_2\text{NSO}_3)_2$ per 100 gms. $\text{H}_2\text{O}$	Solid Phase
0	100.3	$\text{Mg}(\text{H}_2\text{NSO}_3)_2 \cdot 4\text{H}_2\text{O}$	50	135.3	$\text{Mg}(\text{H}_2\text{NSO}_3)_2 \cdot 4\text{H}_2\text{O}$
10	103.2	"	60	148.6	"
20	107.7	"	70	164.7	"
25*	110	"	75	177.8	"
30	114.2	"	80	197.8	"
40	122.8	"			

\*Interpolated. Cupery, 1938 found the solubility of magnesium sulfamate in water to be 119 gms. per 100 gms.  $\text{H}_2\text{O}$  at  $25^\circ$ .

# Mg MAGNESIUM

## SeO MAGNESIUM SELENITE $MgSeO_3$

The  $K_{sp}$  of magnesium selenite is  $1.29 \times 10^{-5}$  at room temperature.  
(Chukhlantsev, 1956)

## SeO MAGNESIUM SELENATE $MgSeO_4$

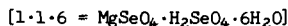
### THE SOLUBILITY OF MAGNESIUM SELENATE IN WATER (Klein, 1940)

These results are considerably higher than those of Meyer and Aulich, 1928 who allowed only 4-6 hours shaking. Note that the data of other authors agree with those of Klein.

t°	Density	Gms. $MgSeO_4$ per 100 gms. Sat. Sol.	Gms. $MgSeO_4$ per 100 gms. gms. $H_2O$	Solid Phase
- 3.5	1.2057	18.89	23.28	Ice
- 7.1	1--	26.55	36.14	" + $MgSeO_4 \cdot 7H_2O$
0.0	1.3860	31.41	45.79	$MgSeO_4 \cdot 7H_2O$
3.6	--	--	--	" + $MgSeO_4 \cdot 6H_2O$
12.8	1.4333	34.78	53.30	$MgSeO_4 \cdot 6H_2O$
20	1.4400	35.32	54.61	"
25	--	35.70 (1)	--	"
30	--	36.60 (2)	--	"
30.4	1.4488	36.20	56.54	"
40	1.4640	37.14	59.08	"
46.2	1.4732	37.81	60.79	"
60	1.5003	39.84	63.30	"
75	1.5361	42.21	73.04	"
89.5	--	--	--	$MgSeO_4 \cdot 6H_2O$ + $MgSeO_4 \cdot 4.5H_2O$
91.2*	1.5940	45.50	83.48	$MgSeO_4 \cdot 6H_2O$
95	1.5986	45.71	84.19	$MgSeO_4 \cdot 4.5H_2O$
99.5	1.6065	46.50	86.91	"

\* - metastable (1) Hill, Soth, and Ricci; (2) Lawrence and King, 1938.

### THE SYSTEM MAGNESIUM SELENATE - SELENIC ACID - WATER AT 30° (Furukawa and King, 1944)



Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$MgSeO_4$	$H_2SeO_4$		$MgSeO_4$	$H_2SeO_4$	
34.02	4.61	$MgSeO_4 \cdot 6H_2O$	21.09	44.32	1·1·6
28.33	14.65	"	17.50	48.99	"
23.78	24.85	"	16.06	50.90	"
22.94	29.20	"	15.13	52.63	"
22.57	34.55	"	12.66	56.79	" + $MgSeO_4$
22.98	35.50	" + $MgSeO_4 \cdot 4H_2O$	10.10	59.60	$MgSeO_4$
23.01	37.77	$MgSeO_4 \cdot 4H_2O$	7.28	63.47	"
22.93	39.22	"	3.24	70.29	"
22.60	41.30	"	1.98	74.09	"
22.63	41.87	"	1.68	76.11	"
22.22	43.08	" + 1·1·6	1.28	77.69	"

THE SYSTEM MAGNESIUM SELENATE - AMMONIUM SELENATE - WATER AT 30°  
(Lawrence and King, 1938)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$(\text{NH}_4)_2\text{SeO}_4$	$\text{MgSeO}_4$	Solid Phase	$(\text{NH}_4)_2\text{SeO}_4$	$\text{MgSeO}_4$	Solid Phase
0.0	36.60	$\text{MgSeO}_4 \cdot 6\text{H}_2\text{O}$	20.24	5.63	1.1.6
1.25	36.66	"	26.20	3.24	"
2.26	36.76	" + 1.1.6	33.60	1.55	"
2.53	36.08	1.1.6	36.40	1.17	"
5.03	27.60	"	40.50	0.70	"
9.73	17.48	"	52.26	0.22	"
16.60	8.95	"	55.15	0.21	" + $(\text{NH}_4)_2\text{SeO}_4$
			54.16	0.0	$(\text{NH}_4)_2\text{SeO}_4$ SeO

1.1.6 =  $\text{MgSeO}_4 \cdot (\text{NH}_4)_2\text{SeO}_4 \cdot 6\text{H}_2\text{O}$ .

THE SYSTEMS MAGNESIUM AMMONIUM SELENATE - MAGNESIUM AMMONIUM  
SULFATE - WATER AND MAGNESIUM AMMONIUM SELENATE - MAGNESIUM POTASSIUM  
SELENATE - WATER AT 25°  
(Hill, Soth, and Ricci, 1940)

The salts form continuous, hexahydrated solid solutions. Each determination was made in duplicate, and equilibrium was approached from two directions.

$\text{Mg}(\text{NH}_4)_2(\text{SeO}_4)_2 - \text{Mg}(\text{NH}_4)_2(\text{SO}_4)_2 - \text{H}_2\text{O}$				$\text{Mg}(\text{NH}_4)_2(\text{SeO}_4)_2 - \text{MgK}_2(\text{SeO}_4)_2 - \text{H}_2\text{O}$			
Sat. Sol. Wt. %		Solid Wt. %		Sat. Sol. Wt. %		Solid Wt. %	
A	B	A	B	A	C	A	C
0.0	16.58	0.0	70.02	23.31	0.0	76.21	0.0
5.68	13.32	11.45	59.71	19.01	5.96	67.98	8.18
10.39	10.39	24.91	47.20	15.07	11.91	58.22	18.15
15.32	6.93	43.9	29.7	11.42	17.16	47.23	29.61
18.28	4.57	57.92	16.87	9.07	20.50	38.81	38.26
20.12	2.68	67.53	8.30	7.29	22.97	30.59	46.61
23.31	0.0	76.21	0.0	0.0	32.15	0.0	78.23

A =  $\text{Mg}(\text{NH}_4)_2(\text{SeO}_4)_2$

B =  $\text{Mg}(\text{NH}_4)_2(\text{SO}_4)_2$

C =  $\text{MgK}_2(\text{SeO}_4)_2$

THE SYSTEM MAGNESIUM SELENATE - SODIUM SELENATE - WATER AT 25°  
(Meyer and Aulich, 1928)

The mixtures were shaken for periods of 24-36 hours. Note that the solubility in water alone is lower than that of other workers.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{Na}_2\text{SeO}_4$	$\text{MgSeO}_4$	Solid Phase	$\text{Na}_2\text{SeO}_4$	$\text{MgSeO}_4$	Solid Phase
0.0	27.5	$\text{MgSeO}_4 \cdot 6\text{H}_2\text{O}$	24.32	14.36	$\text{MgSeO}_4 \cdot 6\text{H}_2\text{O}$
12.32	20.20	"	28.76	15.18(?)	"
14.36	19.90	"	31.22	10.66	" + $\text{Na}_2\text{SeO}_4 \cdot 10\text{H}_2\text{O}$
17.20	18.30	"	33.24	8.22	$\text{Na}_2\text{SeO}_4 \cdot 10\text{H}_2\text{O}$
20.11	16.98	"	36.4	0.0	"

# Mg MAGNESIUM

## SIF MAGNESIUM FLUOSILICATE $\text{MgSiF}_6$

[See also p. 499, this volume]

### THE SYSTEM MAGNESIUM FLUOSILICATE - AMMONIUM FLUOSILICATE - WATER AT 25° (Ricci and Skarulis, 1951)

An average of 0.3%  $\text{H}_2\text{SiF}_6$  was present in the solutions.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$(\text{NH}_4)_2\text{SiF}_6$	$\text{MgSiF}_6$		$(\text{NH}_4)_2\text{SiF}_6$	$\text{MgSiF}_6$	
15.85	7.85	$(\text{NH}_4)_2\text{SiF}_6$	11.37	20.52	$(\text{NH}_4)_2\text{SiF}_6 + \text{MgSiF}_6 \cdot 6\text{H}_2\text{O}$
14.77	10.91	"	10.45	21.28	$\text{MgSiF}_6 \cdot 6\text{H}_2\text{O}$
14.36	12.23	"	7.51	22.08	"
13.61	14.01	"	4.14	22.85	"
12.48	17.32	"	2.37	23.06	"
11.62	20.19	"	0.0	23.54	"

### THE SYSTEM $\text{MgO} - \text{P}_2\text{O}_5 - \text{H}_2\text{SiF}_6 - \text{H}_2\text{O}$ AT 25° (Shpunt and Mostovich, 1957)

Additional data and diagrams are given in the original.

Solubility of  $\text{MgSiF}_6$  in  $\text{H}_3\text{PO}_4$  solutions: Solid Phase  $\text{MgSiF}_6 \cdot 6\text{H}_2\text{O}$  throughout.

Gms per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{MgO}$	F	$\text{P}_2\text{O}_5$	$\text{MgO}$	F	$\text{P}_2\text{O}_5$
5.7	16.5	0.0	1.5	2.8	33.5
4.6	12.5	7.7	1.5	3.0	35.3
4.3	10.3	13.0	0.7	1.7	45.1
2.9	7.0	21.8	0.6	0.8	55.5
2.2	4.8	27.9	0.5	0.7	57.7

### Composition of Invariant Solutions:

Gms. per 100 gms. sat. sol.			Solid Phase
$\text{MgO}$	F	$\text{P}_2\text{O}_5$	
8.7	2.3	32.9	$\text{MgSiF}_6 \cdot 6\text{H}_2\text{O} + \text{MgHPO}_4 + \text{Mg}(\text{H}_2\text{PO}_4)_2 \cdot 2\text{H}_2\text{O}$
4.0	0.3	54.9	" + $\text{Mg}(\text{H}_2\text{PO}_4)_2 + \text{Mg}(\text{H}_2\text{PO}_4)_2 \cdot 2\text{H}_2\text{O}$
8.3	0.0	33.1	$\text{MgHPO}_4 \cdot 3\text{H}_2\text{O} + \text{Mg}(\text{H}_2\text{PO}_4)_2 \cdot 4\text{H}_2\text{O}$
4.6	0.0	53.3	$\text{Mg}(\text{H}_2\text{PO}_4)_2 \cdot 2\text{H}_2\text{O} + \text{Mg}(\text{H}_2\text{PO}_4)_2 \cdot 4\text{H}_2\text{O}$
3.2	0.0	59.6	" + $\text{Mg}(\text{H}_2\text{PO}_4)_2$

MAGNESIUM SILICATES  $MgSiO_3$ ,  $Mg_2SiO_4$ 

SiO

Melting point data are given for:

$MgSiO_3 + MnSiO_3$	Lebedew, 1911
$MgSiO_3 + Na_2SiO_3$	Wallace, 1909
$Mg_2SiO_4 + Mg_2GeO_4$	Ringwood, 1956
$Mg_2SiO_4 + Ca_2SiO_4$	Toropov and Shchetnikova, 1957, 1957a

## MANGANESE Mn

SOLUBILITY OF MANGANESE IN MERCURY AT 20°  
(Irvin and Russell, 1932)

An amalgam of 1 gm. Mn in 200 gms. Hg was passed through a sintered glass filter and the manganese in the weighed filtrate found to correspond to a solubility of 0.001 percent with an error of 10%. A determination by Tammann, Kollmznn and Hinuber, 1927, by the electrometric method, gave 0.00025 gm. Mn per 100 gm. Hg.

For data on the system Mn-C, see Isobe, 1951.

## MANGANESE ARSENATES

AsO

THE SYSTEM  $MnO - As_2O_5 - H_2O$ 

The results of Takahashi and Sasaki, 1953 at 30° are in good agreement with those of Amadori, 1922 at 25°. The data of Grube, Heller and Herrmann (25°) obtained from supersaturation ( $MnCO_3$  added to  $H_3AsO_4$  solutions) are apparently incorrect.

At 75°, Kuperman and Belopol'skii, 1955 found  $MnHASO_4 \cdot 4H_2O$  in contact with solutions containing up to 40%  $As_2O_5$ . At 25° the monohydrate  $MnHASO_4 \cdot H_2O$  is reported over the same range of concentration (T. and S., A.). In addition, Grube et al reported finding the 4-hydrate but not the 1-hydrate at 25°. Thus both hydrates probably exist but their stability relations are not certain.

Results at 25°  
(Amadori, 1922)

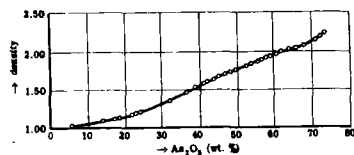
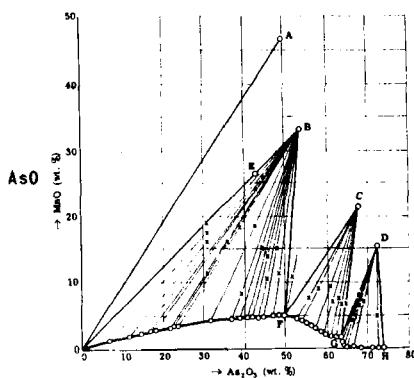
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$As_2O_5$	MnO		$As_2O_5$	MnO	
7.51	1.08	$MnHASO_4 \cdot H_2O$	55.50	4.01	$Mn(H_2AsO_4)_2 \cdot H_2O$
13.72	1.87	"	58.42	2.68	"
19.97	2.57	"	59.81	2.75	"
26.90	3.21	"	60.62	2.70	"
33.18	3.82	"	64.57	1.28	$Mn(H_2AsO_4) \cdot H_3AsO_4$
40.24	4.42	"	70.54	0.15	"
47.22	5.39	"	72.42	0.05	"
52.25	5.02	$Mn(H_2AsO_4)_2 \cdot H_2O$	72.77	0.03	"

(Cont.)

# Mn MANGANESE

## THE SYSTEM MnO - As<sub>2</sub>O<sub>5</sub> - H<sub>2</sub>O--Cont.

Results at 30°  
(Takahashi and Sasaki, 1953)



A = Mn<sub>3</sub>(AsO<sub>4</sub>)<sub>2</sub>·H<sub>2</sub>O

B = MnHAsO<sub>4</sub>·H<sub>2</sub>O

C = Mn(H<sub>2</sub>AsO<sub>4</sub>)<sub>2</sub>

D = Mn(H<sub>2</sub>AsO<sub>4</sub>)<sub>2</sub>·H<sub>3</sub>AsO<sub>4</sub>

E = MnHAsO<sub>4</sub>·4H<sub>2</sub>O

F = 50.19% As<sub>2</sub>O<sub>5</sub>

G = 63.14% As<sub>2</sub>O<sub>5</sub>

H = 72.97% As<sub>2</sub>O<sub>5</sub>

Results at 75°  
(Kuperman and Belopol'skii, 1955)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
As <sub>2</sub> O <sub>5</sub>	MnO		As <sub>2</sub> O <sub>5</sub>	MnO	
0.22	0.71	MnHAsO <sub>4</sub> ·4H <sub>2</sub> O	7.57	0.73	MnHAsO <sub>4</sub> ·4H <sub>2</sub> O
0.33	0.78	"	15.65	0.98	"
3.37	0.50	"	17.00	1.13	"
3.47	0.43	"	19.19	1.14	"
4.22	0.49	"	25.57	1.39	"
6.36	0.72	"	30.18	1.73	"
6.83	0.72	"	39.98	2.44	"

The Ksp of Mn<sub>3</sub>(AsO<sub>4</sub>)<sub>2</sub> is  $1.9 \pm 0.7 \times 10^{-29}$  at 20°.

(Chuklantsev, 1956)

MANGANESE BORATES  $\text{MnH}_4(\text{BO}_3)_2$ ,  $\text{MnBO}_3$ 

80

SOLUBILITY IN WATER AND IN AQUEOUS SALT SOLUTIONS  
(Hartley and Ramage, 1893)

t°	Grams $\text{MnH}_4(\text{BO}_3)_2$ per Liter in Solutions of:				
	$\text{H}_2\text{O}$ + trace $\text{Na}_2\text{SO}_4$	$\text{Na}_2\text{SO}_4$ (0.2 Gms. per Liter)	$\text{Na}_2\text{SO}_4$ (20 Gms. per Liter)	$\text{NaCl}$ (20 Gms. per Liter)	$\text{CaCl}_2$ (20 Gms. per Liter)
14	0.94	1.7	0	--	--
18	--	--	0.77	1.31	2.91
40	0.50	0.69 (52°)	0.65	--	2.44
60	--	--	0.36	0.60	2.25
80	0.08	--	0.12	0.29	1.35

100 gms. of a saturated solution in furfural contain 0.02 gms. of  $\text{MnBO}_3$  at 25°. (Trimble, 1941)

MANGANESE BROMIDE  $\text{MnBr}_2$ 

Br

SOLUBILITY IN WATER  
(Etard, 1894)

t°	Gms. $\text{MnBr}_2$ per 100 Gms. Solution	Solid Phase	t°	Gms. $\text{MnBr}_2$ per 100 Gms. Solution	Solid Phase
-20	52.3	$\text{MnBr}_2 \cdot 4\text{H}_2\text{O}$	40	62.8	$\text{MnBr}_2 \cdot 4\text{H}_2\text{O}$
-10	54.2	"	50	64.5	"
0	56.0	"	60	66.3	"
10	57.6	"	70	68.0	"
20	59.5	"	80	69.2	$\text{MnBr} \cdot 2\text{H}_2\text{O}$
25	60.2	"	90	69.3	"
30	61.1	"	100	69.5	"

MANGANESE ACETATE  $\text{Mn}(\text{CH}_3\text{COO})_2$ 

CH

100 gms.  $\text{H}_2\text{O}$  dissolve 64.5 gms.  $\text{Mn}(\text{CH}_3\text{COO})_2 \cdot 4\text{H}_2\text{O}$  at 5°. The determination was made by adding water gradually to a weighed amount of the pure compound until the last few remaining fragments of crystals just disappeared.

(Cadenhead and Vining, 1924)

100 gms. Methyl Alcohol, sat. with anhydrous Mn Acetate, dissolve 4.76 gms.  $\text{Mn}(\text{CH}_3\text{COO})_2$  at 15° and 12.30 gm. at 66.2° (b.pt.).

(Henstock, 1934)

100 gms. of a saturated solution in furfural contain 0.02 gms.  $\text{Mn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 4\text{H}_2\text{O}$  at 25°.

(Trimble, 1941)



## Mn MANGANESE

### CH MANGANESE GLUCONATE $\text{Mn}(\text{C}_6\text{H}_{11}\text{O}_7)_2$

100 gms. sat. solution of manganese gluconate in water contain 16.8 gms.  $\text{Mn}(\text{C}_6\text{H}_{11}\text{O}_7)_2$  at 25°.

(May, Weisberg and Herrick, 1929)

### MANGANESE BENZOATE $\text{Mn}(\text{C}_6\text{H}_5\text{COO})_2$ (and derivatives)

SOLUBILITY OF VARIOUS BENZOATES IN WATER AT 20°  
(Ephraim and Pfister, 1925)

Compound	Formula	Gms. anhydrous cmpd. per 100 cc. sat. sol.
Manganese Benzoate	$\text{Mn}(\text{C}_6\text{H}_5\text{COO})_2 \cdot 2\text{H}_2\text{O}$	4.82
" -4 Chlor Benzoate	$\text{Mn}(\text{C}_6\text{H}_4 \cdot \text{Cl} \cdot \text{COO})_2 \cdot 2\text{H}_2\text{O}$	1.157
" -4 Oxy "	$\text{Mn}(\text{C}_6\text{H}_4 \cdot \text{OH} \cdot \text{COO})_2 \cdot 8\text{H}_2\text{O}$	3.324
" -4 Methoxy "	$\text{Mn}(\text{C}_6\text{H}_4 \cdot \text{OCH}_3 \cdot \text{COO})_2 \cdot 3\text{H}_2\text{O}$	1.452
" -4 Nitro "	$\text{Mn}(\text{C}_6\text{H}_4 \cdot \text{NO}_2 \cdot \text{COO})_2 \cdot 6\text{H}_2\text{O}$	1.341

### CH MANGANESE CINNAMATE $\text{MnC}_{18}\text{H}_{14}\text{O}_4 \cdot 2\text{H}_2\text{O}$

t°	Solubility	Author
20	0.214 gm. $\text{MnC}_{18}\text{H}_{14}\text{O}_4$ per 100 cc. sat. sol.	(Ephraim and Pfister, 1925)
26	0.26 gm. $\text{MnC}_{18}\text{H}_{14}\text{O}_4$ per 100 gms. $\text{H}_2\text{O}$	(DeJong, 1909)

### MANGANESE FUMARATE $\text{MnC}_4\text{H}_2\text{O}_4$

100 gms.  $\text{H}_2\text{O}$  dissolve 0.14 gm.  $\text{MnC}_4\text{H}_2\text{O}_4$  at 30°.

(Weiss and Downs, 1923)

### MANGANESE HELIANTHATE $(\text{C}_{14}\text{H}_{14}\text{N}_3\text{SO}_3)_2 \cdot 4\text{H}_2\text{O}$

1000 cc.  $\text{H}_2\text{O}$  dissolve 0.06 gm. of the salt at 20-25°.

(Stark and Dehn, 1918)

## MANGANESE Anthracene, Benzene and Naphthalene SULFONATES

CH

SOLUBILITY OF EACH SEPARATELY IN WATER  
(Ephraim and Pfister, 1925, 1925a; Ephraim and Seger, 1925)

Compound	Formula	t°	Gms. Anhydrous compd. per 100 cc. sat. sol.
Manganese Anthracene-1-sulfonate	$\text{Mn}(\text{C}_{14}\text{H}_9\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	20	0.0477
" " -2- "	"	20	0.00575
" Benzene sulfonate	$\text{Mn}(\text{C}_6\text{H}_5\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	18	13.998
" " "	"	20	16.348
" " "	"	34	18.840
" " "	"	49.5	24.696
" " "	"	64.5	32.215
" " "	"	80.5	42.924
" Naphthalene-1-sulfonate	$\text{Mn}(\text{C}_{10}\text{H}_7\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	17.0	0.479
" " -2- "	"	16.5	0.334
" " " "	"	20	0.384
" " " "	"	32	0.532
" " " "	"	45	0.816
" " " "	"	59	1.359
" " " "	"	70.5	1.946
" " " "	"	74	2.186
" " " "	"	77	2.382
" " " "	"	81.5	2.859
" " -5-chlor-1-sulfonate	$\text{Mn}(\text{C}_{10}\text{H}_6\text{SO}_3\text{Cl})_2 \cdot \text{H}_2\text{O}$	20	0.742
" " -6- oxy -2- "	$\text{Mn}(\text{C}_{10}\text{H}_7\text{SO}_3)_2 \cdot 8\text{H}_2\text{O}$	20	1.200

## MANGANESE QUINOLATES

CH

- (1) Manganese 8-hydroxy quinolate pH for complete extrac-  
tion into  $\text{CHCl}_3$  = 7.2 - 12.5
- (2) " " "  $K_{sp}$  (room temperature) =  $1.6 \times 10^{-18}$
- (2) " 2 methyl-8-hydroxy quinolate  $K_{sp}$  (room temperature) =  $4.5 \times 10^{-19}$
- (3) " 8 quinilinol-5-sulfonate  $K_{sp}$  (25°) =  $1.62 \times 10^{-10}$

- (1) Gentry and Sherrington, 1950  
(2) Borrel and Paris, 1952  
(3) Laasanen and Uusitalo, 1954

MANGANESE FERROCYANIDE  $\text{Mn}_2\text{Fe}(\text{CN})_6$ 

CN

A saturated solution of manganese ferrocyanide in water at 2° contains  $4.0 \times 10^{-3}$  gm. ions  $\text{Mn}^{++}$  per liter.

(Tananaev, Glushkova and Seifer, 1956)

Mg MANGANESE

CO MANGANESE OXALATE  $\text{MnC}_2\text{O}_4$

SOLUBILITY OF EACH OF THE HYDRATES SEPARATELY IN WATER  
(Chamberlain, Hume and Topley, 1926)

Saturation was secured by constant stirring in a thermostat. The trihydrate changes gradually to the dihydrate. The error due to this change was very slight.

The results in parentheses are by Chatterjee and Dhar, 1924.

Results for the Dihydrate			Results for the Trihydrate		
t°	Gms. $\text{MnC}_2\text{O}_4$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{MnC}_2\text{O}_4$ per 100 gms. sat. sol.	Solid Phase
0.0	0.0198	$\text{MnC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$	0.0	0.0326	$\text{MnC}_2\text{O}_4 \cdot 3\text{H}_2\text{O}$
6.3	0.0225	"	6.3	0.0388	"
12.8	0.0256	"	12.8	0.0476	"
18	0.02697 (1)	"	18	0.05368 (1)	"
20.1	0.0285	"	20.1	0.0582	"
25.0	0.0308	"	25.0	0.0669	"
	0.03087 (2)	"	30.0	0.0769	"
	0.03104 (4)	"	93.0	(0.0780)	$\text{MnC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$
	0.0312 (3)	"			
30.3	0.0335	"			
36.0	0.0369 (0.0375)	"			

(1) Scholder, 1930 (gms./100 cc. sat. sol.)

(2) Money and Davis, 1934 (gms./100 cc. sat. sol.)

(3) Hauser and Wirth, 1909

(4) Accascina, Schiavo and Sorrentino, 1953 (g./100 g.  $\text{H}_2\text{O}$ )

SOLUBILITY OF MANGANESE OXALATE IN VARIOUS SOLUTIONS AT 25°  
(Results of Hauser and Wirth, 1909)

Aq. Oxalic Acid Per 1000		Aq. Ammonium Oxalate Per 1000		Aq. Sulfuric Acid Per 1000		Solid Phase
Gms. Sat. sol.		Gms. Sat. Sol.		Gms. Sat. Sol.		
G. Mols. ( $\text{COOH}$ ) <sub>2</sub>	Gms. $\text{Mn}(\text{COO})_2$	G. Mols. ( $\text{NH}_4$ ) <sub>2</sub> ( $\text{COO}$ ) <sub>2</sub>	Gms. $\text{Mn}(\text{COO})_2$	Normality $\text{H}_2\text{SO}_4$	Gms. $\text{Mn}(\text{COO})_2$	
0	0.312	0.005	0.338	0.025	1.825	$\text{MnC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$
0.0125	0.759	0.025	0.479	0.24	8.850	"
0.025	0.930	0.050	0.761	1.00	25.955	"
0.050	1.080	0.125	1.789	2.389	51.080	"
0.125	1.396	0.245	3.970	2.987	60.109	$\text{MnC}_2\text{O}_4 \cdot 2\text{H}_2\text{O} +$ ( $\text{COOH}$ ) <sub>2</sub>
0.25	1.708	0.245	4.005	3.952	73.200	"
0.49	2.081	0.281	4.650	4.500	82.401	"

Results are also given for the solubility of  $\text{MnC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$  in aq. solutions of  $\text{H}_2\text{SO}_4$  containing also about 0.25 gm. mols. free oxalic acid per liter at 25°.

(Results of Money and Davies, 1934)

Aq. Manganese Chloride		Aq. Potassium Oxalate		Aq. Sodium Oxalate	
Gm. Mols. per liter sat. sol.		Gm. Mols. per liter sat. sol.		Gm. Mols. per liter sat. sol.	
MnCl <sub>2</sub>	MnC <sub>2</sub> O <sub>4</sub>	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	MnC <sub>2</sub> O <sub>4</sub>	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	MnC <sub>2</sub> O <sub>4</sub>
0.0	0.00216	0.0405	0.002869	0.07806	0.004624
0.005	0.001672	0.1198	0.006065	0.1600	0.007708
0.05	0.0016	0.1994	0.009529	0.2411	0.01097

(Results of Accascina, Schiavo and Sorrentino, 1953)

m = molality of salt

s = soly. MnC<sub>2</sub>O<sub>4</sub> in moles/1000 gms. H<sub>2</sub>O

Aq. K <sub>2</sub> SO <sub>4</sub>		Aq. Na <sub>2</sub> SO <sub>4</sub>		Aq. NaCl		Aq. KCl	
m	s	m	s	m	s	m	s
0.000	0.00217	--	--	--	--	--	--
0.0110	0.00283	0.00957	0.00277	0.0940	0.00309	0.157	0.00344
0.0318	0.00350	0.0291	0.00345	0.190	0.00356	0.401	0.00438
0.0841	0.00482	0.0493	0.00398	0.473	0.00459	0.427	0.00445
0.165	0.00607	0.0976	0.00502	0.950	0.00557	0.841	0.00545
0.251	0.00743	0.240	0.00725	1.434	0.00629	1.276	0.00636
0.353	0.00870	0.476	0.01001	1.929	0.00688	1.617	0.00695
0.426	0.00964	0.726	0.01249	2.480	0.00732	2.193	0.00751
		0.971	0.01433	3.014	0.00751	3.001	0.00822
				3.540	0.00783		

MANGANESE CARBONATE MnCO<sub>3</sub>

CO

SOLUBILITY OF MANGANESE CARBONATE IN WATER  
(Smurov, 1938)(The total pressure of CO<sub>2</sub> + H<sub>2</sub>O was one atmosphere)

Partial Pressure CO <sub>2</sub> in atm.	Gms. Mn per 100 gms. Sat. Sol.				
	5°	15°	40°	50°	80°
0.0005	0.0011	0.0009	0.0003	0.0002	0.0001
0.005	.0026	.0022	.0008	.0006	.0002
0.05	.0061	.0052	.0019	.0014	.0005
0.10	.0078	.0068	.0025	.0018	.0007
1.0	--	.04 (18°)*	--	--	--
56	--	.080 (18°)*	--	--	--

\*Haehnel, 1924

Data for the system  $\text{MnCO}_3 + \text{CaCl}_2 \rightleftharpoons \text{CaCO}_3 + \text{MnCl}_2 (+\text{H}_2\text{O})$  at 100° and 200° in solutions containing 1-8 moles CaCl<sub>2</sub> per liter are given by Shamovskii, 1955. Up to 3.4M CaCl<sub>2</sub>, the Mn<sup>++</sup>/Ca<sup>++</sup> ratio =  $6.65 \times 10^{-3}$ .

For data in the system  $\text{MnCO}_3 + \text{CaCO}_3$  at high temperatures and pressures see Goldsmith and Graf, 1957.

# Mn MANGANESE

## CO MANGANESE Camphor CARBONATE $\text{Mn}(\text{C}_{10}\text{H}_{15}\text{O}\cdot\text{COO})_2$

1000 cc. sat. solution of Manganese Campho Carbonate in Methyl Alcohol contain 10.5 gms.  $\text{Mg}(\text{C}_{10}\text{H}_{15}\text{O}\cdot\text{COO})_2$  at  $10.5^\circ$ .

1000 cc. sat. solution of Manganese Campho Carbonate in Ethyl Alcohol contain 0.36 gm.  $\text{Mg}(\text{C}_{10}\text{H}_{15}\text{O}\cdot\text{COO})_2$  at  $9^\circ$ .  
(Picon, 1931)

## CI MANGANESE CHLORIDE $\text{MnCl}_2$

### SOLUBILITY IN WATER

(Etard; Dawson and Williams, 1899; Suss, 1913;  
above  $100^\circ$ : Benrath, 1934, 1941)

Figures in parentheses are densities.

t°	Gms. $\text{MnCl}_2$ per 100 gms. sat. sol.	Solid Phase
-25.6	30.5*	Ice + $\text{MnCl}_2\cdot 6\text{H}_2\text{O}$
-2	38.6*	$\text{MnCl}_2\cdot 4\text{H}_2\text{O}$ + "
-20	35.0m	$\text{MnCl}_2\cdot 4\text{H}_2\text{O}$
-10	37.0m	"
0	38.8	"
+10	40.5	"
20	42.5	"
25	43.55 (1.4991)	"
30	44.68 (1.5049)	"
40	46.96 (1.5348)	"
50	49.53 (1.5744)	"
58	51.35 (1.6097)	" + $\text{MnCl}_2$
60	52.06 (1.6108)	•• $\text{MnCl}_2$
70	52.52 (1.6134)	"
80	52.98	"
90	53.2	"
100	53.5	"
113	54.5	"
121	55.0	"
146	56.7	$\text{MnCl}_2\cdot 2\text{H}_2\text{O}$
155	57.9	"
176	58.6	"
189	61.3	"
198	63.7	" + $\text{MnCl}_2\cdot \text{H}_2\text{O}$
217	64.5	$\text{MnCl}_2\cdot \text{H}_2\text{O}$
249	66.9	"
272	69.6	"
286	71.3	"
313	75.1	"
321	76.5	"
328	78.5	"
333	79.5	"
345	81.5	"
350	82.5	"
353	83.5	"
362	85.0	$\text{MnCl}_2\cdot \text{H}_2\text{O}$ + $\text{MnCl}_2$
392	85.5	$\text{MnCl}_2$
430	86.5	"

m & metastable

\*Ozerov, 1953 reports the eutectic to be  $-49.1^\circ$ , 37.3%  $\text{MnCl}_2$ , and the  $6 \rightarrow 4\cdot\text{H}_2\text{O}$  transition to be at  $-6.4^\circ$ . These values do not fall on the same curve as the above data.

THE SYSTEM MANGANESE CHLORIDE - POTASSIUM CHLORIDE - WATER  
(Suss, 1913)

Gms. per 100 gms. sat. sol.

MnCl <sub>2</sub> KCl		Solid Phase
<u>At 6°</u>		
40.23	0.0	MnCl <sub>2</sub> ·4H <sub>2</sub> O
35.94	9.41	" + 1·1·2 + KCl
0.0	23.00	KCl
<u>At 28.4°</u>		
44.46	0.0	MnCl <sub>2</sub> ·4H <sub>2</sub> O
43.28	8.66	" + 1·1·2
38.65	13.79	"
0.0	26.91	KCl
<u>At 52.8°</u>		
50.14	6.01	MnCl <sub>2</sub> ·4H <sub>2</sub> O + MnCl <sub>2</sub> ·2H <sub>2</sub> O + 1·1·2
<u>At 58.3°</u>		
51.72	0.0	MnCl <sub>2</sub> ·4H <sub>2</sub> O + MnCl <sub>2</sub> ·2H <sub>2</sub> O
<u>At 62.6°</u>		
51.86	0.0	MnCl <sub>2</sub> ·2H <sub>2</sub> O
49.95	6.67	" + 1·1·2
44.05	12.49	1·1·2 + 1·2·2
36.85	18.77	1·2·2 + 1·4
0.0	31.57	KCl
1·1·2 = MnCl <sub>2</sub> ·KCl·2H <sub>2</sub> O;      1·2·2 = MnCl <sub>2</sub> ·2KCl·2H <sub>2</sub> O;      1·4 = MnCl <sub>2</sub> ·4KCl.		

1·1·2 = MnCl<sub>2</sub>·KCl·2H<sub>2</sub>O;    1·2·2 = MnCl<sub>2</sub>·2KCl·2H<sub>2</sub>O;    1·4 = MnCl<sub>2</sub>·4KCl.

THE SYSTEM MANGANESE CHLORIDE - AMMONIUM CHLORIDE - WATER

This system has been studied extensively with generally good agreement among the results. The double salt MnCl<sub>2</sub>·2NH<sub>4</sub>Cl·2H<sub>2</sub>O is found which forms solid solutions with NH<sub>4</sub>Cl and to some degree with MnCl<sub>2</sub>. At some temperatures these are three series of solid solutions that are all dihydrated. MnCl<sub>2</sub>·4H<sub>2</sub>O exists as a pure solid. The data of Foote and Saxton, 1914 and Clendinnen and Rivett, 1921 (below) are typical.

In addition, Clendinnen and Rivett, 1921 give data at 25°, and in 1923 give results upon a critical solution temperature for solids in the binary system ammonium chloride-manganous chloride dihydrate. Eight isotherms between 10° and 60° were studied and the results of the analyses of the solutions and wet solid phases are given. The percentage of ammonium chloride in the solution and solid phases were plotted and the isothermal distribution curves thus obtained. These show regions of homogeneous single-phase mixed crystals and also a heterogeneous region. This latter was studied in considerable detail.

## Mn MANGANESE

Other data in agreement with these are given by Kurnakow and Woskressenskaya, 1937 at 25°, Greenberg and Walden, 1940 and Grenall, 1949. The latter authors (G. and W., G.) made x-ray studies of the solid phases. The results of Benrath and Schackmann, 1935 may be in error.

### Results at 25° (Foote and Saxton, 1914)

$\alpha$  mixed crystals consist of  $\text{NH}_4\text{Cl}$  with varying amounts of  $\text{MnCl}_2 \cdot 2\text{H}_2\text{O}$ ;  $\beta$  mixed crystals consist of the double salt  $2\text{NH}_4\text{Cl} \cdot \text{MnCl}_2 \cdot 2\text{H}_2\text{O}$  with excess of  $\text{NH}_4\text{Cl}$ .

Cl	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{NH}_4\text{Cl}$	$\text{MnCl}_2$		$\text{NH}_4\text{Cl}_2$	$\text{MnCl}_2$	
	23.97	7.97	$\alpha$ mixed crystals	17.09	18.76	$\beta$ mixed crystals or double salt $2\text{NH}_4\text{Cl} \cdot \text{MnCl}_2 \cdot 2\text{H}_2\text{O}$
	22.94	9.65		15.05	22.44	
	21.44	12.31		13.17	24.52	
	21.18	13.38		9.15	29.24	
	20.10	15.19		5.90	34.78	
				3.77	39.48	
	19.70	15.92	$\alpha$ and $\beta$ mixed crystals			$2\text{NH}_4\text{Cl} \cdot \text{MnCl}_2 \cdot 2\text{H}_2\text{O}$ + $\text{MnCl}_2 \cdot 2\text{H}_2\text{O}$
	19.75	16.02		2.98	43.71	
	19.67	15.47		2.94	43.44	

### Results at 60° (Clendinnen and Rivett, 1921)

The solid phases lie on the line connecting the compositions of pure ammonium chloride and the dihydrate of manganous chloride. The system is of a somewhat uncommon type. There are three very well-defined series of mixed crystals, namely, AF, GH, and KD with two gaps, FG and HK. The composition of the alleged compound  $2\text{NH}_4\text{Cl} \cdot \text{MnCl}_2 \cdot 2\text{H}_2\text{O}$  is well within the second series GH.

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{NH}_4\text{Cl}$	$\text{MnCl}_2$			$\text{NH}_2\text{Cl}$	$\text{MnCl}_2$	
1.105	33.52	2.91	Mixed	1.365	10.52	32.80	Mixed Crystals Series GH
1.129	31.93	5.84	Crystals	1.426	7.55	38.02	
1.183	29.50	10.16	Series	1.482	5.44	43.10	
1.192	27.81	12.95	AF	1.543	3.98	47.20	H and K
1.200	27.07	13.79	F and G	1.575	2.94	49.33	
1.210	25.28	15.91	Mixed	1.581	2.45	50.22	Mixed Crystals
1.239	22.51	18.81	Crystals	1.583	2.21	50.68	
1.267	19.04	22.42	Series	1.592	1.61	51.16	Series KD
1.317	14.33	27.74	GH	1.619	0.91	51.47	

### SOLUBILITY OF MANGANESE CHLORIDE IN OTHER SOLVENTS

100 cc of a saturated solution of  $\text{MnCl}_2$  in a mixture of equal volumes of ethyl ether and water, saturated with  $\text{HCl}$  at 0°, contain 0.86 gms.  $\text{MnCl}_2$ .

(Fischer and Seidel, 1941)

100 gms. sat. solution of manganese chloride in selenium oxychloride ( $\text{SeOCl}_2$ ) contain 0.16 gm.  $\text{MnCl}_2$  at  $25^\circ$ .

(Wise, 1923)

100 cc. anhydrous hydrazine dissolve 13 gms.  $\text{MnCl}_2$  at about  $20^\circ$ .

(Welsh and Broderson, 1915)

100 gms. pyridine dissolve 1.28 gms.  $\text{MnCl}_2$  at  $0^\circ$  and 1.06 gms. at  $25^\circ$ .

(Miller, R., 1924)

Melting point data are given for:

$\text{MnCl}_2 + \text{PbCl}_2$	(Sandonnini, 1911, 1914)
$\text{MnCl}_2 + \text{SnCl}_2$	(Sandonnini, 1911; Sandonnini and Scarpa, 1911)
$\text{MnCl}_2 + \text{ZnCl}_2$	(Sandonnini, 1912, 1914)
$\text{MnCl}_2 + \text{TlCl}$	(Gromakov, 1951)
$\text{MnCl}_2 + \text{RbCl}$	(Markov and Chernov, 1958)
$\text{MnCl}_2 + \text{CsCl}$	(Markov and Chernov, 1958)

#### MANGANESE PERCHLORATE $\text{Mn}(\text{ClO}_4)_2 \cdot 6\text{H}_2\text{O}$

C10

SOLUBILITY OF MANGANESE PERCHLORATE IN SEVERAL SOLVENTS AT ABOUT  $20^\circ$

(Chaney and Mann, 1931)

The determinations were made by adding, at room temperature, successive small amounts of solvent to a weighed amount of the salt until, upon vigorous shaking, the last trace of perchlorate just disappeared.

Solvent	Gms. $\text{Mn}(\text{ClO}_4)_2 \cdot 6\text{H}_2\text{O} (?)$ per 100 cc. solvent
Water	268*
Furfural ( $\text{C}_4\text{H}_3\text{OCHO}$ of $d_{20} = 1.550$ )	90
Cellosolve (Monoethyl ether of ethylene glycol)	130

\*Salvadori, 1912.

#### MANGANESE Hexa Antipyrine PERCHLORATE $\text{Mn}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6 \cdot (\text{ClO}_4)_2$

100 cc. sat. solution of the salt in water contain 3.63 gm.  $\text{Mn}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6 \cdot (\text{ClO}_4)_2$  at  $20^\circ$ .

(Wilke-Dorfurt and Schliephake, 1929)



# Mn MANGANESE

## F MANGANESE FLUORIDE $\text{MnF}_2$

SOLUBILITY IN WATER  
(Nuka, 1929; Ryss and Vitukhnovskaya, 1955)

Nuka did not identify the solid phase. His data agree with those found by Ryss and Vitukhnovskaya for the anhydrous salt. The tetrahydrate is stable below 23.5°. The result of Carter, 1928 is incorrect.

$t^\circ$	Gms. $\text{MnF}_2$ per 100 gms. sat. sol.	Solid Phase	$t^\circ$	Gms. $\text{MnF}_2$ per 100 gms. sat. sol.	Solid Phase
0	0.800	$\text{MnF}_2 \cdot 4\text{H}_2\text{O}$	30	1.060	$\text{MnF}_2$
12	0.908	"	40	0.66	"
20	0.970	"	60	0.44	"
23.5	1.00	" + $\text{MnF}_2$	100	0.48	"
0	1.380*	$\text{MnF}_2$			
20	1.060*	"			
	1.05 *(N.)	"			

\*metastable; N. = Nuka

SOLUBILITY OF MANGANESE FLUORIDE IN AQUEOUS SOLUTIONS OF  
HYDROFLUORIC ACID

Results at 0°			Results at 20°		
Ryss and Vitukhnovskaya, 1955			Kurtenacker, Finger and Hey, 1933		
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
HF	$\text{MnF}_2$		HF	$\text{MnF}_2$	
3.85	2.80	$\text{MnF}_2 \cdot 4\text{H}_2\text{O}$	5.28	2.88	$\text{MnF}_2$
7.56	3.65	"	17.05	3.73	"
12.00	3.53	"	36.42	0.72	"
13.28	5.10	"			

## F MANGANESE AMMONIUM FLUORIDE $\text{MnNH}_4\text{F}_3$

100 gms. sat. solution of Manganese Ammonium Fluoride in Water contain 1.2 gm.  $\text{MnNH}_4\text{F}_3$  at 20°.

(Nuka, 1929)

## MANGANESE AMINE FLUORIDES

F

SOLUBILITY OF EACH SEPARATELY IN ETHYL ALCOHOL AND  
IN ACETIC ACID AT 20°  
(Olsson, 1930)

An excess of each compound was shaken with the solvent and the saturated solution analyzed for manganese by reduction with SO<sub>2</sub> and precipitating as manganese ammonium phosphate and weighing as the pyrophosphate.

Compound	Formula	Gms. Compound (7H <sub>2</sub> O of Cryst.) per 100 cc. sat. sol. in:	
		C <sub>2</sub> H <sub>5</sub> OH	CH <sub>3</sub> COOH
Manganese:			
Pyridine Tetra Fluoride	C <sub>5</sub> H <sub>5</sub> NHMnF <sub>4</sub> ·H <sub>2</sub> O	0.729	3.926
Quinoline " "	C <sub>9</sub> H <sub>7</sub> NHMnF <sub>4</sub> ·3H <sub>2</sub> O	1.560	15.456
Tetra methyl ammonium fluoride	(CH <sub>3</sub> ) <sub>4</sub> NMnF <sub>4</sub> ·2H <sub>2</sub> O	0.289	4.326
Ethylene di amine penta "	C <sub>2</sub> H <sub>4</sub> (NH <sub>2</sub> ) <sub>2</sub> H <sub>2</sub> MnF <sub>5</sub> ·(H <sub>2</sub> O?)	0.003	0.102
Guanidine tetra fluoride	CNH(NH <sub>2</sub> ) <sub>2</sub> H MnF <sub>4</sub> ·3H <sub>2</sub> O	0.029	0.449
" penta "	[CNH(NH <sub>2</sub> ) <sub>2</sub> H] <sub>2</sub> MnF <sub>5</sub>	0.013	0.053

DISTRIBUTION OF MnF<sub>2</sub> BETWEEN ETHER AND AQ. HF SOLUTIONS AT 20°  
(Bock and Herrmann, 1956)

Acidic 0.1 molar MnF<sub>2</sub> solution was shaken with an equal volume of diethyl ether. α = MnF<sub>2</sub> in organic layer/MnF<sub>2</sub> in aqueous layer.

Molarity of HF:	1	5	10	15	20
α :	<0.0005	<0.0005	0.002	0.005	0.013

MANGANESE Hexa Antipyrine FLUOBORATE [Mn(COC<sub>10</sub>H<sub>12</sub>N<sub>2</sub>)<sub>6</sub>](BF<sub>4</sub>)<sub>2</sub>

BF

100 cc. sat. solution of Manganese Hexa Antipyrine Fluoroborate in water contain 5.4 gms. Mn(COC<sub>10</sub>H<sub>12</sub>N<sub>2</sub>)<sub>6</sub> (BF<sub>4</sub>)<sub>2</sub> at 20°.  
(Wilke-Dorfurt and Mureck, 1929)

MANGANESE FLUOSILICATE MnSiF<sub>6</sub>·6H<sub>2</sub>O

SiF

100 gms. H<sub>2</sub>O dissolve 140 gms. of the salt at 17.5°. Sp. Gr. of the solution = 1.448.

(Stolba, 1883)

MANGANESE IODIDE MnI<sub>2</sub>

100 gms. Liquid Ammonia dissolve 0.02 gm. MnI<sub>2</sub> at 0°.

(Hunt and Boncyk, 1933)

# Mn MANGANESE

## I MANGANESE MERCURIC IODIDE $3\text{MnI}_2 \cdot 5\text{HgI}_2 \cdot 20\text{H}_2\text{O}$

A saturated solution of the salt in water at 17° has the composition  $1.4 \text{ MnI}_2 \cdot \text{HgI}_2 \cdot 10.22\text{H}_2\text{O}$  and density 2.98.

(Duboin, 1906)

## IO MANGANESE IODATE $\text{Mn}(\text{IO}_3)_2$

### SOLUBILITY IN VARIOUS SOLUTIONS

(Hayes and Martin, Jr., 1951)

Solvent, moles per 100 gms. $\text{H}_2\text{O}$	Sat. sol.: Moles $\text{Mn}(\text{IO}_3)_2$ per 1000 gms. $\text{H}_2\text{O}$			
	3°	25°	45°	90°
Water	0.00568	0.00658	0.00713	0.00854
0.01007m NaCl	0.00621	0.00694	---	---
0.02462 "	0.00665	0.00761	---	---
0.0554 "	0.00751	0.00836	---	---
0.1108 "	0.00786	0.00896	---	---
0.407 "	0.00902	0.01041	---	---
0.00688m $\text{KIO}_3$	---	0.00474	---	---
0.02213 "	---	0.00211	---	---
0.0622 "	---	0.000685	---	---
0.1091 "	---	0.000301	---	---
0.01030m $\text{Mn}(\text{ClO}_4)_2$	---	0.00531	---	---
0.00743 "	---	0.00560	---	---

## MOO MANGANESE AMMONIUM MOLYBDATE $\text{Mn}_2(\text{Mo}_2\text{O}_7)_3 \cdot 5(\text{NH}_4)_2\text{MoO}_4 \cdot 12\text{H}_2\text{O}$

100 gms.  $\text{H}_2\text{O}$  dissolve 0.98 gms. of the salt at 17°. (Struve, 1854)

## NO MANGANESE NITRATE $\text{Mn}(\text{NO}_3)_2$

### SOLUBILITY IN WATER

(Ewing and Rasmussen, 1942; Funk, 1900)

The more recent results are lower than those of Funk, and indicate the presence of four hydrates, but not the trihydrate previously reported.  $\text{Mn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  and  $\text{Mn}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$  are stable at their melting points. The data of Ewing and Rasmussen were obtained by the freezing point method.

(Ewing and Rasmussen, 1942)

(Funk, 1900)

t°	Sat. sol.		Solid Phase	t°	Sat. sol.		Solid Phase	t°	Sat. sol.		Solid Phase
	Wt. %	$\text{Mn}(\text{NO}_3)_2$			Wt. %	$\text{Mn}(\text{NO}_3)_2$			Wt. %	$\text{Mn}(\text{NO}_3)_2$	
10.3	52.9		6	34.2	73.9	4		-36	40.5		6 + 1
15.5	54.8		6	31.3	75.4	4		-29	42.29		6
19.1	56.0		6	31.0	75.3	4		-26	43.15		6
21.7	57.8		6	29.7	76.1	4		-21	44.30		6
24.0	59.8		6	28.4	76.9	4		-16	45.52		6
25.0	61.1		6	26.5	77.2	4		-5	48.88		6
25.2	62.1		6	28.0	77.9	2		0	50.49		6
25.3	62.4		6	30.0	78.5	2		+11	54.50		6
25.3	62.5		6	32.2	79.2	2		18	57.33†		6
25.3	62.7		6	34.3	79.8	2		20	58.84		6
24.9	63.8		6	35.2	80.3	2		25	62.37		6
24.7	64.0		6 + 4	29.0	80.6m	2		27	65.66		3
27.3	64.9		4	26.0	—	1		29	66.99		3
52.5	67.2		4	27.0	80.9	2 + 1		30	67.33†		3
58.5	68.4		4	40.1	81.0	1		34	71.3		3
58.2	69.7		4	45.0	81.2	1		35.5	76.82		3
57.2	71.3		4	50.0	81.6	1					
57.0	71.6		4	59.9	82.1	1					
56.8	71.7		4	68.1	82.8	1					
56.6	72.2		4	75.0	83.3	1					

m = metastable; 6 =  $\text{Mn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ ; 4 =  $\text{Mn}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$ ; 3 =  $\text{Mn}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$ ;  
 2 =  $\text{Mn}(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O}$ ; 1 =  $\text{Mn}(\text{NO}_3)_2 \cdot \text{H}_2\text{O}$ ; \* = melting point; † = density at 18° = 1.624;  
 ‡ = dicapua, 1929.

THE SYSTEM MANGANOUS NITRATE - NITRIC ACID - WATER AT 20°  
(Ewing and Glick, 1940)

NO

In addition to the hydrates found in the system Manganous Nitrate - Water (6, 4, 2, and 1), the compounds  $\text{Mn}(\text{NO}_3)_2 \cdot 1.5\text{H}_2\text{O}$  and  $\text{Mn}(\text{NO}_3)_2 \cdot 0.5\text{H}_2\text{O}$  were found to be in equilibrium with solutions containing large amounts of  $\text{HNO}_3$ .

Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.		
$\text{HNO}_3$	$\text{Mn}(\text{NO}_3)_2$	Solid Phase	$\text{HNO}_3$	$\text{Mn}(\text{NO}_3)_2$	Solid Phase
0.0	56.9	$\text{Mn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$	10.5	69.0	$\text{Mn}(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O}$
2.5	55.5	"	16.2	65.2	"
5.9	54.6	"	18.6	63.7	"
6.5	56.6	"	19.9	62.7	" + $\text{Mn}(\text{NO}_3)_2 \cdot 1.5\text{H}_2\text{O}$
7.7	55.7	$\text{Mn}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$	24.4	58.3	$\text{Mn}(\text{NO}_3)_2 \cdot 1.5\text{H}_2\text{O}$
10.2	53.7	"	47.0	37.8	" + $\text{Mn}(\text{NO}_3)_2 \cdot \text{H}_2\text{O}$
11.4	52.8	"	46.9	37.8	$\text{Mn}(\text{NO}_3)_2 \cdot \text{H}_2\text{O}$
16.7	48.8	"	61.5	24.8	"
26.9	41.8	"	68.1	19.1	"
31.9	40.8	"	69.0	18.5	"
28.4	45.7	"	78.0	11.7	"
19.4	57.0	"	84.1	7.4	" + $\text{Mn}(\text{NO}_3)_2 \cdot \frac{1}{2}\text{H}_2\text{O}$
13.3	63.6	"	88.6	4.7	$\text{Mn}(\text{NO}_3)_2 \cdot \frac{1}{2}\text{H}_2\text{O}$
9.5	68.0	"	91.5	3.5	"
5.9	72.4	$\text{Mn}(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O}$	96.3	1.1	"
8.3	71.0	"	99.3	0.5	"

MANGANESE HYDROXIDE  $\text{Mn}(\text{OH})_2$ 

OH

## SOLUBILITY IN WATER

t°	Solubility	Author
18	$2.15 \times 10^{-5}$ moles $\text{Mn}(\text{OH})_2$ per liter	(Sackur and Fritzmann, 1909)
	$2.10 \times 10^{-4}$ "	(Tamm, 1910)
22	$4 \times 10^{-6}$ (in "ordinary" distilled $\text{H}_2\text{O}$ , containing a little $\text{CO}_2$ )	(Almqvist, 1918)
Room	$3.1 \times 10^{-5}$ moles $\text{Mn}(\text{OH})_2$ per liter	(Oka, 1940)
25	$3.6 \times 10^{-5}$ "	(Nasanen, 1942)
	$4.1 \times 10^{-5}$ "	(Fox, Swinehart and Garrett, 1941)

# Mn MANGANESE

## SOLUBILITY OF MANGANESE HYDROXIDE IN ACIDIC AND BASIC SOLUTIONS AT 25° (Fox, Swinehart, and Garrett, 1941)

The determinations were made in an atmosphere of nitrogen. Each value is the average of a determination in which equilibrium was approached from undersaturation and one from supersaturation.

	In NaOH Solutions		In HCl Solutions			
	Moles NaOH per 1000 gms. H <sub>2</sub> O	Moles Mn(OH) <sub>2</sub> per 1000 gms. H <sub>2</sub> O x 10 <sup>5</sup>	Moles HCl per 1000 gms. H <sub>2</sub> O	Moles Mn(OH) <sub>2</sub> per 1000 gms. H <sub>2</sub> O x 10 <sup>5</sup>	Moles HCl per 1000 gms. H <sub>2</sub> O	Moles Mn(OH) <sub>2</sub> per 1000 gms. H <sub>2</sub> O x 10 <sup>5</sup>
0	0.0	4.1*	0.00150	74.5	0.00850	430
OH	1.924	7.5	.00200	102	.0120	605
	2.880	14.7	.00300	141	.0160	805
	3.72	24.2	.00500	249	.0200	985
	4.14	29.2	.00600	298		

\*Average of 6 determinations ( $K_{sp} = 1.6 \times 10^{-13}$ )

## SOLUBILITY OF MANGANESE HYDROXIDE IN AQUEOUS SOLUTIONS OF ORGANIC SALTS (Tamm, 1910)

(25 cc. of the neutral salt solution + 25 cc. of aqueous suspension of Mn(OH)<sub>2</sub> were shaken different lengths of time. Temp. not stated.)

100 cc. sat. solution in 1 n sodium tartrate solution contain 0.052 gm. Mn<sub>3</sub>O<sub>4</sub>.

100 cc. sat. solution in 1 n sodium malate solution contain 0.032 gm. Mn<sub>3</sub>O<sub>4</sub>.

100 cc. sat. solution in 1 n sodium citrate solution contain 0.095 gm. Mn<sub>3</sub>O<sub>4</sub>.

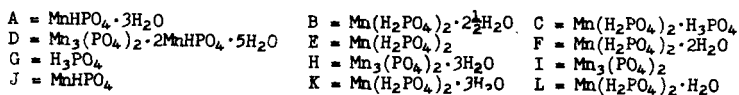
Fusion data for the system MnO + SiO<sub>2</sub> are given by Doernickel, 1907 and for the reaction  $2\text{MnO} + \text{Si} \rightleftharpoons 2\text{Mn} + \text{SiO}_2$  at 1640° by Herasymenko, 1938.

## MANGANESE PHOSPHATES

PO

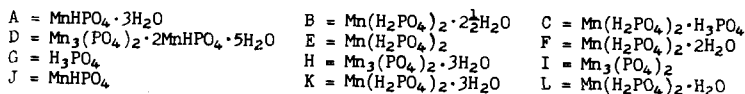
THE SYSTEM  $\text{MnO} - \text{P}_2\text{O}_5 - \text{H}_2\text{O}$ 

(Amadori, 1922; Grube and Stasche, 1927; Taperova and Isaeva, 1949;  
Salmon and Terrey, 1950; Goloshchapov, 1956)



Sat. Sol. wt. %			Sat. Sol. Wt. %			Sat. Sol. Wt. %		
$\text{P}_2\text{O}_5$ MnO		Solid Phase	$\text{P}_2\text{O}_5$ MnO		Solid Phase	$\text{P}_2\text{O}_5$ MnO		Solid Phase
At 25° (A., 1922)			At 25° (Cont.) (G., 1956)			At 50° (S. and T., 1950)		
5.88	1.97	A	In Aq. $\text{H}_3\text{PO}_4$ :			1.25	0.57	D
12.22	5.04	A	0.4	0.2	H	2.95	1.21	D
15.46	6.55	A	0.6	0.3	H	4.40	1.76	D
23.16	9.74	A	2.7	1.1	A	4.73	1.85	D
27.45	11.57	A + F	7.1	2.5	A	6.89	2.94	D
30.42	9.21	F	9.8	4.6	A	7.81	3.05	D
36.00	6.02	F	12.4	5.9	A	9.28	3.56	D
43.10	3.78	F				10.50	4.04	D
45.76	2.76	F	At 37°			20.20	7.99	D
47.40	2.29	F	(S. and T., 1950)			21.04	8.28	D
50.75	1.81	F	1.260	0.619	A	24.2	9.41	D
53.45	1.40	F	3.206	1.475	A	25.3	9.65	D
59.45	1.08	F	5.96	2.58	A	28.7	11.44	D
62.25	0.62	C	10.57	4.56	A	33.4	9.98	B
65.57	0.39	C	14.26	6.05	A	33.5	9.36	B
(S. and T., 1950)			19.67	8.13	A	34.1	8.87	B
0.764	0.375	A	22.66	9.50	A	41.4	5.70	B
18.44	7.83	A	28.2	11.70	B	42.7	5.25	B
25.12	10.29	A	29.3	10.98	B	51.1	3.24	B
29.1	9.13	B	33.6	8.20	B	53.5	2.73	B
37.3	5.09	B	38.3	5.84	B	55.4	2.54	B
49.3	1.93	B	39.0	5.39	B	56.8	2.24	B
57.7	1.30	B	40.0	4.86	B	60.2	2.26	C
61.2	0.65	C	41.9	4.43	B	61.0	2.08	C
64.1	0.16	C	43.1	3.92	B	62.8	0.99	C
(G., 1956)			48.0	2.88	B	63.4	0.87	C
0.03	0.07	A	50.9	2.35	B	At 75°		
12.3	0.06	A	52.4	2.04	B	(S. and T., 1950)		
28.0	1.6	A	56.9	1.69	B	4.29	1.46	D
32.4	2.0	A	59.6	1.94	B	4.41	1.49	D
41.5	2.2	A	60.6	1.19	C	8.25	2.58	D
54.0	6.2	F	61.7	0.71	C	14.29	5.16	D
55.7	1.4	F	62.1	0.78	C	16.91	5.95	D
58.5	3.5	F	63.0	0.31	C	21.1	7.58	D
59.6	0.2	F	63.5	0.52	C	27.8	10.17	D
62.2	0.0	G	64.0	0.29	C	30.4	11.04	D
			64.4	0.28	C	34.5	13.02	D
			65.0	0.25	C	35.5	12.45	D

(Cont.)

THE SYSTEM MnO - P<sub>2</sub>O<sub>5</sub> - H<sub>2</sub>O--Cont.

Sat. Sol. wt. %			Sat. Sol. wt. %			Sat. Sol. wt. %		
P <sub>2</sub> O <sub>5</sub>	MnO	Solid Phase	P <sub>2</sub> O <sub>5</sub>	MnO	Solid Phase	P <sub>2</sub> O <sub>5</sub>	MnO	Solid Phase
At 75° (S. and T., 1950)			At 85° (S. and T., 1950)			At 100° (T. and I., 1949)		
35.7	12.89	D	2.58	0.78	D	32.95	6.19	J
46.1	6.63	B	3.46	1.02	D	36.90	6.25	J
47.7	5.73	B	5.92	1.82	D	39.50	7.11	J
52.6	5.35	B	11.56	3.48	D	48.50	12.00	J + L
57.6	3.86	B	22.22	7.18	D	4.20	0.87*	A
58.6	3.33	E	27.32	9.68	D	4.27	1.26*	A
59.8	2.98	E				11.04	5.20*	A
60.2	2.53	E	At 100° (T. and I., 1949)			15.00	5.40*	A
60.9	2.21	E				23.81	7.15*	A + K
61.6	2.20	E				26.20	6.33*	K
62.2	1.65	E	0.08	Trace	J	34.70	10.70*	K
63.6	1.58	E	2.38	0.24	J	43.50	13.85*	K
63.9	1.70	E	18.52	2.73	J	46.22	13.31*	K
			19.82	3.13	J	50.26	9.63*	F
			22.43	4.85	J	54.80	8.17*	F
			28.37	4.04	J	56.00	6.90*	F

## Results of Grube and Stasche, 1927

Norm. of aq. H <sub>3</sub> PO <sub>4</sub> Solvent	Sat. Sol. wt. %		Solid	Norm. of aq. H <sub>3</sub> PO <sub>4</sub> Solvent	Sat. Sol. wt. %		Solid
	H <sub>3</sub> PO <sub>4</sub>	Mn <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>			H <sub>3</sub> PO <sub>4</sub>	Mn <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>	
At 25°				At 55°			
1.0	2.61	1.36	I?	3.0	8.92	7.14	I
2.0	5.23	3.72	I?	4.5	13.35	10.50	I
2.98	7.60	5.37	I?	6.0	16.75	14.16	I
3.54	8.56	5.88	J	9.0	21.67	18.10	I
6.09	14.02	10.36	J	12.0	27.30	24.50	I
9.00	19.98	13.74	J	13.5	31.30	27.13	J
9.29	21.07	14.59	J	15.0	32.40	28.70	J
11.00	25.32	17.33	J	18.0	36.00	30.90	J
15.25	28.02	19.55	K	21.0	41.40	24.60	K
17.96	29.90	17.27	K	27.0	57.30	13.30	K
20.95	42.78	11.07	K	36.0	69.00	7.70	K
24.07	49.76	8.43	K	45.0	83.30	7.30	K
29.42	56.29	6.07	K				
34.78	64.51	3.97	K				
39.93	74.62	2.46	K				
44.79	82.05	2.38	K				
50.00	85.95	0.0	G				
					*metastable		

\*metastable

MANGANESE AMMONIUM PHOSPHATE  $\text{MnNH}_4\text{PO}_4 \cdot 7\text{H}_2\text{O}$ 

PO

100 cc. sat. solution of Manganese Ammonium Phosphate in Water contain 0.00042 gm.  $\text{MnNH}_4\text{PO}_4 \cdot \text{H}_2\text{O}$  (? temp.).

(Breunar, 1920, 1922)

SOLUBILITY OF MANGANESE AMMONIUM PHOSPHATE IN SEVERAL SOLVENTS  
(Wenger, 1911)

t°	Gme. $\text{NH}_4\text{MnPO}_4$ per 100 Gms. Solvent in:			
	Water	Aq. 5% $\text{NH}_4\text{NO}_3$	Aq. 5% $\text{NH}_4\text{Cl}$	Mixture of 1 Pt. $\text{NH}_3$ ( $d = 0.96$ ) + 4 parts $\text{H}_2\text{O}$
0	--	0.021	0.002	0.0116
20	0	0.020	0.025	0.0122
30	--	0.023	0.034	--
40	0	0.021	0.039	0.0118
50	--	0.023	0.035	0.0132
60	0	0.027	0.038	0.0194
70	0.005	0.028	0.041	0.0191
80	0.007	0.033	0.045	0.0197

The solubilities of various soil phosphates (including manganese) under varying conditions were determined by Fraps, 1911.

MANGANESE HYPOPHOSPHITE  $\text{Mn}(\text{H}_2\text{PO}_2)_2 \cdot \text{H}_2\text{O}$ 

PO

100 gms.  $\text{H}_2\text{O}$  dissolve 15.15 gms. salt at 25°, and 16.6 gms. at b. pt.  
(U. S. P.)

Melting points for the system  $\text{Mn}_3\text{P}_2\text{O}_8 + \text{MnO}$  are given by Pearson, Turkdogan and Fenn, 1954.

MANGANESE SULFIDE  $\text{MnS}$ 

S

t°	Solubility Product	Author
25	$1.1 \times 10^{-15}$	(Kapatinsky, 1940)
25	$1 \times 10^{-11}$	(Goates, Gordon and Faux, 1952)

Purified manganese sulfide was agitated in 0.01  $\text{N}$   $\text{H}_2\text{SO}_4$  containing  $\text{H}_2\text{S}$  for 10 hours at 20°. The determination was repeated after another period of 10 hours. The sat. solution contained 0.4874 gm.  $\text{MnS}$ , corresponding to  $5.6 \cdot 10^3$  gm. mols.  $\text{MnS}$ , per 1000 cc.

(Moser and Behr, 1924)



## Mn MANGANESE

SO MANGANESE SULFATE  $\text{MnSO}_4$ 

## SOLUBILITY IN WATER

The stable phases are  $\text{MnSO}_4 \cdot 7\text{H}_2\text{O}$ ,  $\text{MnSO}_4 \cdot 5\text{H}_2\text{O}$ , and  $\text{MnSO}_4 \cdot \text{H}_2\text{O}$ . In addition, wholly metastable 4- and 2- hydrates are formed; the 2-hydrate was found by Rohmer, 1938. The agreement on the solubility of each hydrate is generally very good. The data between 23° and 42° are those given by Rohmer, 1938, at other temperatures, Krepelka and Rejha, 1933. Earlier results are reported by Cottrell, 1901 and Richards and Fraple, 1901. The values from 120° to 170° are those of Eddy, Machemer and Menzies, 1941. However, their data at 90-110° seem too high (not listed), and the results of Benrath, 1941 (107°-188°) are also high.

t°	Gms. $\text{MnSO}_4$ per 100 gms. sat. sol.	Density	Solid Phase	t°	Gms. $\text{MnSO}_4$ per 100 gms. sat. sol.	Density	Solid Phase
- 5	23.3	--	Ice	45	41.4*	--	4
-10	31.3	--	"	31	39.3*	1.499	2
-11.4	32.2	--	" + 7	34	39.3*	1.498	2
- 5	33.4	--	7	38	39.2*	1.498	2
0	34.6	--	7	42	39.2*	1.497	2
+ 5	36.1	--	7	10	40.6*	--	1
12	38.2*	--	7	20	39.7*	--	1
8.6	37.2	--	7 + 5	25	39.2	--	1
5	36.8*	--	5	31	39.4	1.480	1
15	38.0	1.4772 <sup>a</sup>	5	34	38.2	1.475	1
20	38.6	1.4866 <sup>a</sup>	5	38	37.7	1.467	1
23.9	39.0	1.494	5 + 1	40	37.5	--	1
26.1	39.4*	1.500	5 + 2	42	37.3	1.460	1
27.5	39.7*	1.503	5 + 4	50	36.3	--	1
31	40.4*	1.513	5	60	34.9	--	1
34	41.0*	1.521	5	70	38.2	--	1
38	41.7*	1.532	5	80	31.3	--	1
42	42.2*	1.542	5	90	29.0	--	1
15	38.8*	--	4	100.7 <sup>†</sup>	26.1	--	1
20	39.1*	--	4	120	19.3	--	1
22.4	39.3*	--	4 + 1	130	12.8	--	1
31	40.0*	1.505	4	140	7.8	--	1
34	40.2*	1.507	4	150	4.33	--	1
38	40.6*	1.510	4	160	2.00	--	1
42	41.0*	1.513	4	170	0.77	--	1

<sup>†</sup>b. pt. \*metastable <sup>a</sup>density determined by Flottmann, 1928.

7 =  $\text{MnSO}_4 \cdot 7\text{H}_2\text{O}$ ; 5 =  $\text{MnSO}_4 \cdot 5\text{H}_2\text{O}$ ; 4 =  $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$ ; 2 =  $\text{MnSO}_4 \cdot 2\text{H}_2\text{O}$ ;  
1 =  $\text{MnSO}_4 \cdot \text{H}_2\text{O}$ .

SOLUBILITY OF  $\text{MnSO}_4$  IN WATER AND DEUTERIUM OXIDE  
(Eddy, Machemer and Menzies, 1941)

Note that the data in water alone are high when compared with those of other authors.

t°	Gms. $\text{MnSO}_4$ per 100 gms.		Solid Phase	
	$\text{H}_2\text{O}$	$\text{D}_2\text{O}$		
90	36.4	--	$\text{MnSO}_4 \cdot \text{H}_2\text{O}$	
99	--	24.8	"	
100	28.8	--	"	
110	22.2	--	"	
116	--	12.9	"	
120	16.2	--	"	SO
138.1	--	4.48	"	
140	7.2	--	"	

THE SYSTEM MANGANESE SULFATE - SULFURIC ACID - WATER  
(Taylor, 1952; Montemartini and Losana, 1928 (12.6°))

Figures in parentheses at 12.6° are densities.

Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
$\text{MnSO}_4$	$\text{H}_2\text{SO}_4$			$\text{MnSO}_4$	$\text{H}_2\text{SO}_4$		
<u>Results at 0°</u>				<u>Results at 25°-Cont.</u>			
13.10	27.90		5 + 1	0.58	56.18	1	
				0.39	62.30	1	
				0.41	66.90	1	
				0.53	70.05	1 + 1.1.1	
				0.45	70.90	1.1.1	
				0.28	72.89	"	
				0.19	84.90	"	
				0.33	88.20	"	
				0.42	89.30	" + 1.3	
				0.34	89.54	1.3	
				0.20	90.90	1.3	
				0.09	92.08	"	
				0.02	96.29	"	
				<u>Results at 45°</u>			
				38.49	0.0	1	
				18.40	19.54	1	
				2.63	44.75	1	
				5.22	62.20	1	
				0.81	70.30	1 + 1.1.1	
				0.25	77.70	1.1.1	
				0.27	83.80	"	
				0.74	90.02	" + 1.3	
				0.41	91.59	1.3	
				0.08	96.92	"	
				<u>Results at 20°</u>			
36.61	8.98		5 + 1				
0.47	69.64		1 + 1.1.1				
0.37	89.09		1.1.1 + 1.3				
				<u>Results at 25°</u>			
38.81	0.23		1				
25.08	12.98		1				
7.07	34.34		1				
2.71	43.26		1				

5 =  $\text{MnSO}_4 \cdot 5\text{H}_2\text{O}$ ; 1 =  $\text{MnSO}_4 \cdot \text{H}_2\text{O}$ ; 1.1 =  $\text{MnSO}_4 \cdot \text{H}_2\text{SO}_4$ ; 1.3 =  $\text{MnSO}_4 \cdot 3\text{H}_2\text{SO}_4$ ;  
1.1.1 =  $\text{MnSO}_4 \cdot \text{H}_2\text{SO}_4 \cdot \text{H}_2\text{O}$ ; 0 =  $\text{MnSO}_4$ .

(Cont.)

## Mn MANGANESE

## THE SYSTEM MANGANESE SULFATE - SULFURIC ACID - WATER—Cont.

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
MnSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	Solid Phase	MnSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	Solid Phase
Results at 65°			Results at 95°		
35.88	0.0	1	25.87	0.0	1
16.78	20.40	1	2.06	69.41	1
2.87	45.93	1	2.48	71.20	1 + 1.1.1
0.89	61.73	1	2.11	27.28	1.1.1
1.26	70.70	1 + 1.1.1	1.70	88.40	"
0.54	76.10	1.1.1	1.89	88.50	" + 1.1
0.44	83.41	"	1.79	89.15	1.1
0.94	89.20	"	1.61	90.58	"
1.35	90.70	" + 1.1	1.52	91.41	"
1.31	90.80	1.1	1.43	92.40	"
1.30	90.91	" + 1.3	1.38	93.0	"
1.04	91.68	1.3	1.35	93.63	"
0.72	92.79	"	1.34	94.49	"
			1.39	95.87	"

1 = MnSO<sub>4</sub>·H<sub>2</sub>O; 1.1 = MnSO<sub>4</sub>·H<sub>2</sub>SO<sub>4</sub>; 1.3 = MnSO<sub>4</sub>·3H<sub>2</sub>SO<sub>4</sub>; 1.1.1 = MnSO<sub>4</sub>·H<sub>2</sub>SO<sub>4</sub>·H<sub>2</sub>O

## THE SYSTEM MANGANESE SULFATE - AMMONIUM SULFATE - WATER

## Results at 0°

(Caven and Johnston, 1927)

Gm. Mole. per 1000 gms. H <sub>2</sub> O		Solid Phase	Gm. Mols. per 1000 gms. H <sub>2</sub> O		Solid Phase
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	MnSO <sub>4</sub>		(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	MnSO <sub>4</sub>	
0.0	3.533	MnSO <sub>4</sub> ·7H <sub>2</sub> O	1.864	0.377	1.1.6
0.168	3.623	"	3.551	0.167	"
0.251	3.665	" + 1.1.6	3.993	0.138	"
0.260	3.565	1.1.6	5.135	0.075	"
0.531	1.868	"	5.229	0.081	" + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
1.069	0.769	"	5.254	0.017	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
1.315	0.531	"	5.327	0.0	"

(Data of Schreinemakers, 1909)

At 25°		Solid Phase	At 50°		Solid Phase
Gms. per 100 Gms. Sat. Sol.			Gms. per 100 Gms. Sat. Sol.		
MnSO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Solid Phase	MnSO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Solid Phase
39.3	0.		36.26	0	
38.49	3.64	MnSO <sub>4</sub> ·5H <sub>2</sub> O	35.35	2.95	MnSO <sub>4</sub> ·H <sub>2</sub> O
33.44	4.91	" + 1.1.6	30.57	5.14	" + 2.1
22.06	9.65	1.1.6	16.86	17.62	2.1
9.02	20.36	"	6.92	35.98	"
2.91	37.42	"	6.29	39.71	"
1.75	42.58	" + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	5.70	43.24	" + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
1.77	43.24	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	3.49	44.02	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
0	43.4	"	0	45.7	"

1.1.6 = MnSO<sub>4</sub>·(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>·6H<sub>2</sub>O2.1 = 2MnSO<sub>4</sub>·(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>

(Cont.)

## THE SYSTEM MANGANESE SULFATE - AMMONIUM SULFATE - WATER--Cont.

(Data of Benrath, 1931a)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	MnSO <sub>4</sub>		(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	MnSO <sub>4</sub>	
At 12.5°			At 40°--Cont.		
3.17	36.9	MnSO <sub>4</sub> ·5H <sub>2</sub> O + 1.1.6	29.7	7.99	1.1.6
3.24	34.91	1.1.6	40.75	4.26	"
21.23	3.29	"	41.81	3.80	" + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
41.75	1.2	" (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	At 100°		
At 40°			3.45	25.96	MnSO <sub>4</sub> ·H <sub>2</sub> O + 2.1 \$0
1.76	37.39	MnSO <sub>4</sub> ·H <sub>2</sub> O	3.91	23.81	2.1
4.84	35.23	2.1	5.49	18.47	"
7.6	31.32	"	10.62	10.04	"
10.33	28.61	"	25.35	5.15	"
17.8	17.89	1.1.6	39.19	2.83	"
19.98	14.77	"	50.15	1.66	" + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>

## THE SYSTEM MANGANESE SULFATE - SODIUM SULFATE - WATER

(0°, 25°, 35°, Caven and Johnston, 1928; 11°-50°, Benrath, 1929a;  
97°, Benrath and Benrath, 1929)

Caven and Johnston's results at 35° fail to confirm the existence of the double salts: MnSO<sub>4</sub>·3Na<sub>2</sub>SO<sub>4</sub> and 9MnSO<sub>4</sub>·10Na<sub>2</sub>SO<sub>4</sub> previously reported by Schreinemakers and Provijs, 1913, or of MnSO<sub>4</sub>·Na<sub>2</sub>SO<sub>4</sub>·4H<sub>2</sub>O.

Benrath considers that Caven and Johnston failed to find the 1.3 salt on account of the slowness with which it is formed in the vicinity of its transformation points.



## Results at 0°

Gm. Mols. per 1000 gms. H <sub>2</sub> O		Solid Phase	Gm. Mols. per 1000 gms. H <sub>2</sub> O		Solid Phase
MnSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>		MnSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	
3.533	0.0	MnSO <sub>4</sub> ·7H <sub>2</sub> O	1.650	0.445	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
3.499	0.158	"	0.897	0.383	"
3.424	0.509	"	0.773	0.389	"
3.413	0.566	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	0.254	0.369	"
2.818	0.520	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	0.0	0.331	

(Cont.)

## Mn MANGANESE

## THE SYSTEM MANGANESE SULFATE - SODIUM SULFATE - WATER--Cont.

Results at 25°			Results at 35°		
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
MnSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>		MnSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	
39.10	0.0	MnSO <sub>4</sub> ·4H <sub>2</sub> O	39.56	0.0	MnSO <sub>4</sub> ·H <sub>2</sub> O
38.43	1.66	"	37.12	3.05	"
36.94	5.09	" + 1·1·2	34.46	6.62	" + 1·1·2
34.69	6.23	1·1·2	30.43	8.49	1·1·2
29.52	8.78	"	26.56	11.12	"
22.88	13.51	"	15.64	19.79	"
50 18.62	17.42	"	12.54	22.96	"
17.15	19.26	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	10.21	25.75	"
15.15	19.55	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	9.35	27.49	" + Na <sub>2</sub> SO <sub>4</sub>
9.14	20.53	"	6.55	29.05	Na <sub>2</sub> SO <sub>4</sub>
5.44	21.16	"	4.25	30.49	"
2.81	21.54	"	0.0	32.83	"
0.0	21.89	"			

## Results of Benrath, 1929a at 11°-50°

t°	Gms. per 100 gms. sat. sol.		Solid Phase
	Na <sub>2</sub> SO <sub>4</sub>	MnSO <sub>4</sub>	
11	7.52	33.50	MnSO <sub>4</sub> ·5H <sub>2</sub> O + 1·1·2
"	10.45	29.0	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O + 1·1·2
25	28.64	8.62	1·3
30	27.64	6.40	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
41	7.52	32.28	MnSO <sub>4</sub> ·H <sub>2</sub> O + 1·1·2
"	18.09	17.13	1·3 + 1·1·2
"	24.73	7.93	1·3
"	34.38	2.50	" + Na <sub>2</sub> SO <sub>4</sub>
50	0.0	37.3	MnSO <sub>4</sub> ·H <sub>2</sub> O
"	4.70	33.22	"
"	7.09	31.60	"
"	8.57	30.95	"
"	9.95	29.25	1·1·2
"	12.45	24.89	"
"	13.59	22.42	"
"	16.42	18.33	"
"	17.17	17.53	" + 1·3
"	18.62	14.91	1·3
"	20.78	11.59	"
"	23.04	7.84	"
"	25.99	5.16	"
"	27.76	3.09	"
"	30.2	2.68	" + Na <sub>2</sub> SO <sub>4</sub>
"	31.8	0.0	Na <sub>2</sub> SO <sub>4</sub>

(Cont.)

THE SYSTEM MANGANESE SULFATE - SODIUM SULFATE - WATER--Cont.  
(Benrath and Benrath, 1929)

Results at 97°

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	Na <sub>2</sub> SO <sub>4</sub>	MnSO <sub>4</sub>			Na <sub>2</sub> SO <sub>4</sub>	MnSO <sub>4</sub>	
1.216	0.0	28.49	MnSO <sub>4</sub> ·H <sub>2</sub> O	1.304	14.89	18.54	1.3
1.244	2.16	26.48	"	1.263	15.93	14.77	"
1.275	4.91	24.60	"	1.249	16.87	12.48	"
--	11.42	22.84	"	1.241	17.90	10.42	"
--	11.94	22.81	" + 1.1.2	1.216	19.43	6.79	"
1.326	12.64	22.09	" + "	1.215	23.53	2.58	"
1.317	13.13	21.41	1.1.2	--	25.38	1.41	"
1.329	13.70	20.49	"	1.230	29.54	0.69	" + Na <sub>2</sub> SO <sub>4</sub>
1.339	14.72	19.25	" + 1.3	1.237	29.85	0.0	Na <sub>2</sub> SO <sub>4</sub>

50

1.1.2 = MnSO<sub>4</sub>·Na<sub>2</sub>SO<sub>4</sub>·2H<sub>2</sub>O;

1.3 = MnSO<sub>4</sub>·3Na<sub>2</sub>SO<sub>4</sub>

THE SYSTEM MANGANESE SULFATE - RUBIDIUM SULFATE - WATER  
(Benrath, 1931a)

t°	Gms. per 100 gms. sat. sol.		Solid Phase	t°	Gms. per 100 gms. sat. sol.		Solid Phase
	Rb <sub>2</sub> SO <sub>4</sub>	MnSO <sub>4</sub>			Rb <sub>2</sub> SO <sub>4</sub>	MnSO <sub>4</sub>	
0	4.8	33.4	MnSO <sub>4</sub> ·7H <sub>2</sub> O + 1.1.6	55	3.58	29.0	2.1
"	8.95	9.3	1.1.6	"	5.77	20.56	"
"	10.83	6.32	"	"	10.55	11.60	"
"	26.51	1.69	" + Rb <sub>2</sub> SO <sub>4</sub>	"	23.95	5.72	"
25	3.3	37.5	MnSO <sub>4</sub> ·H <sub>2</sub> O + 1.1.6	"	30.75	4.08	"
"	10.67	26.93	1.1.6	75	2.97	30.8	MnSO <sub>4</sub> ·H <sub>2</sub> O + 2.1
"	32.73	3.77	" + Rb <sub>2</sub> SO <sub>4</sub>	"	2.81	29.25	2.1
"	33.47	3.03	" + "	"	9.61	7.59	"
40	5.50	32.05	2.1	"	26.48	2.31	"
"	6.17	24.02	"	"	45.56	2.12	"
"	13.21	14.8	"	100	2.26	22.65	"
"	25.34	7.72	"	"	9.09	3.91	"
"	33.49	5.11	"	"	20.74	1.76	"
60	39.75	3.17	" + Rb <sub>2</sub> SO <sub>4</sub>	"	31.96	1.34	"

1.1.6 = MnSO<sub>4</sub>·Rb<sub>2</sub>SO<sub>4</sub>·6H<sub>2</sub>O;

2.1 = 2MnSO<sub>4</sub>·Rb<sub>2</sub>SO<sub>4</sub>

# Mn MANGANESE

## THE SYSTEM MANGANESE SULFATE - THORIUM SULFATE - WATER AT 30° (Caven, 1932)

1.1.7 =  $\text{MnSO}_4 \cdot \text{Th}(\text{SO}_4)_2 \cdot 7\text{H}_2\text{O}$ . This double salt forms very slowly and could only be obtained by preparing a hot concentrated solution of thorium and manganese sulfates and stirring this for a long period at 30°. It cannot be recrystallized from  $\text{H}_2\text{O}$ .

	Gms. per 100 100 gms. $\text{H}_2\text{O}$		Solid Phase	Gms. per 100 100 gms. $\text{H}_2\text{O}$		Solid Phase
	$\text{Th}(\text{SO}_4)_2$	$\text{MnSO}_4$		$\text{Th}(\text{SO}_4)_2$	$\text{MnSO}_4$	
50	0.0	66.41	$\text{MnSO}_4 \cdot 5\text{H}_2\text{O}$	7.91	13.79	1.1.7 + $\text{Th}(\text{SO}_4)_2 \cdot 8\text{H}_2\text{O}$
	0.135	65.67	" + 1.1.7	8.66	17.68*	$\text{Th}(\text{SO}_4)_2 \cdot 8\text{H}_2\text{O}$
	0.50	54.59	1.1.7	8.23	15.49*	"
	1.38	45.27	"	7.75	13.54	"
	1.87	36.78	"	6.64	9.33	"
	3.11	29.75	"	4.69	4.54	"
	5.82	19.86	"	3.94	2.93	"
	6.65	16.94	"	3.03	1.41	"
				2.14	0.0	"

\* = metastable.

## THE SYSTEM MANGANESE SULFATE - THALLIUM SULFATE - WATER (Benrath, 1931a)

$t^\circ$	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{Tl}_2\text{SO}_4$	$\text{MnSO}_4$	
0	3.26	34.4	$\text{MnSO}_4 \cdot 7\text{H}_2\text{O}$ + 1.1.6
"	9.85	3.88	$\text{Tl}_2\text{SO}_4$ + "
8	6.0	14.2	" + "
25	3.2	38.6	$\text{MnSO}_4 \cdot 5\text{H}_2\text{O}$ + 2.1
30	2.52	38.42	$\text{MnSO}_4 \cdot \text{H}_2\text{O}$ + "
"	7.39	28.91	2.1
"	9.32	31.21	1.1.6
"	11.08	27.14	2.1 + $\text{Tl}_2\text{SO}_4$
50	2.83	35.41	$\text{MnSO}_4 \cdot \text{H}_2\text{O}$ + 2.1
"	4.58	30.14	2.1
"	9.07	22.45	"
"	13.38	13.77	" + $\text{Tl}_2\text{SO}_4$
"	11.37	8.50	$\text{Tl}_2\text{SO}_4$
"	10.08	4.38	"
40	3.62	36.78	$\text{MnSO}_4 \cdot \text{H}_2\text{O}$ + 2.1
"	5.43	27.92	2.1
"	13.05	21.85	" + $\text{Tl}_2\text{SO}_4$
66	2.06	34.57	$\text{MnSO}_4 \cdot \text{H}_2\text{O}$ + 2.1
"	5.84	20.24	2.1
"	7.65	15.01	"
"	11.81	9.07	"
"	14.75	8.85	" + $\text{Tl}_2\text{SO}_4$
"	12.80	7.23	$\text{Tl}_2\text{SO}_4$
100	2.33	24.17	$\text{MnSO}_4 \cdot \text{H}_2\text{O}$ + 2.1
"	4.75	7.56	2.1
"	7.25	4.29	"
"	16.06	2.49	"
"	17.28	2.14	" + $\text{Tl}_2\text{SO}_4$

1.1.6 =  $\text{MnSO}_4 \cdot \text{Tl}_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$ ;

2.1 =  $2\text{MnSO}_4 \cdot \text{Tl}_2\text{SO}_4$

THE SYSTEM MANGANESE SULFATE - ZINC SULFATE - WATER AT 35°  
(Benrath and Blankenstein, 1934a)

The results are expressed in the Janecke System in terms of the gm. mole. H<sub>2</sub>O to dissolve 1.0 gm. mol. anhydrous salt mixture containing the reported percentage of MnSO<sub>4</sub>. Results for the isotherms 0°, 20°, 23°, 27.2°, 30°, 35°, 45° and 60° are given. Both the saturated solutions and moist solids were analyzed and the composition of the solid phase deduced from the results. The solid phases of mixed crystals over considerable regions and the limiting percentage of the constituents in these are shown. The following values at 35° are typical of the entire series.

Percent MnSO <sub>4</sub> in 1 mol. dissolved salt mixture	Mols. H <sub>2</sub> O to dissolve 1 mol. salt mixture	Crystalline Phase	SO
100.0	13.53	MnSO <sub>4</sub> ·H <sub>2</sub> O	
93.6 (98.1)	13.2 (1.0)	"	
81.6	12.5	"	
70	12.1	"	
59.6	11.63	" + MnSO <sub>4</sub> ·5H <sub>2</sub> O	
49.9	11.5	MnSO <sub>4</sub> ·5H <sub>2</sub> O	
43.3 (61.0)	11.3 (5.0)	"	
41.8	11.5	MnSO <sub>4</sub> ·5H <sub>2</sub> O	
38.0	11.4	" + ZnSO <sub>4</sub> ·6H <sub>2</sub> O	
37.8 (15.0)	12.0 (6.0)	ZnSO <sub>4</sub> ·6H <sub>2</sub> O	
34.0	11.8	"	
22.2 (5.5)	12.4 (7.0)	ZnSO <sub>4</sub> ·7H <sub>2</sub> O	
15.9	12.9	"	
5.69	13.3	"	
0.0	13.5	"	

The figures in parentheses are the limiting values respectively for MnSO<sub>4</sub>·H<sub>2</sub>O, MnSO<sub>4</sub>·5H<sub>2</sub>O, ZnSO<sub>4</sub>·6H<sub>2</sub>O and ZnSO<sub>4</sub>·7H<sub>2</sub>O in the mixed crystals composing the moist solid phases.

Additional data for the solubility of mixed crystals of manganese and zinc sulfates between 0° and 39° are given by Sehmen, 1905-06.

SOLUBILITY OF MANGANESE SULFATE IN AQUEOUS ETHYL ALCOHOL  
(Schreinemakers, 1909; Schreinemakers and Deuse, 1912;  
see also Cuno, 1908)

Results at 25°			Results at 50°		
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
C <sub>2</sub> H <sub>5</sub> OH	MnSO <sub>4</sub>		C <sub>2</sub> H <sub>5</sub> OH	MnSO <sub>4</sub>	
0	39.3	MnSO <sub>4</sub> ·5H <sub>2</sub> O	0	36.26	MnSO <sub>4</sub> ·H <sub>2</sub> O
6.81	33.72	"	6.67	28.12	"
liquid layers separate here			16.02	18.75	"
53.09	1.23	"	22.63	12.54	"
57.39	0.56	"	36.47	4.12	"
76.70	0	MnSO <sub>4</sub> ·H <sub>2</sub> O			

(Cont.)



## Mn MANGANESE

## SOLUBILITY OF MANGANESE SULFATE IN AQUEOUS ETHYL ALCOHOL--Cont.

Composition of the liquid layers. The following reciprocally saturated stable solutions were obtained at 50°.

Water rich Layer		C <sub>2</sub> H <sub>5</sub> OH rich Layer		Water rich Layer		C <sub>2</sub> H <sub>5</sub> OH rich Layer	
%C <sub>2</sub> H <sub>5</sub> OH	%MnSO <sub>4</sub>	%C <sub>2</sub> H <sub>5</sub> OH	%MnSO <sub>4</sub>	%C <sub>2</sub> H <sub>5</sub> OH	%MnSO <sub>4</sub>	%C <sub>2</sub> H <sub>5</sub> OH	%MnSO <sub>4</sub>
6.81	33.72*	53.09	1.23*	5.68	34.95	53.64	0.97
8.48	31.51	49.76	1.83	7.69	30.99	45.83	2.19
15.02	22.61	32.75	8.01	8.70	29.20	41.93	3.11
				11.85	24.84	35.15	5.95

\*These liquids in contact with MnSO<sub>4</sub>·5H<sub>2</sub>O.

S0 Similar data are also given for 30° and 35°. Both stable and metastable liquid pairs were obtained at these intermediate temperatures.

Composition of the conjugated liquids in contact with excess of solid salt:

t°	C <sub>2</sub> H <sub>5</sub> OH rich Layer		Aqueous rich Layer		Solid Phase
	%C <sub>2</sub> H <sub>5</sub> OH	%MnSO <sub>4</sub>	%C <sub>2</sub> H <sub>5</sub> OH	%MnSO <sub>4</sub>	
10	37.06	5.44	13.78	25.25	MnSO <sub>4</sub> ·5H <sub>2</sub> O
15	44.56	2.79	9.25	29.79	"
17	47.11	2.22	8.53	30.88	"
21	53.55	1.10	6.10	35.05	"
25	53.09	1.23	6.81	33.72	"
30	45.20	2.49	8.69	30.15	MnSO <sub>4</sub> ·H <sub>2</sub> O
31	43.90	2.74	8.47	30.10	"
35	41.71	3.44	9.24	28.61	"
37	38.26	4.84	11.03	26.47	"
41	34.01	5.86	11.93	24.97	"
42	32.37	6.89	13.57	23.09	"
43	31.42	8.51	14.33	22.01	"

SOLUBILITY OF MANGANESE SULFATE IN AQUEOUS ETHYL AND PROPYL  
ALCOHOL SOLUTIONS AT 20°  
(Linebarger, 1892; Snell, 1898)

Conc. of Alcohol in Wt. percent	Gms. MnSO <sub>4</sub> per 100 Gms. Aq.		Conc. of Alcohol in Wt. percent	Gms. MnSO <sub>4</sub> per 100 Gms. Aq.	
	Ethyl Alc.	Propyl Alc.		Ethyl Alc.	Propyl Alc.
34	9.5	6	44	3.3	1.9
36	7.2	4.6	48	2.2	1.4
38	5.8	3.5	52	1.4	1.1
40	4.7	2.8			

THE SYSTEM MANGANESE SULFATE - URETHAN - WATER AT 25°  
(Palitsch, 1928, 1929)

Gm. Mols. per 1000 gms. H <sub>2</sub> O		
MnSO <sub>4</sub>	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>	Solid Phase
4.306	0.0	MnSO <sub>3</sub> ·?H <sub>2</sub> O
4.108	0.228	MnSO <sub>4</sub> ·?H <sub>2</sub> O + NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>
0.007	52.16	Upper Liquid Layer
3.817	0.317	Lower Liquid Layer
0.0	53.07	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>

SOLUBILITY OF ANHYDROUS MANGANESE SULFATE IN METHYL  
AND ETHYL ALCOHOLS  
(Gibson, Driscoll and Jones, 1929)

SO

Results for Methyl Alcohol			Results for Ethyl Alcohol		
t°	Gms. MnSO <sub>4</sub> per 100 gms. CH <sub>3</sub> OH	Solid Phase	t°	Gms. MnSO <sub>4</sub> per 100 gms. C <sub>2</sub> H <sub>5</sub> OH	Solid Phase
15	0.190	MnSO <sub>4</sub>	15	0.012	MnSO <sub>4</sub>
25	0.114	"	35	0.014	"
35	0.064	"	35	0.021	"
45	0.043	"			
55	0.029	"			

100 gms. sat. solution of Manganese Sulfate in glycol contain 0.5 gm. MnSO<sub>4</sub>.  
(de Connick, 1905)

100 cc. anhydrous hydrazine dissolve about 1 gm. MnSO<sub>4</sub> at room temp.  
(Welsh and Broderon, 1915)

Fusion-point data for mixtures of MnSO<sub>4</sub> + K<sub>2</sub>SO<sub>4</sub> and MnSO<sub>4</sub> + Na<sub>2</sub>SO<sub>4</sub> are given by Calcaqui and Marotta, 1914.

MANGANESE SELENITE MnSeO<sub>3</sub>

SeO

The K<sub>sp</sub> at 20° is  $1.2 \pm 0.4 \times 10^{-7}$ .  
(Chukhlantsev and Tomashevskii, 1957)

MANGANESE SELENATE MnSeO<sub>4</sub>

SeO

SOLUBILITY IN WATER  
(Klein, 1940)

t°	Gms. MnSeO <sub>4</sub> per 100 gms. sat. sol.	Solid Phase
30	36.8	MnSO <sub>4</sub> ·5H <sub>2</sub> O (?)
60	35.4	MnSO <sub>4</sub> ·2H <sub>2</sub> O (?)

## Mn MANGANESE

### VO MANGANESE POTASSIUM VANADATE $\text{MnKV}_5\text{O}_{14} \cdot 8\text{H}_2\text{O}$

100 gms.  $\text{H}_2\text{O}$  dissolve 1.7 gms. salt at  $18^\circ$ .

(Radan, 1889)

## MOLYBDENUM Mo

### SOLUBILITY OF MOLYBDENUM IN MERCURY (Irvin and Russell, 1932)

An amalgam containing approximately 0.2 gm. of Mo per 200 gms. of Hg was prepared by electrolysis and allowed to stand two days. This was filtered and the molybdenum in the filtrate found to be less than 0.00002 percent.

The distribution of molybdenum between Fe and FeS at the eutectic temperature of the system was studied by Noddack, Noddack and Bohnstedt, 1940. The molybdenum was concentrated in the Fe layer.

### CH MOLYBDENUM OXINE, CUPFERRATE

50 ml of an aqueous  $\text{Mo}^{+6}$  solution containing 50-200  $\mu\text{g}$ . Mo were shaken for 1 minute with 10 ml. of 1% solution of 8-hydroxyquinoline (oxine) in  $\text{CHCl}_3$ . Extraction was complete between pH 1.6 - 5.6.

(Gentry and Sherrington, 1950)

Data for the extraction of  $\text{Mo}^{+6}$  from acidic solution by  $\text{CHCl}_3$  solutions of cupferron are given by Furman, Mason and Pekola, 1949.

### CI MOLYBDENUM CHLORIDE COMPLEXES

The distribution of Mo chloride complexes between 0-9 N HCl and butyl, iso-butyl, iso amyl alcohols, ethyl ether, butyl formate and other ethers was studied by Zharovskii, 1957.

Data for the extraction of  $\text{Mo}^{+6}$  between aq. HCl and ethyl ether in the presence of  $\text{K}_2\text{HPO}_4$ ,  $\text{H}_2\text{C}_2\text{O}_4$  and NaF are reported by Zharovskii, 1957a.

### F MOLYBDENUM FLUORIDE COMPLEXES

Data for the extraction of  $\text{Mo}^{+6}$  from 1-20 M HF solutions by ethyl ether at  $20^\circ$  are given by Bock and Herrmann, 1956. See also Kitahara, 1949.

### I MOLYBDENUM IODIDE $\text{MoI}_6$

For data on the extraction of  $\text{MoI}_6$  from 6.9 N HCl by ether, see Kitahara, 1948. ("6.5% extracted.")

MOLYBDENUM TRIOXIDE  $\text{MoO}_3$ 

0

SOLUBILITY IN WATER  
(Rosenheim and Davidsohn, 1903)

The dihydrate is stable below about  $33^\circ$ . Crystals of monohydrate separate from solutions of the dihydrate that are held at  $40$ – $50^\circ$ . The dihydrate has sometimes been referred to as the acid, and the monohydrate as

t°	Gms. MoO <sub>3</sub> per 100 gms.		t°	Gms. MoO <sub>3</sub> per 100 gms.	
	sat. sol.	H <sub>2</sub> O		sat. sol.	H <sub>2</sub> O
<u>Solid Phase MoO<sub>3</sub>·2H<sub>2</sub>O</u>					
18	0.1065	0.1066	59	1.0117	1.1258*
23	0.1822	0.1856	60	1.0760	1.2057*
30	0.2570	0.2638	66	1.4730	1.7274*
40	0.4541	0.4761*	70	1.7048	2.0550*
48	0.5980	0.6360*	74.4	1.7290	2.0904*
50.2	0.6431	0.6873*	75	1.7300	2.0920*
54	0.7283	0.7855*	79	1.7400	2.1064*
<u>Solid Phase MoO<sub>3</sub>·H<sub>2</sub>O</u>					
14.8	0.2112	0.2117*	45	0.3648	0.3661
24.6	0.2612	0.2619*	52	0.4167	0.4184
30.3	0.2964	0.2973*	60	0.4213	0.4231
36.8	0.3284	0.3295	70	0.4665	0.4685
42	0.3434	0.3446	80	0.5185	0.5212

\*metastable

SOLUBILITY OF MOLYBDIC OXIDE IN PERCHLORIC ACID SOLUTIONS AT  $25^\circ$   
(Jones, 1954)

Molarity of $\text{HClO}_4$ in Solvent	Molarity $\text{MoO}_3$ in Sat. Sol.	Molarity of $\text{HClO}_4$ in Solvent	Molarity $\text{MoO}_3$ in Sat. Sol.
0.182	0.00321	0.910	0.0107
0.364	0.00596	1.092	0.0134
0.546	0.00795	1.274	0.0149
0.728	0.0103		

## Mo MOLYBDENUM

SOLUBILITY OF MOLYBDIC OXIDE IN HYDROCHLORIC ACID SOLUTIONS  
(Issa and Khalifa, 1954)In  $10^{-6}$  N to 1 N HCl solutions:

pH		Gms. MoO <sub>3</sub> per liter sat. sol.	pH		Gms. MoO <sub>3</sub> per liter sat. sol.
before saturation	after saturation		before saturation	after saturation	
0.218	0.265	4.420	2.69	2.46	0.660
0.631	0.670	1.680	2.84	2.51	1.18
1.07	1.10	0.412	3.09	2.66	1.416
1.12	1.16	0.35	3.96	2.80	1.856
1.42	1.39	0.320	4.73	2.38	1.712
1.53	1.48	0.316	5.82	2.46	1.640
1.72	1.69	0.312*	6.40	2.11	1.630
2.09	2.03	0.328			

In 2 N to 6 N HCl solutions:

In more concentrated acid, longer times were needed for equilibration:

N HCl:	2	3	4	5	6
Gms. MoO <sub>3</sub> per liter	68.08	49.4	29.62	18.1	9.84

\*Minimum solubility (isoelectric point) = pH 1.7. Basko and Nabivanets, 1957 report the isoelectric pH to be 1.8, and the solubility 0.093 gms. per liter by solubility method and 1.46 gms. per liter by a method of "precipitation of the hydrated oxide." Neither value agrees with the value of Issa and Khalifa, above.

Results for the distribution of Mo<sup>+6</sup> between a large number of aqueous and organic phases are given by Nelidow and Diamond, 1955. 2-12 M HCl, HBr, H<sub>2</sub>SO<sub>4</sub>, HNO<sub>3</sub>, etc. and 10<sup>-2</sup> to 10<sup>-9</sup> M Mo<sup>+6</sup> were present in the aqueous phase, and 32 organic solvents were used as extractants.

SOLUBILITY OF MOLYBDIC OXIDE IN POTASSIUM FLUORIDE SOLUTIONS AT 95°  
(Schmitz-Dumont and Opgenhoff, 1954)[Solid Phase K<sub>3</sub>MoO<sub>4</sub>O<sub>13</sub>F·3H<sub>2</sub>O on cooling the solutions.]

Moles per liter	KF	0.05	0.1	0.2	0.27
sat. sol.	MoO <sub>3</sub>	0.10	0.19	0.37	0.50

SOLUBILITY OF MOLYBDIC ACID DIHYDRATE IN AQ. AMMONIUM SALT SOLUTIONS  
(Rosenheim and Davidsohn, 1903)

t°	Solvent	Gms. MoO <sub>3</sub> per 1000 Gms.	
		Sat. Solution	Solvent
29.6	10% (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	18.91	19.27
31.5	10% NH <sub>4</sub> HSO <sub>4</sub>	26.79	27.53
41.8	"	33.22	34.36
49.7	"	36.32	37.69

Melting points are given for:

MoO <sub>3</sub> + Na <sub>2</sub> MoO <sub>4</sub>	(Zelikman and Gorovits, 1954; Groschuff, 1908)
MoO <sub>3</sub> + WO <sub>3</sub>	(Rieck, 1943)
MoO <sub>3</sub> + V <sub>2</sub> O <sub>5</sub>	(Magneli and Oughton, 1951)

NITROGEN N<sub>2</sub>

## SOLUBILITY IN WATER

(Winkler, 1891; Bohr and Bock, 1891; Morrison and Billett, 1952)

Results in reasonable agreement with these are given by Braun, 1900; Hufner, 1906-07; Bohr, 1910; Müller, 1912-13; von Hamel, 1915; Cassuto, 1904; Orcutt and Seever, 1936, 1937; Van Slyke, 1939.

Of the several determinations, Winkler's are generally lowest; above 35° the recent values of Morrison and Billett are considerably higher than the older work.

$\beta$  = Bunsen absorption coefficient = ml N<sub>2</sub> (at 0°, 760 mm.) dissolved by 1 ml. H<sub>2</sub>O when partial pressure N<sub>2</sub> = 760 mm.

$\beta'$  = "Solubility" = ml N<sub>2</sub> (at 0°, 760 mm) dissolved by 1 ml. H<sub>2</sub>O when total pressure (N<sub>2</sub> + H<sub>2</sub>O) = 760 mm.

q = gms. N<sub>2</sub> per 100 gms. H<sub>2</sub>O when total pressure = 760 mm.

t°	(M.&B. 1952)	(B.&B. 1891)	(W., 1891)		
	$\beta$	$\beta$	$\beta$	$\beta'$	q
0	--	0.0239	0.0235	0.0233	0.00239
5	--	0.0215	0.0208	0.0206	0.00259
10	--	0.0196	0.0186	0.0183	0.00230
15	0.01745	0.0179	0.0168	0.0165	0.00208
20	0.01599	0.0164	0.0154	0.0151	0.00189
25	0.01485	0.0150	0.0143	0.0139	0.00174
30	0.01377	0.0138	0.0134	0.0128	0.00161
35	0.01283	0.0127	0.0125	0.0118	0.00148
40	0.01215	0.0118	0.0118	0.0110	0.00139
50	0.01125	0.0106	0.0109	0.0096	0.00121
60	0.01085	0.0100	0.0102	0.0082	0.00105
70	0.01058	--	--	--	--
80	--	--	0.0096	0.0051	0.00069
100	--	0.0100	0.0095	0.0000	0.00000

## SOLUBILITY OF NITROGEN IN WATER AT HIGH TEMPERATURES AND PRESSURES

The results in the table are by Wiebe, Gaddy and Heins, Jr., 1932, 1933 unless otherwise indicated. The apparatus consisted of two steel cylinders respectively of 1000 cc and 300 cc capacity. They were filled with water to three fourths capacity and N<sub>2</sub> bubbled through at the desired temperature and pressure. Equilibrium was approached from pressures above and below that for the particular determination, and gas bubbled through at the final pressure for three hours and the saturated solutions allowed to stand 2-14 hours before samples were removed for analysis. The nitrogen was 99.9% pure, the impurities being argon and a trace of oxygen.

Data in excellent agreement with these are given by Saddington and Krase, 1934 in the table following. When compared with the findings of W. G. and H. and S. and K.: The values of Frolich, Tauch, Hogan and Peer, 1931 are within  $\pm 8\%$  at 25°, while those of Goodman and Krase are up to 20% high at high temperatures and pressures. Additional data are given by Eichelberger, 1955.

# N NITROGEN

## SOLUBILITY OF NITROGEN IN WATER AT HIGH TEMPERATURES AND PRESSURES--Cont.

cc N <sub>2</sub> (at 0°, 760 mm) dissolved by 1 gm. H <sub>2</sub> O										
	0°	18°	25°	50°	75°	100°	169°	200°	260°	311°
10	--	--	0.14 <sup>g</sup>	--	--	--	--	--	0.44 <sup>f</sup>	0.78 <sup>f</sup>
25	--	--	0.348	0.273	0.254	0.266	--	--	1.13 <sup>f</sup>	1.95 <sup>f</sup>
50	--	--	0.674	0.533	0.494	0.516	--	--	--	--
100	1.45 <sup>a</sup>	--	1.264	1.011	0.946	0.986	1.08 <sup>a</sup>	--	2.027 <sup>c,d</sup>	--
200	3.19 <sup>a</sup>	--	2.257	1.830	1.732	1.822	3.29 <sup>a</sup>	3.287 <sup>c</sup>	4.378 <sup>c,d</sup>	--
300	3.62 <sup>a</sup>	--	3.061	2.534	2.413	2.546	3.83 <sup>a</sup>	--	6.062 <sup>c,e</sup>	--
500	--	4.3 <sup>b</sup>	4.441	3.720	3.583	3.799	--	--	--	--
800	--	--	6.134	5.221	5.062	5.365	--	--	--	--
1000	--	6.1 <sup>b</sup>	7.15	6.123	5.934	6.250	--	--	--	--
2000	--	6.9 <sup>b</sup>	--	--	--	--	--	--	--	--
3000	--	7.0 <sup>b</sup>	--	--	--	--	--	--	--	--
4000	--	6.4 <sup>b</sup>	--	--	--	--	--	--	--	--
4500	--	6.0 <sup>b</sup>	--	--	--	--	--	--	--	--

<sup>a</sup>Goodman and Krase, 1931; <sup>b</sup>Basset and Dode, 1936; pressures in Kg. per cm<sup>2</sup>; <sup>c</sup>Saddington and Krase, 1934; <sup>d</sup>at 240°; <sup>e</sup>at 230°; <sup>f</sup>Fray, Schweickert and Minnich, 1952; <sup>g</sup>Cassuto, 1904, 1913.

## SOLUBILITY OF NITROGEN IN WATER AT 50° TO 240° AND AT PRESSURES FROM 100 TO 300 ATMOSPHERES (Saddington and Krase, 1934)

It is pointed out that a quantitative solution of the problem requires density measurements of both the liquid and vapor phase in these systems at high temperatures and pressures, as well as a knowledge of the compressibility coefficient of the liquid. The highly perfected apparatus permitted saturation of the water with N<sub>2</sub> at the desired temperatures and pressures and subsequent removal of samples of the liquid and gas phases for analysis.

The data are in excellent agreement with those of Wiebe, Gaddy and Heins, Jr. in the preceding table. Calculated results for the compressibility factors of the gas phase are also given.

Liquid Phase		Gas Phase			
t°	cc N <sub>2</sub> (reduced to 0° and 760 mm) to saturate 1.0 gm. H <sub>2</sub> O	t°	Gm. H <sub>2</sub> O per liter gas phase	Gm. per 1.0 gm. Gas Phase	Density of Gas Phase gms. per liter
Results at 100 Atmospheres Pressure					
65	0.981	50	0.1236	0.00118	0.9988
80	0.777	80	0.3817	0.00403	0.9960
125	1.198	100	0.6474	0.00726	0.9927
180	1.644	150	2.710	0.0341	0.9659
210	1.817	190	5.880	0.0828	0.9172
240	2.027	230	13.300	0.1958	0.8042
Results at 200 Atmospheres Pressure					
50	1.806	50	0.1463	0.00085	0.9992
80	1.748	85	0.3116	0.00290	0.9971
100	1.825	150	2.960	0.0203	0.9797
150	2.172	190	7.350	0.0564	0.9436
200	3.287	225	14.640	0.1180	0.8820
240	4.378				
Results at 300 Atmospheres Pressure					
50	2.572	50	0.1975	0.00073	0.9993
70	2.425	75	0.4607	0.00262	0.9974
105	2.598	100	0.9126	0.00372	0.9963
135	3.128	115	1.450	0.00629	0.9937
165	3.905	145	3.240	0.0155	0.9835
230	6.062	165	5.320	0.0296	0.9741
		230	16.400	0.0933	0.9067

## SOLUBILITY OF NITROGEN IN AQUEOUS SOLUTIONS OF SULFURIC ACID

Results at 21° (Bohr, 1910)				Results at 20° (Christoff, 1906)	
Normality of Aq. H <sub>2</sub> SO <sub>4</sub>	Absorption Coef. $\beta$ (Bunsen)	Normality of Aq. H <sub>2</sub> SO <sub>4</sub>	Absorption Coef. $\beta$ (Bunsen)	Percent H <sub>2</sub> SO <sub>4</sub>	Ostwald Solubility Expression $\ell_{20}^a$
0	0.0156	24.8	0.0048	0	0.01537
4.9	0.0091	29.6	0.0051	35.82	0.008447
8.9	0.0072	34.3	0.0100	61.62	0.006144
10.7	0.0066	35.8*	0.0129	95.6	0.01672
20.3	0.0049				

\* = about 96%

<sup>a</sup> = Ostwald solubility = ml N<sub>2</sub> (at 20°, 760 mm) dissolved in 1 ml of solvent.

## SOLUBILITY OF NITROGEN IN AQUEOUS SALT SOLUTIONS

(Braun, 1900)

Coefficient of Absorption of N<sub>2</sub> in Barium Chloride Solutions of:

t°	13.83%	11.92%	6.90%	3.87%	3.33%
5	0.0127	0.0137	0.0160	0.0180	0.0183
10	0.0117	0.0125	0.0147	0.0166	0.0168
15	0.0104	0.0114	0.0132	0.0148	0.0150
20	0.0092	0.0098	0.0118	0.0132	0.0135
25	0.0078	0.0086	0.0104	0.0114	0.0119

Coefficient of Absorption of N<sub>2</sub> in Sodium Chloride Solutions of:

t°	11.73%	8.14%	6.4%	2.12%	0.67%
5	0.0102	0.0127	0.0138	0.0179	0.0200
10	0.0093	0.0113	0.0126	0.0164	0.0185
15	0.0081	0.0101	0.0113	0.0147	0.0164
20	0.0066	0.0087	0.0098	0.0131	0.0148
25	0.0047	0.0075	0.0083	0.0113	0.0130

## SOLUBILITY OF NITROGEN IN VARIOUS ACETATE SOLUTIONS AT 25°

(Brasted and Hirayama, 1958)

Solvent, moles per liter			Vapor pressure solution, mm.	Ostwald coefficient $\ell_{25}$
HQAc	NaQAc	Added Salt		
1	0.50	Cu(QAc) <sub>2</sub> 0.050	23.0	0.00130
1	0.52	" 0.157	22.8	0.00133
1	0.50	Zn(QAc) <sub>2</sub> 0.15	22.6	0.00125
1	0.51	Ni(QAc) <sub>2</sub> 0.051	23.0	0.00133
1	0.50	" 0.15	22.9	0.00139
1	0.50	Co(QAc) <sub>2</sub> 0.033	23.2	0.00128
1	0.50	" 0.10	22.8	0.00130
1	0.50	Mn(QAc) <sub>2</sub> 0.050	23.1	0.00134
1	0.50	" 0.15	23.0	0.00134
1	0.50	Hg(QAc) <sub>2</sub> 0.05	23.0	0.00145
1	0.50	" 0.15	23.0	0.00136
0	0	None (H <sub>2</sub> O)	--	0.00161



## N NITROGEN

### SOLUBILITY OF NITROGEN IN SALT SOLUTIONS (Morrison and Billet, 1952)

Values of "salting-out" constants  $k = \frac{\log S_0/S}{C}$

$S_0$  = Solubility in pure  $H_2O$  ( $\beta$ )

$C$  = Moles salt per 1000 gms.  $H_2O$ .

t°	S <sub>0</sub>	k		
		NaCl	LiCl	KI
12.6	0.01837	0.145	0.125	0.134
30	0.01377	0.121	0.095	0.100
50	0.01125	0.106	0.084	0.086
72	0.1054	0.106	0.092	0.084

### SOLUBILITY OF NITROGEN IN SEA WATER (Fox, 1909a)

Before using the sample of sea water for the solubility determinations it was found necessary to add acid, otherwise the  $CO_2$  could not be boiled out or the precipitation of neutral carbonates prevented. The very small amount of acid was titrated back, using phenolphthaleine as indicator.

The results are in terms of number of cc. of nitrogen (containing argon) absorbed by 1000 cc. of sea water from a free dry atmosphere of 760 mm. pressure.

The calculated formula expressing the solubility is:

$$1000a = 18.639 - 0.4304t + 0.007453t^2 - 0.0000549t^3 \\ - CI(0.2172 - 0.007187t + 0.0000952t^2).$$

Parts Chlorine per 1000	t°=0°	4°	8°	12°	16°	20°	24°	28°
0	18.64	17.02	15.63	14.45	13.45	12.59	11.86	11.25
4	17.74	16.27	14.98	13.88	12.94	12.15	11.46	10.89
8	16.90	15.51	14.32	13.30	12.44	11.70	11.07	10.52
12	16.03	14.75	13.66	12.72	11.93	11.25	10.67	10.16
16	15.18	14	13	12.15	11.73	10.81	10.27	9.80
20	14.31	13.27	12.34	11.57	10.92	10.36	9.87	9.44

A critical examination of the available data upon the Solubility of Nitrogen in pure water and in sea water has been made by Coste, 1917, 1927. It is concluded that "When proper allowances have been made for the effect of argon in the solubility of atmospheric nitrogen, considerable uncertainty exists as to the absorption coefficients of both this mixed gas and pure nitrogen in distilled Water. A similar uncertainty exists in the case of sea water.

## SOLUBILITY OF NITROGEN IN AQUEOUS ETHANOL SOLUTIONS AT 25°

 $\ell$  = Ostwald Coefficient

Results of Just, 1901		Results of Kretschmer, Nowakowska and Wiebe, 1946		
Vol. % Alcohol in Mixture	Dissolved N ( $\ell_{25}$ )	95% Ethanol by Volume (+ H <sub>2</sub> O)		
		t°	$\ell_{N_2}$	$\ell_{air}$
0	0.01634	-25	0.0944	0.1137
20	0.01536	0	.1053	.1232
33	0.01719	25	.1160	.1326
99.8	0.1432	50	.1290	.1450

SOLUBILITY OF NITROGEN IN AQUEOUS PROPIONIC ACID AND UREA SOLUTIONS  
(Braun, 1900)

t°	Coefficient of Absorption of N <sub>2</sub> in C <sub>2</sub> H <sub>5</sub> COOH Solutions of:				
	11.22%	9.54%	6.07%	4.08%	3.82%
5	0.0195	0.0204	0.0208	0.0210	0.0209
10	0.0178	0.0182	0.0186	0.0192	0.0191
15	0.0159	0.0163	0.0164	0.0169	0.0167
20	0.0146	0.0147	0.0148	0.0154	0.0155
25	0.0130	0.0134	0.0134	0.0137	0.0137

t°	Coefficient of Absorption of N <sub>2</sub> in CO(NH <sub>2</sub> ) <sub>2</sub> Solutions of:					
	15.65%	11.9%	9.42%	6.90%	5.15%	2.28%
5	0.0175	0.0179	0.0190	0.0198	0.0197	0.0199
10	0.0162	0.0167	0.0176	0.0183	0.0182	0.0184
15	0.0150	0.0149	0.0158	0.0165	0.0165	0.0171
20	0.0140	0.0139	0.0146	0.0151	0.0151	0.0155
25	0.0130	0.0130	0.0133	0.0137	0.0135	0.0139

The solubility of N<sub>2</sub> in aq. 37.5% isobutyric acid solution (d<sub>25</sub>° = 0.9985) is  $\ell_{23}$  = 0.0396,  $\ell_{29}$  = 0.0384 (Ostwald coefficients).

(Drucker and Moles, 1910)

## N NITROGEN

### SOLUBILITY OF NITROGEN IN AQUEOUS SOLUTIONS OF CHLORAL HYDRATE AT 15°

Results by Müller, C (1912-13)			Results by von Hammel (1915)		
Gms. CCl <sub>2</sub> ·CH(OH) <sub>2</sub> per 100 Gms. Aq. Sol.	d <sub>20</sub> of Aq. Sol.	Absorp. Coef. β at 15°	Gms. CCl <sub>2</sub> CH(OH) <sub>2</sub> per 100 Gms. Aq. Sol.	Abs. Coef. β at 15°	Solubility l <sub>25</sub> (Ostwald)
0	1.000	0.0170	0	0.0170	0.01796
15.8	1.0738	0.0158	15.0	0.0152	0.0160
28.2	1.1422	0.01422	26.1	0.0141	0.0149
37.25	1.1946	0.01300	37.6	0.0123	0.0130
47.0	1.2535	0.01275	48.9	0.0115	0.0121
56.52	1.3225	0.01245	61.3	0.0114	0.0120
71.5	1.441	0.01420	70.9	0.0131	0.0138
78.8	1.503	0.01492	79.1	0.0156	0.0165

### SOLUBILITY OF NITROGEN IN AQUEOUS SOLUTIONS OF GLYCEROL

Results of Müller, C (1912-13)			Results of von Hammel (1915)	
Gms. (CH <sub>2</sub> OH) <sub>2</sub> -CHOH per 100 Gms. Aq. Sol.	d <sub>16</sub> of Aq. Sol.	Abs. Coef. β at 15°	Gms. (CH <sub>2</sub> OH) <sub>2</sub> -CHOH per 100 Gms. Aq. Sol.	Abs. Coef. β at 15°
25	1.061	0.01266	15.7	0.01400
42.2	1.108	0.00976	29.9	0.01087
51.5	1.133	0.00759	46.6	0.00840
58	1.151	0.00703	57.6	0.00698
80.25	1.212	0.00530	67.1	0.00635
90	1.240	0.00583	77.0	0.00527
95	1.249	0.00716	88.5	0.00536
			99.25	0.00524

### Results of Drucker and Moles (1910)

Gms. (CH <sub>2</sub> OH) <sub>2</sub> -CHOH per 100 Gms. Aq. Sol.	d <sub>25</sub> of Aq. Sol.	Solubility l <sub>25</sub> (Ostwald)
0	0	0.0156
16	1.0392	0.0103
29.7	1.0744	0.0067
48.9	1.1263	0.0052
74.5	1.1931	0.0025
84.1	1.2213	0.0024

SOLUBILITY OF NITROGEN IN AQUEOUS SOLUTIONS OF SEVERAL COMPOUNDS  
(Hüner, 1906-07)

Aq. Solution of:	Conc. of Aq. Solution		t°	Abs. Coef. $\beta$
	Normality	Gms. per Liter		
Glucose	1	180	20.18	0.01215
"	0.5	90	20.21	0.01380
"	0.25	45	20.2	0.01480
Alanine ( $\alpha$ Aminopropionic Acid)	1	89	20.19	0.01213
Glycocol (Aminoacetic Acid)	1	75	20.16	0.01212
Aribinose	1	150	20.21	0.01203
Levulose	1	180	20.25	0.01221
Erythritol	1	122	20.25	0.01321
Urea	1	60	20.18	0.01477
Acetamide	1	59	20.22	0.01475

SOLUBILITY OF NITROGEN IN AQUEOUS SOLUTIONS OF CANE SUGAR AT 15°  
(Müller, C., 1912-13)

Gms. $C_{12}H_{22}O_{11}$ per 100 Gms. Aq. Solution			Abs. Coef. $\beta$ at 15°	Gms. $C_{12}H_{22}O_{11}$ per 100 Gms. Aq. Solution			Abs. Coef. $\beta$ at 15°
$d_{16}$ of Aq. Sol.				$d_{16}$ of Aq. Sol.			
11.38	1.050	0.01480		30.12	1.129	0.01090	
20	1.082	0.01280		47.89	1.220	0.00785	
29.93	1.128	0.01053		48.57	1.223	0.00700	

SOLUBILITY OF NITROGEN IN WATER AND IN WHOLE BLOOD AT 38°  
(Hawkins and Shilling, 1938)

Calves and dogs blood oxalated to 0.02% was either used immediately or after being kept at 0° until next day. The Van Slyke and Neill (1920) manometric apparatus was used and the determinations made upon 5cc samples.

9 samples of blood were used varying in  $O_2$  capacity from 15.70 to 20.14 Vol. percent. These results are for the sample having 20.14  $O_2$  capacity. The abs. coef. varied from 0.0138 to 0.0148 for dogs' blood and 0.0135 to 0.0140 for ox blood.

$\alpha$  = the Bunsen Absorption Coefficient = the cc of  $N_2$  (reduced to 0° and 760 mm) which are dissolved by 1cc of the saturated solution at a pressure of 760mm Hg.

Results for Water

$N_2$ Pressure in Mm Hg	$N_2$ content of $H_2O$ Vol. %	Abs. Coef. $\alpha$ cc $N_2$ per cc solution
714	1.21	0.01281
1486	2.55	0.01300
2980	4.97	0.01261
4592	7.67	0.01270

(Cont.)

## N NITROGEN

### SOLUBILITY OF NITROGEN IN WATER AND IN WHOLE BLOOD AT 38°--Cont.

#### Results for Blood

N <sub>2</sub> Pressure in Mm Hg	N <sub>2</sub> content of Blood Vol. %	Abs. Coef. ∞ cc N <sub>2</sub> per cc solution	Abs. Coef. ∞ cc N <sub>2</sub> per gm. H <sub>2</sub> O in Blood
715	1.31	0.0138	0.0171
1481	2.68	0.0136	0.0169
3071	5.52	0.0136	0.0169
4508	8.04	0.0134	0.0166

### SOLUBILITY OF NITROGEN IN PLASMA, BLOOD, ETC. AT 38°

(Van Slyke, Dillon and Margaria, 1934; Sandroy,  
Dillon and Van Slyke, 1934)

Solvent	cc N <sub>2</sub> * per l cc solvent	cc N <sub>2</sub> * per l gm. H <sub>2</sub> O of solvent
Water	0.01272	0.01281
0.155 Mol. Aq. NaCl	0.01220	0.01228
Plasma	0.117	0.0124
Cells	0.0146	0.0200
Blood (20 Vol. % O <sub>2</sub> cap.)	0.0130	0.0158
Haemoglobin	0.017†	--

\*reduced to 0° and 760mm; † is ccN<sub>2</sub> dissolved by 1 gm. dissolved Haemo-  
globin when the gas tension is 760mm.

### SOLUBILITY OF NITROGEN IN SERUM, PLASMA AND HAEMOGLOBIN SOLUTIONS

Solvent	t°	Cc. N <sub>2</sub> per 100 cc. solvent	Authority
Water	20	1.561	(Stoddard, 1927)
Plasma proteins, series 1	20	1.5168	"
" " 2	20	1.5156	"
Haemoglobin solutions	20	1.613	"
Blood Plasma	15	1.7	(O'Brien and Parker, 1922; quoted from Bohr, 1905)
"	38	1.2	"
Whole Blood	15	1.6	"
"	38	1.1	"
Blood Corpuscles	15	1.4	"
"	38	1.0	"

The solubility of nitrogen in blood at 23° was determined by  
Conant and Scott, 1926.

Data for the solubility of nitrogen in defibrinated ox-blood and ox  
serum under pressures varying 760-1400 mm. Hg are given by Findlay and  
Creighton (1910-11).

Data for the solubility of nitrogen in liquid oxygen are given by  
Erdman and Bedford (1904) and Stock (1904).

The Solubility of Nitrogen in Water and in aqueous suspensions of blood lipoids was determined by Grollman, 1929, with results showing that the lipoids increase the solubility of the nitrogen.

Determinations of the Solubility of Nitrogen in Azobacter Cells are given by Lineweaver, 1938.

Data for the absorption of nitrogen in solutions of organic dyes are given by Weigert, 1910.

#### SOLUBILITY OF NITROGEN IN METHANOL

##### Results at 1 atm.

$\ell$  = Ostwald coeff.

(Levi, 1901)		(Kretschmer, Nowakowska and Wiebe, 1946)	
t°	$\ell$	t°	$\ell$
5	0.2154	-25	0.1435
15	0.1923	0	.1532
25	0.1649	25	.1645
		50	.1765

##### Results at High Pressures

(Krichevskii and Lebedeva, 1947)

cm<sup>3</sup> of nitrogen measured at 0°, 760 mm. dissolved in 1 gm. of methanol.

Pressure Atm.	0°	25°	50°	75°
48.4	7.7	8.2	8.7	9.3
97.8	15.1	16.4	17.4	18.7
145	21.9	23.2	25.1	27.1
194	28.5	30.5	33.1	36.0
242	--	37.2	40.1	44.5
280	--	--	--	51.6
291	--	--	47.4	--

#### SOLUBILITY OF NITROGEN IN ETHANOL

<u>Results of</u> <u>Bunsen, Carius, 1955</u>		<u>Results of</u> <u>Kretschmer, Nowakowska and Wiebe, 1946</u>		
t°	$\beta$ (Bunsen coeff.)	t°	$\ell_{N_2}^*$	$\ell_{air}^*$
0	0.1263	-25	0.1280	0.1523
5	0.1244	0	.1391	.1615
10	0.1228	25	.1489	.1692
15	0.1214	50	.1606	.1798
20	0.1204			
24	0.1198			

(\*Ostwald coeff.)

(Cont.)

## N NITROGEN

### SOLUBILITY OF NITROGEN IN ETHANOL--Cont.

Results of Frolich, Touch, Hogan and Peer, 1931 at 25°

#### at high pressures

$\ell$  = Ostwald coeff. = ml N<sub>2</sub> (25°, 1 atm) per ml solvent.

P <sub>atm</sub>	$\ell$	P <sub>atm</sub>	$\ell$
20	2.0	100	10.2
40	4.25	120	12.0
60	6.25	140	13.75
80	8.1	160	15.5

### SOLUBILITY OF NITROGEN IN ISOPROPYL ALCOHOL

Results at 1 atm. (Kretschmer, Nowakowska and Wiebe, 1946)      Results at 25° at High Pressure (Frolich, Touch, Hogan and Peer, 1931)

t°	$\ell_{N_2}$	$\ell_{air}$	P <sub>atm</sub>	$\ell_{N_2}$	P <sub>atm</sub>	$\ell_{N_2}$
0	0.1353	0.1592	20	2.5	100	12.5
25	.1465	.1684	40	5.0	120	15.0
50	.1617	.1822	60	7.5	140	17.5
			80	10.0	160	20.0

### SOLUBILITY OF NITROGEN IN METHYL ALCOHOL SOLUTIONS OF POTASSIUM IODIDE AND OF UREA (Levi, 1901)

Solvent	Solubility of N (in terms of the Ostwald Solubility Expression $\ell$ )					
	At 5°		At 15°		At 25°	
	d <sub>5</sub> of Solvent	$\ell_5$	d <sub>15</sub> of Solvent	$\ell_{15}$	d <sub>25</sub> of Solvent	$\ell_{25}$
Gms. KI or of Urea per 100 Gms. CH <sub>3</sub> OH Solution						
0 (=pure CH <sub>3</sub> OH)	0.8080	0.2154	0.7980	0.1923	0.7937	0.1649
2.152 KI	0.8171	0.2028	0.8070	0.1802	0.8019	0.1524
3.053 "	0.8249	0.1966	0.8015	0.1756	0.8101	0.1466
10.939 "	0.8930	0.1676	0.8841	0.1464	0.8801	0.1258
2.738 Urea	0.8148	0.2030	0.8050	0.1823	0.7997	0.1561
4.841 "	0.8231	0.1951	0.8122	0.1750	0.8080	0.1491
7.377 "	0.8350	0.1878	0.8241	0.1690	0.8193	0.1444

### SOLUBILITY OF NITROGEN IN CARBON TETRACHLORIDE

At 1 atm. (Horiuti, 1931, 1932)

At high pressures at 25°

t°	$\ell$	(Frolich, Touch, Hogan and Peer, 1931)			
		P <sub>atm</sub>	$\ell$	P <sub>atm</sub>	$\ell$
-19.7	0.1256				
0	0.1403				
20	0.1572	20	3.0	100	15.6
25	0.162	40	6.25	120	18.75
40.1	0.1754	60	9.3	140	22.0
60.1	0.1953	80	12.5		
77	(a)				

SOLUBILITY OF NITROGEN IN SEVERAL SOLVENTS AT DIFFERENT TEMPERATURES  
(Horiuti, 1931, 1932)

Ethyl Ether		Benzene		Acetone	
t°	l	t°	l	t°	l
-77.7	0.2055	7.1	0.1063	-78.1	0.0967
-60.6	0.2144	20	0.1162	-60.3	0.1081
-41.1	0.2286	25	0.120	-40.75	0.1211
-20.5	0.2452		0.124 <sup>b</sup>	-25	0.1340*
0	0.2672	40	0.1355	-20.2	0.1376
20	0.2870	60	0.1575	0	0.1553*
25	0.293				0.1554
				20	0.1747
				25	0.179
					0.1816*
				40.1	0.1946

Methyl Acetate		Chlorobenzene	
t°	l	t°	l
-78.7	0.0900	-39.7	0.0695
-60.1	0.1032	-19.7	0.0778
-40.6	0.1190	0.0	0.0881
-20.3	0.1353	20.0	0.0994
0.0	0.1551	25	0.102
20	0.1748	40.1	0.1116
25	0.179	60.05	0.1259
40.1	0.1957	80.3	0.1399

\*Kretschmer, Nowakowska and Wiebe, 1946

<sup>b</sup>Gjaldbaek and Hildebrand, 1949

so.15 ml N<sub>2</sub> (0°, 1 atm) dissolve in 1 gm. CCl<sub>4</sub> at 77°, 1 atm N<sub>2</sub> (Dean and Walls, 1947)

<sup>c</sup>For data on the solubility of nitrogen in benzene, alone and in mixtures with hydrogen, at 25° and 100-500 atm. see Krichevskii and Efremova, 1950

SOLUBILITY OF NITROGEN IN VARIOUS ORGANIC SOLVENTS

- |                                            |                              |
|--------------------------------------------|------------------------------|
| (1) Kretschmer, Nowakowska and Wiebe, 1946 | (4) Drucker and Moles, 1910  |
| (2) Gjaldbaek and Hildebrand, 1949         | (5) DuPont, 1955             |
| (3) Roemer, Johnson and Piercey, 1938      | (6) Luther and Hiemenz, 1957 |

Solvent	t°	Ostwald Solubility coeff. l
n-butanol	0	0.1075 (1)
	25	0.1225 (1)
	50	0.1358 (1)
Is-o-Octane	-25	0.1943 (1)
	0	0.2088 (1)
	25	0.2258 (1)
	50	0.2452 (1)

(Cont.)



# N NITROGEN

## SOLUBILITY OF NITROGEN IN VARIOUS ORGANIC SOLVENTS--Cont.

- |                                            |                              |
|--------------------------------------------|------------------------------|
| (1) Kretschmer, Nowakowska and Wiebe, 1946 | (4) Drucker and Moles, 1910  |
| (2) Gjaldbaek and Hildebrand, 1949         | (5) DuPont, 1955             |
| (3) Roomer, Johnson and Piercey, 1938      | (6) Luther and Hiemenz, 1957 |

Solvent	t°	Ostwalt Solubility coeff. $\ell$
50 vol. % acetone in ethanol	0	0.1427 (1)
	25	0.1609 (1)
	50	0.1829 (1)
50 vol. % isooctane in ethanol	0	0.1785 (1)
	25	0.1939 (1)
	50	0.2100 (1)
n-hexane	25	0.239 (2)
cyclohexane	25	0.156 (2)
n-Perfluoroheptane	0	0.411 (2)
	25	0.385 (2)
	50	0.360 (2)
Perfluoromethyl cyclohexane	25	0.375 (2)
Perfluorodimethyl cyclohexane	25	0.328 (2)
	50	0.317 (2)
Carbon disulfide	25	0.0823 (2)
n-heptane	25-115°	100.9 atm (3)
iso butyric acid	25	0.1651 (4)
dimethylformamide	25	0.04 (5)
50 mol % decanol in dodecanol	20	0.0754 (6)
	41	0.0928 (6)
	61.5	0.105 (6)
	82	0.120 (6)

Data for the solubility of nitrogen in 17 organic liquids at 20 and 25° are given by Just, 1901, but the results are generally lower than those of other authors.

## SOLUBILITY OF NITROGEN IN EDIBLE OILS

	ml. N <sub>2</sub> (0°, 760 mm.) per 100 ml. of Oil				
	21.5°	22°	37°	40°	60°
Olive Oil	6.44(5)	5.2(1)	6.7(2)(3)	--	--
Corn Oil	--	6.3(2)	6.3(2)	--	--
Butter Oil	--	--	--	8.9(4)	7.9(4)
Cottonseed Oil	--	--	--	6.2(4)	--
Lard	--	--	--	6.6(4)	--

(1) Vernon, 1907

(2) Vibrons, 1935

(3) Behnke and Yarbrough, 1938

(4) Schaffer and Haller, 1943

(5) Van Slyke, 1939

## SOLUBILITY OF NITROGEN IN PETROLEUM OILS

	t°	g	
Heavy lube oil	21	0.065	} (Szebehely, 1951)
Light " "	21	0.092	
aircraft engine fuel	21	0.1495	
kerosene	-18	0.109	} (Derry, Evans, Faulkner, and Jelfs, 1952)
	+18	0.122	
	25	0.126	
	42	0.134	
paraffin oil	32	0.07	(Nasini and Coraldi, 1932)
paraffin oil	20	0.0833	} (Luther and Hiemenz, 1957)
(M.W = 405, 30%	41	0.0882	
naphthenic)	61.5	0.0920	
	82	0.0957	
American mineral oil	22	0.077	(Kubic, 1927)
(congealing pt. 37° F)			
petroleum	10	0.135	} (Gniewasz and Walfisz, 1887)
	20	0.117	
Heavy naphtha }			
Gas Oil }	25°	at high pressures:	
Butane }			

The heavy naphtha had a sp. gr. of 0.8003 and vapor pressure of 80mm at 25°. The gas oil had a sp. gr. of 0.8319 and vapor pressure of 2mm at 25°.

cc N<sub>2</sub> (measured at 25° and 1 atmosphere) per 1.0 cc liquid

Pressure in Atmospheres	Butane	Heavy	Gas
	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>2</sub> CH <sub>3</sub>	Naphtha	oil
20	10.6	2.1	2.0
40	22.0	4.5	4.5
60	32.8	6.3	6.3
80	44.0	8.1	8.1
100	55.0	10.0	9.8
120	62.5	11.5	11.2
140	76.0	13.0	12.75
160	88.0	--	--
180	99.0	--	--

(Frolich, Touch, Hogan and Peer, 1931)

## SOLUBILITY OF NITROGEN IN POLYSTYRENE AT 170°

(Newitt and Weale, 1948)

P (atm.) of H <sub>2</sub>	287	282.5	232	187	182	118
cc of H <sub>2</sub> (at 0°, 1 atm.) per gm. of Polystyrene	7.77	7.93	6.15	5.57	5.02	2.95

## NITROGEN

### SOLUBILITY OF NITROGEN IN RUBBER (Carpenter, 1947)

Composition of sample, parts by weight: Smoked Sheet Rubber 100, Sulfur 2.5, ZnO 3.0, Stearic Acid 1.0, Mercapto Benzthiazole 0.5, Agrite White 0.5. A vulcanized cylindrical piece was used and the adsorption was carried out in the dark. Diffusion rates were also measured. The results differed by as much as 10% depending on the method of calculating.

t°	Gms. N <sub>2</sub> per cc Rubber per Atm.	cc N <sub>2</sub> (0°, 760mm) per 100 cc Rubber per Atm.	t°	Gms. N <sub>2</sub> per cc Rubber per Atm.	cc N <sub>2</sub> (0°, 760mm) per 100 cc Rubber per Atm.
21	-	4.4 (3.5) <sup>a</sup>	35	6.1 x 10 <sup>-5</sup>	-
25	-	4.6 (3.5) <sup>b</sup>	40	6.4 x 10 <sup>-5</sup>	-
25.3	5.6 x 10 <sup>-5</sup>	-	45	6.2 x 10 <sup>-5</sup>	-
30	5.9 x 10 <sup>-5</sup>	-	50	6.4 x 10 <sup>-5</sup>	-

<sup>a</sup>Venable and Fuwa, 1922

<sup>b</sup>Barrer, 1941

### SOLUBILITY OF NITROGEN IN LIQUID METHANE AND PROPANE AT -183° (Vellinger and Pons, 1945)

The apparatus was immersed in liquid oxygen. The data were read from curves given by the authors:

Total Pressure mm	cc N <sub>2</sub> Dissolved in 100 cc of		Total Pressure mm	cc N <sub>2</sub> Dissolved in 100 cc of	
	Methane	Propane		Methane	Propane
150	1.2	0.7	500	7.9	1.7
250	2.5	1.0	650	14.3	2.4
350	4.1	1.3	750	26	

The solid-liquid equilibria of the systems nitrogen-methane and nitrogen-argon were studied by Federova (1939) from heat capacity curves.

Liquid-Vapor equilibrium data for the system nitrogen-benzene at high pressures is given by Miller and Dodge, 1940.

The solubility of nitrogen in ethylene at 0° and pressures up to 7000 Kg./cm.<sup>2</sup> has been determined by Tsiklis, 1947a.

Results for the solubility of nitrogen in liquid hydrogen at 20°-32° K are given by Petit, 1957.

# SOLUBILITY OF NITROGEN IN LIQUID SULFUR DIOXIDE (Dean and Walls, 1947)

The results disagree with those of Donte and Ferguson, 1939, which showed a considerably greater solubility. The authors point out that the relatively large vapor-volume corrections made by the previous workers may have introduced large errors.

t °F	Pressure Lbs. per sq. In. Absolute	cc. N <sub>2</sub> (32°F, 1 Atm.) per gm. SO <sub>2</sub>	t °F	Pressure Lbs. per sq. In. Absolute	cc. N <sub>2</sub> (32°F, 1 Atm.) per gm. SO <sub>2</sub>
83.0	515	5.0	-25.7	515	2.8
83.0	225	1.8	-25.7	262	1.2
-4.0	253	1.9	-25.7		0.06

1 Atm. Partial Pressure of Nitrogen.

Data for the system N<sub>2</sub>-SO<sub>2</sub> from 25° to 40° at pressures up to 9000 Kg/cm<sup>2</sup> are given by Tsiklis, 1947.

# SOLUBILITY OF NITROGEN IN LIQUID AMMONIA AT 25° AND FROM 25 TO 1000 ATMOSPHERES PRESSURE (Wiebe and Tremearne, 1934)

Liquid ammonia and Nitrogen were shaken together at given pressures in a steel cylinder of 1400cc. capacity. The sample removed for analysis was received in a vessel immersed in liquid air, and subsequently analyzed by appropriate methods. The vapor pressure of liquid ammonia at 25° is 9.8955 atmospheres.

Total Pressure in Atmospheres	cc N <sub>2</sub> (at 0° and 760mm) dissolved per 1.0 gm. NH <sub>3</sub>	Total Pressure in Atmospheres	cc N <sub>2</sub> (at 0° and 760mm) dissolved per 1.0 gm. NH <sub>3</sub>
25	2.22	400	37.02
50	5.73	600	45.43
100	12.04	800	51.10
200	22.48	1000	54.83

Results for the system Nitrogen + Hydrogen + Ammonia (Gas) + Ammonia (Liquid) at temperatures from -22.5 to +18.7° and pressures from 50 to 1000 atmospheres are given by Larson and Black, 1925. A discussion of these and similar results for other systems, in the concept that solubility effect is a change in activity of one component resulting from the presence of the other component, is given by Cupples, 1929. More recent results from 0° to 50° up to 800° atm are given by Bol'shakov, 1954.

A nomograph for the solubility of nitrogen in liquid ammonia is given by Davis, 1941.

The solubility of nitrogen-methane mixtures in liquid ammonia from -20° to 50° up to 560 atm. has been determined by Bolshakov and Lebedeva, 1940.

Liquid-Vapor and Vapor-Vapor equilibrium data in the system N<sub>2</sub>-NH<sub>3</sub> up to 9000 atm and 148° are reported by Tsiklis, 1952, 1952a. Other data below 110° are given by Lindroos and Dodge, 1952. Two phases are formed below 85°.

## N NITROGEN

For data in the two-phase system  $N_2$ - $NH_3$ - $CH_4$  at  $85^\circ$ ,  $105^\circ$  up to 5000 Kg/cm<sup>2</sup> see Tsiklis, 1951.

### SOLUBILITY OF NITROGEN IN METALS

Results for Cobalt	(Sieverts and Hagen, 1934.)
" " Iron	(Jurisch, 1912; Martin, 1929; Sieverts, 1931; 1938; Eisenhutu and Kaupp (1930); Hayasi (1940), and Krichevskii and Khazanova (1947). (Martin, 1929.)
" " Molybdenum	(Martin, 1929.)
" " Tungsten	(Martin, 1929.)

## H AMMONIA $NH_3$

### THE SYSTEM $NH_3$ - $H_2O$ (Postma, 1920; Elliott, 1924)

The closely agreeing determinations of these investigators were plotted on cross-section paper and the following results read from the curve.

Considerable additional data on this system are given by Rupert, 1910; Smits and Postma, 1914; Baumé and Tykociner, 1914; and Moronov, 1955; see the table following. Rollet and Vuillard, 1956 and Vuillard, 1957, report the presence of a dihydrate that is stable within one degree of the eutectic.

t°	Mole percent $NH_3$	Gms. $NH_3$ per 100 gms. solution	Solid Phase
0.0	0.0	0.0	Ice
- 10.0	9.2	8.75	"
- 20.0	15.2	14.49	"
- 40.0	22.9	21.22	"
- 60.0	27.0	25.9	"
- 80.0	31.0	29.8	"
- 90.0	33.0	31.76	"
-100.0 Eutec.	34.5	33.23	" + $NH_3 \cdot H_2O$
- 95.0	37.2	35.88	$NH_3 \cdot H_2O$
- 90.0	40.0	38.6	"
- 85.0	43.0	41.61	"
- 80.0	46.5	45.1	"
- 79 m. pt.	49.5	48.08	"
- 80	52.2	50.81	"
- 82.5	54.6	53.20	"
- 85.0	56.0	54.62	"
- 87.5	57.2	55.8	"
- 88.3 Eutec.	57.5	56.11	$NH_3 \cdot H_2O + 2NH_3 \cdot H_2O$
- 87.5	58.0	56.63	$2NH_3 \cdot H_2O$
- 85	59.2	57.84	"
- 82.5	60.5	59.16	"
- 80	63.0	61.69	"
- 78.2 m. pt.	66.5	65.28	"
- 80	70.5	60.36	"

(Cont.)

THE SYSTEM  $\text{NH}_3 - \text{H}_2\text{O}$ --Cont.

t°	Mole percent $\text{NH}_3$	Gms. $\text{NH}_3$ per 100 gms. solution	Solid Phase
- 85	76.0	75.00	$2\text{NH}_3 \cdot \text{H}_2\text{O}$
- 87.5	78.0	77.05	"
- 90.0	79.7	78.83	"
- 92.5 Eutec.	81.5	80.05	" + $\text{NH}_3$
- 90	83.6	82.87	$\text{NH}_3$
- 87.5	86.0	85.55	"
- 85	88.5	87.92	"
- 82.5	92.0	91.56	"
- 80.0	95.7	95.45	"
- 77.7	100.0	100.00	"

H

COMPARISON OF INVARIANT POINTS IN THE SYSTEM  $\text{NH}_3 - \text{H}_2\text{O}$ 

a) Rupert, 1910	b) Baumé and Tykociner, 1914
c) Postma, 1920	d) Elliott, 1924
e) Muronov, 1955	f) Rollet and Vuillard, 1956

Compositions are wt. %  $\text{NH}_3$ 

Solid Phases	(a)	(b)	(c)	(d)	(e)	(f)
ICE + $\text{NH}_3 \cdot \text{H}_2\text{O}$	-125° 34.0	-100.9° 34.3	-100.3° 33.5	-100.2° 31.3	-101.3° 32.7	-103.3° 33.9 <sup>m</sup>
ICE + $\text{NH}_3 \cdot 2\text{H}_2\text{O}$	-	-	-	-	-	- 98.0
$\text{NH}_3 \cdot 2\text{H}_2\text{O}$ + $\text{NH}_3 \cdot \text{H}_2\text{O}$	-	-	-	-	-	32.9
	-	-	-	-	-	98.8
$\text{NH}_3 \cdot \text{H}_2\text{O}$ m. pt.	- 80° 48.6	- 79.5° 48.6	- 79.0° 48.6	- 79.0° 48.6	- 77.0° 48.6	35.3
$\text{NH}_3 \cdot \text{H}_2\text{O}$ + $2\text{NH}_3 \cdot \text{H}_2\text{O}$	- 87.0° 56.5	- 87.3° 56.7	- 86.0° 57.2	- 88.2° 57.7	- 85.4° 56.7	-
$2\text{NH}_3 \cdot \text{H}_2\text{O}$ m. pt.	- 79.0° 65.4	- 79.4° 65.4	- 78.8° 65.4	- 78.6° 65.4	- 77.4° 65.4	-
$2\text{NH}_3 \cdot \text{H}_2\text{O}$ + $\text{NH}_3$	- 94.0 80.3	- 92.6 79.8	- 92.5 80.7	- 94.7 78.4	- 92.2 79.9	-

<sup>m</sup>metastableEQUILIBRIUM IN THE SYSTEM AMMONIA AND WATER AT  
TEMPERATURES UP TO 150° AND PRESSURES UP TO 10 ATMOSPHERES  
(Clifford and Hunter, 1933)

A dynamic method was used to determine the vapor compositions between 60° and 100° and for pressures up to 1.5 atmospheres. At higher ranges of temperature and pressure a static method was used. Total vapor pressures and vapor compositions were measured. The results were plotted together with those of Perman 1903, Mollier, 1908 and Smits and Postma, 1914 and from the curves so obtained, tables for the isobars and isotherms were constructed. The following are the values for the isobars.

(Cont.)

# N NITROGEN

## EQUILIBRIUM IN THE SYSTEM AMMONIA AND WATER AT TEMPERATURES UP TO 150° AND PRESSURES UP TO 10 ATMOSPHERES--Cont.

0.02 Atm. Total P.			0.2 Atm. Total P.			0.5 Atm. Total P.		
t°	Gms. NH <sub>3</sub> per 100 gms. Solution		t°	Gms. NH <sub>3</sub> per 100 gms.		t°	Gms. NH <sub>3</sub> per 100 gms.	
	Solution	Vapor		Solution	Vapor		Solution	Vapor
-82.9	75.5		-61.0	100	100	-46.3	100	100
-79.8	62.8		-10	31.8	99.0	-40	75.3	--
-70	51.0		0	25.3	98.0	-30	60	--
-60	41.5		10	20.0	95.5	-20	51.2	--
-50	34.3		20	15.0	90.5	-10	43.1	--
-40	27.5		30	10.0	80.0	0	37.2	--
-30	21.0		40	5.5	65.5	20	26.0	97.5
-20	15.0		50	2.7	38.0	40	15.0	87.5
-10	9.5		60.4	0.	0.	60	6.2	63.6
0	5.0					80	0.3	4.5
10	1.7					81.7	0.	0.
17.7	0.0							

1.0 Atm. Total P.			2 Atm. Total P.			4 Atm. Total P.		
t°	Gms. NH <sub>3</sub> per 100 gms.		t°	Gms. NH <sub>3</sub> per 100 gms.		t°	Gms. NH <sub>3</sub> per 100 gms.	
	Solution	Vapor		Solution	Vapor		Solution	Vapor
-33.2	100	100	-18.5	100	100	-1.5	100	100
-30	86.9	--	-10	75.0	--	0	94.7	--
-20	65.4	--	0	61.4	--	10	71.5	--
-10	55.3	--	10	52.6	--	20	60.2	--
0	47.3	--	20	45.6	--	30	52.2	--
10	40.6	99.2	30	39.2	--	40	45.5	--
20	34.6	98.5	40	33.7	98.4	50	39.7	--
30	29.1	97.0	50	28.5	97.5	60	34.2	97.3
40	24.0	94.5	60	23.4	94.8	70	29.2	94.8
50	19.0	90.2	70	18.5	89.2	80	24.4	90.0
60	14.4	82.5	80	14.0	80.3	90	19.8	83.6
70	10.0	70.0	90	10.0	67.5	100	15.5	76.0
80	6.1	52.6	100	6.2	50.6	110	11.5	66.3
90	2.9	31.8	110	2.9	29.0	120	7.7	52.2
100	0	0	120	0.15	1.5	130	4.2	33.0
			120.6	0.	0.	140	1.0	9.8
						144.1	0.	0.

(Cont.)

EQUILIBRIUM IN THE SYSTEM AMMONIA AND WATER AT  
TEMPERATURES UP TO 150° AND PRESSURES UP TO 10 ATMOSPHERES--Cont.

6 Atm. Total P.			8 Atm. Total P.			10 Atm. Total P.		
t°	Gms. NH <sub>3</sub> per 100 gms.		t°	Gms. NH <sub>3</sub> per 100 gms.		t°	Gms. NH <sub>3</sub> per 100 gms.	
	Solution	Vapor		Solution	Vapor		Solution	Vapor
9.7	100	100	18.5	100	100	25.3	100	100
20	74.6	--	20	94.6	--	30.	87.0	--
30	62.0	--	30	73.5	--	40	70.2	--
40	54.0	--	40	62.0	--	50	60.0	--
50	47.5	--	50	54.1	--	60	52.2	--
60	41.9	--	60	47.5	--	70	46.0	98.8
70	36.6	97.0	70	41.9	98.2	80	40.6	97.4
80	31.4	94.2	80	36.4	96.2	90	35.6	95.1
90	26.6	90.0	90	31.4	93.3	100	30.8	91.7
100	22.0	84.8	100	26.7	89.5	110	26.3	87.0
110	17.6	78.4	110	22.4	84.0	120	22.0	81.1
120	13.5	69.9	120	18.3	77.3	130	18.0	74.2
130	9.6	57.1	130	14.1	68.0	140	14.0	64.8
140	5.9	40.0	140	10.2	55.5	150	10.1	51.5
150	2.6	19.5	150	6.4	38.9	160	6.6	36.3
159.3	0.	0.	160	3.1	20.7	170	3.4	20.5
			170	0.3	2.3	180.5	0.	0.
			171	0.0	0.0			

SOLUBILITIES AND PARTIAL PRESSURES OF AMMONIA IN WATER  
(Neuhausen and Patrick, 1921)

The determinations were made by repeatedly introducing ammonia into a receptacle containing a given volume of water, until no further diminution in pressure occurred after thorough shaking. By means of a special device a portion of the saturated solution was withdrawn without a material change in pressure, and thus without alteration in the content of ammonia. Successive samples were titrated and the following results were calculated from these titrations and the pressure readings.

t°	Mole fraction percent ammonia	Partial pressure in mm. of		Density of Solution	Percent contraction in volume
		Ammonia	Water		
0	51.676	915	1.25	0.842	7.50
	52.382	944	1.19	0.842	7.80
	54.735	1140	0.97	0.833	7.80
	61.206	1409	0.77	0.817	9.21
	62.765	1499	0.708	0.812	8.52
	65.076	1684	0.61	0.803	8.51
	65.711	1732	0.545	0.800	8.35
	66.621	1865	0.46	0.795	8.12
	34.886	728	9.4	0.882	7.07
	36.508	798	9.25	0.878	7.25
20	42.077	1140	8.6	0.864	8.30
	42.392	1165	8.55	0.862	8.17

(Cont.)



# N NITROGEN

## SOLUBILITIES AND PARTIAL PRESSURES OF AMMONIA IN WATER--Cont.

t°	Mole fraction percent ammonia	Partial pressure in mm. of		Density of solution	Percent contraction in volume
		Ammonia	Water		
20° (Cont.)	43.086	1226	8.4	0.854	8.16
	43.731	1281	8.3	0.848	7.37
	48.175	1677	7.05	0.845	8.96
	49.941	1938	6.33	0.835	8.36
	53.940	2655	5.1	0.825	9.47
	55.970	3076	4.45	0.817	9.47
	56.923	3277	4.15	0.815	9.65
H 40	25.011	752	36.5	0.902	3.05
	25.366	774	36.2	0.9005	6.21
	30.690	1134	32.1	0.8833	7.21
	32.686	1335	29.5	0.817	7.68
	33.134	1376	29.0	0.8755	7.74
	36.326	1787	23.9	0.864	8.22
	39.026	2180	20.5	0.856	8.52
	41.133	2460	19.0	0.849	9.05
	42.925	2832	18.42	0.843	10.00
	44.624	3226	18.0	0.837	9.49
	44.557	3214	18.0	0.837	9.42
	46.335	3640	17.6	0.828	9.40

## VAPOR PRESSURE OF AQUEOUS AMMONIA SOLUTIONS (Sherwood, 1925)

This author collected the available data on the partial vapor pressure of ammonia in water and plotted the results on logarithmic paper to reduce the curvature and obtain constant percentage errors. The results of Raoult, Carius, Perman, Watts, Sims, Roscoe and Ditmar, Cragoe, Myers and Taylor, Mallet, Mollier, Smits and Postma, Doryer and Gaus were used.

Additional data for the vapor pressure of aqueous solutions of ammonia at 0° are given by Klarmann, 1924; at 25° by Scheffer and de Wijs, 1925; and Breitenbach, 1925; and at 100° by Calingaert and Huggins, 1923. Other determinations of conductivities and vapor pressures at 0°, 10°, 18°, 25° were made by Morgan and Maas, 1931.

Gms. NH <sub>3</sub> per 1000 gms. H <sub>2</sub> O	Partial Pressure of NH <sub>3</sub> in mm. Hg at						
	0°	10°	20°	30°	40°	50°	60°
1000	947						
900	785						
800	636	987					
700	500	780					
600	380	600	945				
500	275	439	686				
400	190	301	470	719			
300	119	190	298	454	692		
250	89.5	144	227	352	534	825	

(Cont.)

## VAPOR PRESSURE OF AQUEOUS AMMONIA SOLUTIONS--Cont.

Gms. NH <sub>3</sub> per 1000 gms. H <sub>2</sub> O	Partial Pressure of NH <sub>3</sub> in mm. Hg at						
	0°	10°	20°	30°	40°	50°	60°
200	64	103.5	166	260	395	596	834
150	42.7	70.1	114	179	273	405	583
100	25.1	41.8	69.6	110	167	247	361
75	17.7	29.9	50.0	79.7	120	179	261
50	11.2	19.1	31.7	51	76.5	115	165
40		16.1	24.9	40.1	60.8	91.1	129.2
30		11.3	18.2	29.6	45	67.1	94.3
25			15	24.4	37.6	55.7	77
20			12	19.3	30	44.5	61
16				15.3	24.1	35.5	48.7
12				11.5	18.3	26.7	36.3
10					15.4	22.2	30.2

THE SYSTEM AMMONIA - HYDROGEN PEROXIDE  
(Maass and Matcher, 1922)

By means of a gas buret definite volumes of ammonia were added to weighed quantities of pure hydrogen peroxide, and the freezing-points of the resulting mixtures were accurately determined.

t° of f. pt.	Gms. NH <sub>3</sub> per 100 gms. mixture	Solid Phase	t° of f. pt.	Gms. NH <sub>3</sub> per 100 gms. mixture	Solid Phase
- 1.72	0.0	H <sub>2</sub> O <sub>2</sub>	9.6	48.6	NH <sub>3</sub> ·H <sub>2</sub> O <sub>2</sub>
-13	3.41	"	1.5	49.7	"
-18	4.31	"	0.0	50.7	"
+48 Eutec.	8.0 approx	" + NH <sub>3</sub> ·H <sub>2</sub> O <sub>2</sub>	- 6.0	51.8	"
+ 5	18.0	NH <sub>3</sub> ·H <sub>2</sub> O <sub>2</sub>	- 9.5	52.8	"
8	19.8	"	-32	56.7	"
15	21.1	"	-53.5	59.5	"
20	23.9	"	below -78	61.3	"
24.5 m.pt.	30.0 approx	"	" "	68.7	"

SOLUBILITY OF AMMONIA IN AQUEOUS SALT SOLUTIONS AT 25°  
(Abegg and Riesenfeld, 1902)

The determinations were made by the dynamic method. In a later paper by Riesenfeld (1903), additional determinations are given for 35°.

(Cont.)

# N NITROGEN

## SOLUBILITY OF AMMONIA IN AQUEOUS SALT SOLUTIONS AT 25°--Cont.

Salt Solution	Mols. NH <sub>3</sub> per Liter Salt Sol. of:			Salt Solution	Mols. NH <sub>3</sub> per Liter Salt Sol. of:		
	0.5 n.	1 n.	1.5 n.		0.5 n.	1 n.	1.5 n.
KCl	0.930	0.866	0.809	KCN	0.926	0.858	0.802
KBr	0.950	0.904	0.857	KCNS	0.932	0.868	0.814
KI	0.970	0.942	0.900	K <sub>2</sub> SO <sub>4</sub>	0.875	0.772	0.678
KOH	0.852	0.716	0.607	K <sub>2</sub> SO <sub>3</sub>	0.865	0.768	0.675
NaCl	0.938	0.889	0.843	K <sub>2</sub> CO <sub>3</sub>	0.788	0.650	0.554
NaBr	0.965	0.916	0.890	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	0.866	0.771	0.675
NaI	0.995	0.992	0.985	K <sub>2</sub> CrO <sub>4</sub>	0.866	0.771	0.675
NaOH	0.876	0.789	0.716	CH <sub>3</sub> COOK	0.866	0.765	0.685
LiCl	0.980	1.008	0.045	HCOOK	0.868	0.760	0.678
LiBr	1.001	1.040	1.090	KBO <sub>2</sub>	0.814	0.677	0.560
LiI	1.030	1.094	1.190	H <sub>2</sub> HPO <sub>4</sub>	0.860	0.749	0.664
LiOH	0.863	0.808	0.768	Na <sub>2</sub> S	0.887	0.795	0.726
KF	0.839	0.722	0.626	*KClO <sub>3</sub>	0.927		
KNO <sub>3</sub>	0.923	0.862	0.804	*KBrO <sub>3</sub>	0.940		
KNO <sub>2</sub>	0.920	0.855	0.798	*KIO <sub>3</sub>	0.951		

\*These salt solutions are 0.25 normal.

Konowalow (1898) expressed the results of determinations of the solubility of ammonia in aqueous silver nitrate by the equation  $H = 56.58 (m - 2n)$  in which  $H$  = partial pressure of NH<sub>3</sub> in mm. of Hg.,  $m$  = molecular concentrations of NH<sub>3</sub> and  $n$  = molecular concentration of AgNO<sub>3</sub>. Similar results are given in later papers (Konowalow, 1899, a, b) for a large number of other salt solutions.

Data for the solubility of ammonia in aqueous sodium hydroxide solutions at 15° are given by Miloslawski, 1931.

## SOLUBILITY OF AMMONIA IN Ca(NO<sub>3</sub>)<sub>2</sub> and KOH SOLUTIONS (Raoult)

t°	In Calcium Nitrate Solutions		In Potassium Hydroxide Solutions	
	Gms. NH <sub>3</sub> per 100 Gms. Solvent in:		Gms. NH <sub>3</sub> per 100 Gms. Solvent in:	
	28.38% Ca(NO <sub>3</sub> ) <sub>2</sub>	In 50.03% Ca(NO <sub>3</sub> ) <sub>2</sub>	11.25% KOH	25.25% KOH
0	96.25	104.5	72.0	49.5
8	78.50	84.75	57.0	37.5
16	65.00	70.5	46.0	28.5
24	-	-	37.3	21.8

THE SYSTEM POTASSIUM CARBONATE - AMMONIA - WATER  
(Newth, 1900)

The solutions used were: potassium carbonate saturated at 15° (contained 57.2 grams  $K_2CO_3$  per 100 cc.). Aqueous ammonia of 0.885 sp. gr. (contained about 33 percent ammonia). The determinations were made by adding successive small quantities of one of the solutions to a measured volume of the other, and observing the point at which opalescence appeared.

t°	Saturated $K_2CO_3$ in Aq. Ammonia		Aq. Ammonia in Saturated $K_2CO_3$	
	cc. $K_2CO_3$ per 100 cc. Ammonia	% $K_2CO_3$ Solution in Mixture	cc. Ammonia in 100 cc. $K_2CO_3$	% $K_2CO_3$ Solution in Mixture
1	2.0	2.0	37.5	72.7
6	3.0	3.0	47.5	67.6
11	5.0	4.7	52.5	65.0
16	6.5	6.1	60.0	63.0
21	8.5	8.0	77.5	56.3
26	10.5	9.5	105.0	49.0
31	12.5	11.1	152.5	39.0
38	20.0	16.6	195.0	33.0
39	21.0	17.0	220.0	31.0
42	25.0	20.0	250.0	28.5
43	35.0	26.0	285.0	26.5

Above 43° the solutions are completely miscible. If 10 percent of water is added to each solution the temperature of complete miscibility is lowered to 25°. The mutual solubilities are:

t°	Percent $K_2CO_3$ Solution in:	
	Ammonia Layer	$K_2CO_3$ Sol. Layer
0	8	62
10	11	52
20	15	38
25 (crit. pt.)		25

With the addition of 12.9 percent of water to each solution the temperature of complete miscibility (crit. pt.) is lowered to 10°. With the addition of 18.1 percent water this temperature becomes 0°.

INFLUENCE OF SALTS AND OTHER COMPOUNDS ON THE VAPOR PRESSURE OF  
AQUEOUS AMMONIA SOLUTIONS  
(Perman, 1902)

Vapor pressure determinations were made as above described on aqueous solutions of the following compositions -- (a) 10.43% Urea + 16.36%  $NH_3$ , (b) 5.29% Urea + 17.22%  $NH_3$ , (c) 4.56% Mannitol + 12.27%  $NH_3$ , (d) 3.05%  $K_2SO_4$  + 7.49%  $NH_3$ , (e) 5.27%  $NH_4Cl$  + 16.85%  $NH_3$ , (f) 10.26%  $NH_4Cl$  + 12.9%  $NH_3$ , (g) 2.68%  $CuSO_4$  + 14.65%  $NH_3$ , (h) 3.94%  $CuSO_4$  + 6.54%  $NH_3$ .

The author's data were plotted on cross section paper and the following values read from the curves.

(Cont.)

# N NITROGEN

## INFLUENCE OF SALTS AND OTHER COMPOUNDS ON THE VAPOR PRESSURE OF AQUEOUS AMMONIA SOLUTIONS--Cont.

t°	Vapor Pressure of Each Solution in mm. of Mercury							
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
20	204	200	120	-	193	130	155	-
30	325	325	198	-	302	220	235	87
40	485	500	311	200	471	345	365	145
50	715	727	465	304	695	522	545	223
60	1050	1060	705	453	975	770	-	344

In an earlier paper Perman (1901) gives data similar to the above for the vapor pressure of ammonia in aqueous solutions of sodium sulfate.

Gaus (1900) gives data for the vapor pressure of ammonia in aqueous 0.4 n. solutions of about 20 salts.

## SOLUBILITY OF AMMONIA IN AQUEOUS ETHYL ALCOHOL (Delepine, 1892)

t°	In 96% Alcohol		In 90% Alcohol		In 80% Alcohol	
	Sp. Gr. Solution	G. NH <sub>3</sub> per 100 Gms. Sol.	Sp. Gr. Solution	G. NH <sub>3</sub> per 100 Gms. Sol.	Sp. Gr. Solution	G. NH <sub>3</sub> per 100 Gms. Sol.
0	0.783	24.5	0.800	30.25	0.808	39.0
10	0.803	18.6	0.794	28.3	0.800	28.8
20	0.788	14.8	0.795	15.8	0.821	19.1
30	0.791	10.7	0.796	11.4	0.826	12.2

t°	In 60% Alcohol		In 50% Alcohol	
	Sp. Gr. Solution	G. NH <sub>3</sub> per 100 Gms. Sol.	Sp. Gr. Solution	G. NH <sub>3</sub> per 100 Gms. Sol.
0	0.830	50.45	0.835	69.77
10	0.831	37.3	0.850	43.86
20	0.842	26.1	0.869	33.8
30	0.846	21.2	0.883	25.2

## SOLUBILITY OF AMMONIA IN ABSOLUTE METHYL ALCOHOL

t°	(de Bruyn, 1892)		(Hatam, 1949)
	G. NH <sub>3</sub> per 100 Grams		moles NH <sub>3</sub> per liter sat. sol.
	Solution	Alcohol	
0	29.3	41.5	13.65
5	26.5	36.4	-
10	24.2	31.8	10.85
15	21.6	27.8	9.66
20	19.2	23.8	8.42
25	16.5	20.0	7.30
30	14.0	16.0	6.19
35	-	-	5.34
40	-	-	4.60

## SOLUBILITY OF AMMONIA IN ABSOLUTE ETHYL ALCOHOL

t°	Moles NH <sub>3</sub> per liter sat. sol. (Hattem, 1949)	Gms. NH <sub>3</sub> per 100 Gms. Solution		Gms. NH <sub>3</sub> per 100 Gms. Alcohol	
		(Delepine, 1892)	(de Bruyn, 1892)	(Delepine, 1892)	(de Bruyn, 1892)
0	8.65	20.95	19.7	26.5	24.5
5	--	19.00	17.5	23.0	21.2
10	6.62	16.43	15.0	19.6	17.8
15	5.69	13.00	13.2	15.0	15.2
20	5.02	10.66	11.5	11.9	13.2
25	4.32	10.0	10.0	11.0	11.2
30	3.72	9.7	8.8	10.7	9.5
35	3.30	--	--	--	--

H

SOLUBILITY OF AMMONIA IN PROPYL ALCOHOLS  
(Hattem, 1949)

t°	n-Propyl Alcohol	Isopropyl Alcohol
0	7.07	~6
10	5.3	4.55
15	4.65	4.05
20	4.15	3.48
25	3.62	2.98
30	3.25	2.52
35	2.39	2.25

DISTRIBUTION OF AMMONIA BETWEEN WATER AND AMYL ALCOHOL AT 20°  
(Herz and Fischer, 1904)

Gms. NH <sub>3</sub> per 100 cc.		Moles NH <sub>3</sub> per 100 cc.	
Aq. Layer	Alcoholic Layer	Aq. Layer	Alcoholic Layer
0.5	0.072	0.25	0.0035
1.0	0.147	0.50	0.0073
2.0	0.272	1.00	0.0148
3.0	0.438	2.00	0.0295
4.0	0.595	3.00	0.0460
5.0	0.756		

SOLUBILITY OF AMMONIA IN CHLOROFORM AT 25°  
(Seward, 1932)

A series of solutions of varying concentrations were prepared from CHCl<sub>3</sub> which had been saturated with NH<sub>3</sub>, by successive dilutions with CHCl<sub>3</sub>. These were each shaken in a closed vessel and after attainment of equilibrium, the NH<sub>3</sub> in both the liquid and vapor phase was determined by titration. The CHCl<sub>3</sub> contained 0.1 percent C<sub>2</sub>H<sub>5</sub>OH. The exact content of C<sub>2</sub>H<sub>5</sub>OH is important since the solubility of NH<sub>3</sub> increases with the proportion of C<sub>2</sub>H<sub>5</sub>OH. The presence of 1.0 percent C<sub>2</sub>H<sub>5</sub>OH was found to increase the solubility of NH<sub>3</sub> in CHCl<sub>3</sub> about 20 percent.

(Cont.)

# N NITROGEN

## SOLUBILITY OF AMMONIA IN CHLOROFORM AT 25°--Cont.

Gm. Mols. NH <sub>3</sub> per liter		Calc. Partial* Pressure of NH <sub>3</sub> in mm. Hg	Gm. Mols. NH <sub>3</sub> per liter		Calc. Partial* Pressure of NH <sub>3</sub> in mm. Hg
CHCl <sub>3</sub> phase	Vapor phase		CHCl <sub>3</sub> phase	Vapor phase	
0.0393	0.000756	14.0	0.423	0.00814	151.3
0.0888	0.001716	31.9	0.661	0.0132	245.4
0.1157	0.002215	41.2	0.851	0.0175	325.4
0.246	0.00474	88.1	1.105	0.0244	453.5
0.392	0.00749	139.2			

\*The partial pressures of NH<sub>3</sub> were calculated from the concentration of the NH<sub>3</sub> in the vapor phase, assuming Dalton's law to hold and neglecting the deviations of ammonia gas from the perfect gas law. The d. of the CHCl<sub>3</sub> was 1.480 at 25° and that of the solution containing 1.315 gm. mols. NH<sub>3</sub> per liter was 1.450. These figures were used in calculating the concentrations of NH<sub>3</sub> to volume of liquid phase.

## DISTRIBUTION OF AMMONIA BETWEEN WATER AND CHLOROFORM

### Results at 20°

(Dawson and McCrae, 1901)

Gms. NH <sub>3</sub> per 100 cc.		Moles NH <sub>3</sub> per 100 cc.	
Aq. Layer	CHCl <sub>3</sub> Layer	Aq. Layer	CHCl <sub>3</sub> Layer
0.2	0.007	0.01	0.00038
0.4	0.015	0.02	0.00073
0.6	0.023	0.03	0.00114
0.8	0.031	0.04	0.00152
1.0	0.039	0.05	0.00193
1.2	0.046	0.06	0.00232
1.4	0.055	0.08	0.00311
1.6	0.063	0.10	0.00396

### Results at 25°

(Occleshaw, 1931)

(Dietrick, 1929)

(Matthews and Davies, 1933)

Gm. Mols. NH <sub>3</sub> per liter		Gm. Mols. NH <sub>3</sub> per 1000 gms.		Gm. Mols. NH <sub>3</sub> per 1000 gms.		(a)
Aqueous layer (a)	CHCl <sub>3</sub> layer (c)	Aqueous layer (a)	CHCl <sub>3</sub> layer (c)	Aqueous layer (a)	CHCl <sub>3</sub> layer (c)	(c)
0.1388	0.00579	0.02183	0.0005936	0.1289	0.003587	35.93
0.2330	0.00978	0.03203	0.0008735	0.4976	0.01408	35.33
0.3232	0.01360	0.04610	0.001263	0.7796	0.02220	34.98
0.3835	0.01624	0.04983	0.001301	1.0264	0.02957	34.71
0.4677	0.01993	0.05871	0.001611	2.2678	0.06762	33.54
0.4868	0.02074	0.1011	0.002772	3.0349	0.09233	32.87

$$\frac{(a)}{(c)} = 23.64$$

$$\frac{(a)}{(c)} = 35.83$$

Additional data for the distribution of ammonia between water and chloroform are given by Hantsch and Sebaldt (1899), Dawson and McCrae (1900), (1901a), (1901b); Dawson (1906), (1909); Abbott and Bray (1907); Sherrill and Russ (1907); Bell (1911), and by Moore and Winmill (1912). The results show that with increase of concentration of ammonia, the relative amount in the aqueous layer diminishes. Thus Bell found that at 25° the distribution ratio is 22.7 when the aqueous layer contains 1.02 gm. mols.  $\text{NH}_3$  per liter and only 10 when 12.23 gm. mols.  $\text{NH}_3$  are present in the aqueous layer. The influence of increase of temperature was also found to be in the direction of diminution of the relative amount in the aqueous layer.

The influence of the presence of a large number of salts in the aqueous layer has been studied by several of the above-mentioned investigators. In the case of copper, zinc and cadmium salts (Dawson and McCrae, 1900), (Dawson, 1909), the distribution ratio varied with salt concentration in a manner indicating that metal ammonia compounds were formed.

Results for the effect of  $\text{KOH}$ ,  $\text{NaOH}$  and  $\text{Ba(OH)}_2$  on the distribution at 18° are given by Dawson (1909).

Results for the effect of ammonium chromate upon the distribution at 25° are given by Sherrill and Russ (1907).

Results for the distribution of ammonia between water and mixtures of chloroform and amyl alcohol at 25° are given by Herz and Kurzer (1910).

Data for the distribution of ammonia between chloroform and aqueous solutions containing various concentrations of both ammonium chloride and magnesium chloride at 18° are given by Fredholm, 1934.

#### DISTRIBUTION OF AMMONIA BETWEEN CARBON TETRACHLORIDE AND AIR AT 15° (Roederer, 1936)

The experiments were made by shaking  $\text{CCl}_4$  containing  $\text{NH}_3$  with air or by shaking  $\text{CCl}_4$  with air containing  $\text{NH}_3$ .

Gm. Mols. $\text{NH}_3$ per liter:		$\frac{(c)}{(a)}$	Gm. Mols. $\text{NH}_3$ per liter:		$\frac{(c)}{(a)}$
$\text{CCl}_4(c)$	Air (a)		$\text{CCl}_4(c)$	Air (a)	
0.0114	0.0016	7.13	0.0899	0.0123	7.31
0.0222	0.00325	6.83	0.1351	0.0188	7.19
0.0533	0.0072	7.40	0.1632	0.0222	7.35
0.0618	0.0087	7.11	0.1668	0.0229	7.28
0.0763	0.0106	7.20	0.1700	0.0228	7.45

One liter of  $\text{CCl}_4$  saturated with ammonia at 15° and under 760 mm. partial pressure contains 0.306 gm. mols.  $\text{NH}_3$ .



## N NITROGEN

### SOLUBILITY OF AMMONIA IN SEVERAL SOLVENTS AT 20° AND 760MM. PRESSURE (Bell, 1931)

The solvents were saturated with  $\text{NH}_3$  and the amount of gas present in a known amount of the saturated solution determined by removing it with a current of air, absorbing in an excess of  $\text{HCl}$  and titrating.

$s$  = the partition coefficient of  $\text{NH}_3$  between the liquid and the vapor, that is,  $s = c$  (the gm. equiv.  $\text{NH}_3$  per liter)  $\div$  0.0417 and  $s/c = 22.4 \times 293/273$ .

$x$  = the mol. fraction (gm. mol.  $\text{NH}_3$  per 1.0 gm. mol.  $\text{NH}_3$  + solvent) calculated on the assumption that the densities of the solutions obey the ideal mixture law.

H	Solvent	s	x	Solvent	s	x
	Hexane	4.16	0.0223	Toluene	7.23	0.0313 <sup>b</sup>
	Octane	2.56	0.0170	Chloroform	69.8	0.1930 <sup>a</sup>
	Dodecane	2.13	0.0197	Bromobenzene	8.08	0.0340
	Cetane	1.84	0.0219	Chlorobenzene	11.35	0.0423
	Carbon Tetrachloride	7.17	0.0281	Benzyl chloride	12.20	0.0556
	Benzene	9.95	0.0474	Ethylene chloride	26.6	0.0797

<sup>a</sup>See also p. 599-601.

<sup>b</sup>See also below.

### DISTRIBUTION OF AMMONIA BETWEEN TOLUENE AND AIR (Hantzsch and Vagt, 1901)

t°	Gms. $\text{NH}_3$ per 1000 cc.		Mols. $\text{NH}_3$ per 1000 cc.	
	$\text{C}_6\text{H}_5\text{CH}_3$ Layer	Air	$\text{C}_6\text{H}_5\text{CH}_3$ Layer	Air
0	0.366	0.0396	0.0215	0.00233
10	0.357	0.0435	0.0210	0.00256
20	0.326	0.0451	0.0192	0.00265
30	0.286	0.0462	0.0168	0.00272

Data for the distribution of ammonia between toluene and aqueous silver ammonium chloride and hydroxide at 25° are given by Randall and Halford, 1930.

One liter of Cyclohexanol ( $\text{C}_6\text{H}_{11}\text{OH}$ ) dissolve 28,166.7 cc. ammonia ( $\text{NH}_3$ ) at 26° and 755 mm. pressure. (Cauquil, 1927.)

### SOLUBILITY OF AMMONIA IN ETHYL ETHER (Christoff, 1912)

Results in terms of the Ostwald Solubility Expression at 0° = 17.13, at 10° = 12.35, at 15° = 10.27.

Data for the reciprocal solubility of gaseous ammonia and the vapors of methyl alcohol, acetone, ether and chloroform, determined by measuring at 25° the changes in pressure produced by adding a weighed amount of the volatile compound to a given volume of ammonia gas, are given by MacFarlane and Wright, 1934.

100 gms. of sat. solution of  $\text{NH}_3$  in hydroxylamine contain 26 gms.  $\text{NH}_3$  at  $0^\circ$  and 19-20 gms. at  $15^\circ$ - $16^\circ$ . (de Bruyn, 1892.)

The solubility of ammonia in nitrobenzene, in terms of the Bunsen Absorption Coefficient, is 18.37 at  $15^\circ$ , 12.61 at  $25^\circ$  and 8.257 at  $40^\circ$  (Baars, 1927).

At  $25^\circ$ , 31 vols. ( $0^\circ$ , 760 mm.) of  $\text{NH}_3$  dissolve in 1 vol. of dimethylformamide (DuPont, 1955).

100 cc. of rubber saturated with ammonia at  $21^\circ$  dissolve 930 cc.  $\text{NH}_3$  ( $0^\circ$  and 760 mm.). The determination was made by pumping out the gas with a Töpler pump and measuring it over mercury. Results for the effect of pressure and temperature upon the solubility are also given (Veneble and Fuwa, 1922). H

Limited gas solubilities in the system ammonia-argon are reported by Tsiklis and Vasil'ev, 1955.

NOTE: For phase equilibria involving liquid ammonia + organic compounds, see "ORGANIC" solubilities volume.

Melting point data are given for:

$\text{NH}_3$ + $\text{CH}_3\text{OH}$	(Baume and Perrot, 1910, 1914)
" + $(\text{CH}_3)_2\text{O}$	" " " "
" + $\text{C}_2\text{H}_5\text{OH}$	(Broderson, 1911)
" + n $\text{CH}_3\text{CH}_2\cdot\text{CH}_2\text{OH}$	(Cady and Jones, 1933)
" + iso $(\text{CH}_3)_2\text{CHOH}$	" " "
" + n $\text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{OH}$	" " "
" + iso $(\text{CH}_3)_2\text{CHCH}_2\text{OH}$	" " "
" + sec. $\text{CH}_3\text{CH}_2\text{CHOHCH}_3$	" " "
" + ter. $(\text{CH}_3)_3\text{COH}$	" " "
" + $\text{C}_6\text{H}_5\text{OH}$	(Briner and Agathon, 1926)
" + $\text{H}_2\text{S}$	(Scheffer, 1912)
" + $\text{NH}_4\text{Br}$	(Kendall and Davidson, 1922)
" + $\text{NH}_4\text{Cl}$	" " "
" + $\text{NH}_4\text{I}$	" " "
" + $\text{NH}_4\text{ClO}_4$	(Mazetti and Decarli, 1926)
" + $\text{NH}_4\text{NO}_3$	(Kuriloff, 1898)
" + $\text{NH}_4\text{CNS}$	(Bradley and Alexander, 1912; Foote, 1920; Foote and Hunter, 1920)
" + $(\text{NH}_2)_2\text{CO}_2$	(Jänecke and Rahlfo, 1930)
" + $\text{CS}(\text{NH}_2)_2$	(Jänecke and Hoffmann, 1932)
" + Li	(Ruff and Geisel, 1906)
" + K	" " "
" + Na	" " "
" + S	(Ruff and Hecht, 1911)
" + $\text{CH}_3\text{CONH}_2$	(Sisler, Davidson, Stoenner, and Lyon, 1944)
" + $\text{H}_2\text{NSO}_2\text{NH}_2$	(Sisler and Rosenbaum, 1952)

# N NITROGEN

## AsO AMMONIUM ARSENITE $\text{NH}_4\text{AsO}_2$

THE SYSTEM AMMONIA - ARSENIC TRIOXIDE - WATER AT 30°  
(Schreinemakers and de Baat, 1915)

Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
$\text{NH}_3$	$\text{As}_2\text{O}_3$		$\text{NH}_3$	$\text{As}_2\text{O}_3$	
0	2.26	$\text{As}_2\text{O}_3$	3.13	12.30	$\text{NH}_4\text{AsO}_2$
1.41	10.98	"	3.91	7.63	"
2.78	20.49	"	6.95	4.72	"
2.86	21.17	"	9.93	3.20	"
2.88	18.43	$\text{NH}_4\text{AsO}_2$	4.28	2.16	"

## AsO AMMONIUM ARSENATES

THE SYSTEM  $(\text{NH}_4)_2\text{O} - \text{As}_2\text{O}_5 - \text{H}_2\text{O}$  AT 20°  
(Duc-Maugé and Gurrin, 1957)

Sat. Sol. wt. %		Solid Phase	Sat. Sol. wt. %		Solid Phase
$\text{As}_2\text{O}_5$	$(\text{NH}_4)_2\text{O}$		$\text{As}_2\text{O}_5$	$(\text{NH}_4)_2\text{O}$	
70.0	0	$\text{As}_2\text{O}_5 \cdot 4\text{H}_2\text{O}$	41.1	15	$\text{NH}_4\text{H}_2\text{AsO}_4 + (\text{NH}_4)_2\text{HASO}_4$
72.5	1.45	" + 1.3.4	32.7	14.8 <sup>b</sup>	$(\text{NH}_4)_2\text{HASO}_4$
70	2.7	1.3.4 + $\text{NH}_4\text{H}_2\text{AsO}_4$	32	14.9	" + $(\text{NH}_4)_3\text{AsO}_4 \cdot 3\text{H}_2\text{O}$
61.1	4.7	$\text{NH}_4\text{H}_2\text{AsO}_4$ + "	8.0	11.8 <sup>c</sup>	$(\text{NH}_4)_3\text{AsO}_4 \cdot 3\text{H}_2\text{O}$
20.8	4.65 <sup>a</sup>	$\text{NH}_4\text{H}_2\text{AsO}_4$	0.15	40	"

1.3.4 =  $(\text{NH}_4)_2\text{O} \cdot 3\text{As}_2\text{O}_5 \cdot 4\text{H}_2\text{O}$

a congruent solubility in  $\text{H}_2\text{O}$  = 40 gms.  $\text{NH}_4\text{H}_2\text{AsO}_4$ /100 gms.  $\text{H}_2\text{O}$

b " " = 100 gms.  $(\text{NH}_4)_2\text{HASO}_4$ /100 gms.  $\text{H}_2\text{O}$

c " " = 34 gms.  $(\text{NH}_4)_3\text{AsO}_4$ /100 gms.  $\text{H}_2\text{O}$

SOLUBILITY OF MONO AMMONIUM ARSENATE IN WATER  
(de Passille, 1936)

t°	d. of sat. sol.	Gms. $\text{NH}_4\text{H}_2\text{AsO}_4$ per 100 gms. $\text{H}_2\text{O}$	Solid Phase	t°	d. of sat. sol.	Gms. $\text{NH}_4\text{H}_2\text{AsO}_4$ per 100 gms. $\text{H}_2\text{O}$	Solid Phase
0	1.1814	33.74	$\text{NH}_4\text{H}_2\text{AsO}_4$	60	1.3464	83.05	$\text{NH}_4\text{H}_2\text{AsO}_4$
20	1.2280	48.67	"	80	1.4200	107.25	"
40	1.2821	63.83	"	90	1.4623	122.4	"

The author also prepared the Di and Tri Ammonium Arsenates but these decompose with loss of ammonia in aqueous solution. (Does not agree with Duc-Maugé and Guérin, 1957, above.)

SOLUBILITY OF AMMONIUM MAGNESIUM ARSENATE IN WATER AND IN  
AQUEOUS SOLUTIONS OF AMMONIUM SALTS  
(Wenger, 1911)

Gms.  $\text{NH}_4\text{MgAsO}_4$  per 100 Gms. of Each Solvent

t°	Water	Aq. 5% $\text{NH}_4\text{NO}_3$	Aq. 5% $\text{NH}_4\text{Cl}$	Aq. * $\text{NH}_4\text{OH}$	Aq. $\text{NH}_4\text{OH}$ + 5%	Aq. $\text{NH}_4\text{OH}$ + 10%	Solid Phase
					$\text{NH}_4\text{Cl}$	$\text{NH}_4\text{Cl}$	
0	0.0339	0.092	0.084	0.0087			$\text{NH}_4\text{MgAsO}_4 \cdot 6\text{H}_2\text{O}$
20	0.0207	0.114	0.113	0.0096	0.013	0.032	"
30	-	0.118	0.113	-			"
40	0.0275	0.139	0.190	0.0117			"
50	0.0226	0.189	0.189	0.0100			"
60	0.0210	0.211	0.219	0.0090	0.047	0.054	"
70	0.0156	0.189	0.221	0.0095			"
80	0.0236	0.189	0.231	0.0091			"

\*Composed of 1 part  $\text{NH}_3$  (d & 0.96) + 4 parts  $\text{H}_2\text{O}$ .

†Contained 4 parts  $\text{NH}_3$  (d & 0.96) per 100 parts  $\text{NH}_4\text{Cl}$  solution.

#### AMMONIUM FLUOBORATE $\text{NH}_4\text{BF}_4$

BF

At 16°, 25 gms.  $\text{NH}_4\text{BF}_4$  dissolve in 100 gms.  $\text{H}_2\text{O}$  (Stolba, 1890).

#### AMMONIUM BORATES $(\text{NH}_4)_2\text{O} \cdot \gamma \text{B}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$

B0

#### THE SYSTEM AMMONIA - BORIC OXIDE - WATER

(At 30°, Sborgi, 1912 and 1913; at 30° and 60°, Sborgi and Mecacci, 1915 and 1916; at 0° and 10°, Sborgi and Mezzetti, 1921; at the other temperatures, Sborgi and Ferri, 1921 and 1922.)

The numerous determinations were plotted on cross section paper and the following tables constructed from the curves.

# N NITROGEN

## THE SYSTEM AMMONIA - BORIC OXIDE - WATER--Cont.

BO	Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Solid Phase at Each Temperature
	(NH <sub>4</sub> ) <sub>2</sub> O B <sub>2</sub> O <sub>3</sub>		(NH <sub>4</sub> ) <sub>2</sub> O B <sub>2</sub> O <sub>3</sub>		(NH <sub>4</sub> ) <sub>2</sub> O B <sub>2</sub> O <sub>3</sub>		(NH <sub>4</sub> ) <sub>2</sub> O B <sub>2</sub> O <sub>3</sub>		
	t = 0°		t = 10°		t = 20°		t = 30°		
	0.0	1.46	0.0	1.96	0.0	2.70	0.0	3.60	H <sub>3</sub> BO <sub>3</sub>
	0.2	2.2	0.2	3.0	0.2	3.7	0.2	4.7	"
	0.3	2.8	0.4	4.0	0.4	4.8	0.5	6.1	"
	0.37	3.26	0.5	4.4	0.5	5.5	0.8	7.6	" + 1.5.8
	0.5	3.5	0.8	5.0	1.0	6.4	1.5	8.8	1.5.8
	0.75	4.0	1.2	5.9	1.5	7.6	2.2	10.5	"
	1.0	4.5	1.6	7.1	2.0	8.9	3.0	12.7	"
	1.3	5.4	2.0	8.2	2.8	10.8	3.8	15.3	" + 1.2.4
	1.0	4.0	1.8	7.0	2.5	9.0	3.5	13.3	1.2.4
	0.9	3.2	1.6	5.0	2.2	6.7	3.0	9.0	"
	1.0	2.8	1.5	3.6	2.5	4.2	4.0	6.0	"
	2.0	2.5	2.0	3.0	3.0	3.8	6.0	5.0	"
	4.0	2.3	4.0	2.6	4.0	3.3	10.0	3.5	"
	10.0	1.8	10.0	2.0	10.0	2.4	15.0	2.5	"
	20.0	1.0	20.0	1.1	20.0	1.4	20.0	1.8	"
	t = 40°		t = 45°		t = 60°		t = 90°		
	0.0	4.5	0.0	5.3	0.0	7.4	0.0	13.5	H <sub>3</sub> BO <sub>4</sub>
	0.5	6.8	0.5	8.0	0.5	10.4	1.0	18.0	"
	0.9	9.5	1.0	10.6	1.4	15.6	2.4	25.0	" + 1.5.8
	1.5	9.9	1.5	11.0	2.0	16.0	3.0	25.4	1.5.8
	2.0	10.7	2.0	11.9	3.0	15.7	4.0	26.5	"
	3.0	13.0	3.0	14.0	3.5	19.0	5.0	28.4	"
	3.5	14.7	3.6	16.4	4.0	20.6	6.1	31.5	" + 1.4.6
	3.8	15.3	4.0	16.9	5.0	22.0	8.0	34.0	1.4.6
	4.0	15.6	4.5	17.6	6.0	23.8	10.0	36.8	"
	4.5	16.3	5.0	18.5	7.0	26.0	12.0	39.7	"
	4.9	17.5	5.6	19.8	7.9	27.8	12.8	40.7	" + 1.2.4
	4.2	12.0	5.0	14.0	7.5	21.0	13.0	39.0	1.2.4
	6.0	7.6	6.0	9.0	8.0	17.0	14.0	35.0	"
	10.0	5.0	10.0	6.0	10.0	12.6	16.0	28.5	"
	20.0	2.4	20.0	3.0	20.0	5.6	20.0	23.3	"
	30.0	1.0	30.0	1.6	30.0	3.0	30.0	19.0	"

1.5.8 = (NH<sub>4</sub>)<sub>2</sub>O·5B<sub>2</sub>O<sub>3</sub>·8H<sub>2</sub>O; 1.2.4 = (NH<sub>4</sub>)<sub>2</sub>O·2B<sub>2</sub>O<sub>3</sub>·4H<sub>2</sub>O; 1.4.6 = (NH<sub>4</sub>)<sub>2</sub>O·4B<sub>2</sub>O<sub>3</sub>·6H<sub>2</sub>O.

The authors also made numerous determinations at 31°, 31.5°, 32° and 35° in order to ascertain the composition of solutions in contact with the 1.4.6 compound near its transition temperature.

The cryohydric points are as follows:

t°	Gms. per 100 gms. sat. sol.		Solid Phase
	(NH <sub>4</sub> ) <sub>2</sub> O	B <sub>2</sub> O <sub>3</sub>	
- 1.37	0.58	3.92	Ice + 1.5.8
- 1.25	0.36	3.02	" + " + H <sub>3</sub> BO <sub>3</sub>
- 2.05	1.21	4.97	" + " + 1.2.4

## THE SYSTEM AMMONIA - BORIC OXIDE - WATER--Cont.

t°	Gms. per 100 gms. sat. sol.		Solid Phase
	(NH <sub>4</sub> ) <sub>2</sub> O	B <sub>2</sub> O <sub>3</sub>	
- 1.08	0.54	1.47	Ice + 1.2.4
- 1.30	1.01	1.03	
- 8.5	3.57	0.85	"
-15.0	17.61	0.57	"
+31 tr. pt.	3.63	13.59	1.5.8 + 4.6 + 1.2.4

 SOLUBILITY OF AMMONIUM DIBORATE [(NH<sub>4</sub>)<sub>2</sub>B<sub>4</sub>O<sub>7</sub>] IN WATER  
 (Sborgi and Ferri, 1921; Sborgi and Gallichi, 1924; Menzel, 1927)

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	Gms. (NH <sub>4</sub> ) <sub>2</sub> O·2B <sub>2</sub> O <sub>3</sub> per 100 gms. sat. sol.	Solid Phase
- 1.08 (cryo.)	3.62	(NH <sub>4</sub> ) <sub>2</sub> O·2B <sub>2</sub> O <sub>3</sub> ·4H <sub>2</sub> O
0	3.75	"
10	5.26	"
	6.78 <sup>m</sup>	"
20	7.63	"
25	9.00	"
	8.76 <sup>m</sup>	"
30	10.80	"
35	13.02	"
40	15.77	"
45	18.41	"
60	27	Interp.
65	30.80	"
90	52.68	"

<sup>m</sup>Menzel, 1927
 SOLUBILITY OF AMMONIUM PENTABORATE IN WATER  
 (Sborgi and Ferri, 1921; Menzel, 1927; Rollet and Andres, 1930)

t°	Gms. (NH <sub>4</sub> ) <sub>2</sub> O·5B <sub>2</sub> O <sub>3</sub> per 100 gms. sat. sol.		Solid Phase	t°	Gms. (NH <sub>4</sub> ) <sub>2</sub> O·5B <sub>2</sub> O <sub>3</sub> per 100 gms. sat. sol.		Solid Phase
0	4.0	(NH <sub>4</sub> ) <sub>2</sub> O·5B <sub>2</sub> O <sub>3</sub> ·8H <sub>2</sub> O		40	11.4	(NH <sub>4</sub> ) <sub>2</sub> O·5B <sub>2</sub> O <sub>3</sub> ·8H <sub>2</sub> O	
10	5.2	"		50	14.2	"	
20	6.9	"		60	18.2	"	
25	8.0	"		75	24.40	"	
30	9.0	"		90	30.29	"	

# N NITROGEN

## THE SYSTEM $(\text{NH}_4)_2\text{B}_4\text{O}_7 - (\text{NH}_4)_2\text{SO}_4 - \text{H}_2\text{O}$ (Sborgi and Gallichi, 1924)

### Results at 10°:

Gms. per 100 gms. sat. sol.	
$(\text{NH}_4)_2\text{SO}_4$	$(\text{NH}_4)_2\text{B}_4\text{O}_7$
0.0	5.255
8.295	3.018
37.09	1.807
41.10	1.60
42.20	0.0

### Results at 20°:

Gms. per 100 gms. sat. sol.	
$(\text{NH}_4)_2\text{SO}_4$	$(\text{NH}_4)_2\text{B}_4\text{O}_7$
3.25	6.39
22.80	3.204
38.369	2.48
41.40	2.36
42.99	0.0

Solid Phase at Each Temperature
$(\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$
"
"
" + $(\text{NH}_4)_2\text{SO}_4$
$(\text{NH}_4)_2\text{SO}_4$

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### Results at 50°:

Gms. per 100 gms. sat. sol.	
$(\text{NH}_4)_2\text{SO}_4$	$(\text{NH}_4)_2\text{B}_4\text{O}_7$
0.0	20.88
16.31	13.73
31.29	10.01
41.14	8.60
45.77	0.0

Solid Phase at Each Temperature
$(\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$
"
"
" + $(\text{NH}_4)_2\text{SO}_4$
$(\text{NH}_4)_2\text{SO}_4$

### Results at 25°:

Gms. per 100 gms. sat. sol.	
$(\text{NH}_4)_2\text{SO}_4$	$(\text{NH}_4)_2\text{B}_4\text{O}_7$
0.0	8.998
5.17	6.747
13.07	5.10
23.865	4.052
29.65	3.518
37.186	3.1388
41.20	2.886
41.62	2.83
42.17	2.016
43.06	0.65
43.41	0.0

### Results at 35°:

Gms. per 100 gms. sat. sol.	
$(\text{NH}_4)_2\text{SO}_4$	$(\text{NH}_4)_2\text{B}_4\text{O}_7$
0.0	13.02
1.594	11.803
2.518	11.326
14.92	7.413
19.50	6.672
25.19	5.881
36.38	4.70
41.56	4.214
43.17	1.69
44.22	0.0

Solid Phase at Each Temperature
$(\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$
"
"
"
"
" + $(\text{NH}_4)_2\text{SO}_4$
$(\text{NH}_4)_2\text{SO}_4$
"

### Cryohydric Data: (Sborgi and Bovalini, 1924)

Gms. per 100 gms. sat. sol.			
t°	$(\text{NH}_4)_2\text{SO}_4$	$(\text{NH}_4)_2\text{B}_4\text{O}_7$	Solid Phase
-19.34	39.68	1.28	$(\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O} + (\text{NH}_4)_2\text{SO}_4 + \text{Ice}$
-16.32	39.81	1.83	$(\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O} + (\text{NH}_4)_2\text{SO}_4$

THE SYSTEM  $(\text{NH}_4)_2\text{B}_4\text{O}_7 - \text{Na}_2\text{B}_4\text{O}_7 - \text{H}_2\text{O}$   
(Sborgi and Gallichi, 1924)

Gms. per 100 gms. sat. sol.				Gms. per 100 gms. sat. sol.			
t°	$\text{Na}_2\text{B}_4\text{O}_7$	$(\text{NH}_4)_2\text{B}_4\text{O}_7$	Solid Phase	t°	$\text{Na}_2\text{B}_4\text{O}_7$	$(\text{NH}_4)_2\text{B}_4\text{O}_7$	Solid Phase
0	0.844	3.216	AB·4+SB·10	45	10.00	18.62	AB·4+SB·10
10	1.37	1.20	SB·10	45	8.38	8.45	SB·10
10	1.24	4.32	"	50.5	12.3	21.21	AB·4
10	1.237	4.91	" + AB·4	50.5	13.83	21.16	" + SB·10
10	0.93	4.96	AB·4	50.5	13.74	21.10	" + SB·5
16	1.83	6.60	" + SB·10	50.5	13.31	18.18	SB·10
20	2.22	7.73	" "	55	13.23	23.58	AB·4
30	3.42	11.02	AB·4	55	17.46	23.47	" + SB·5
30	4.08	11.19	" + SB·10	55	17.33	19.62	SB·5
30	3.86	8.81	SB·10	55	17.30	19.30	SB·5 + SB·10
25	1.19	9.12	AB·4	55	15.92	13.52	SB·10
25	2.96	9.26	"	55	14.03	5.88	"
25	3.07	9.27	" + SB·10	57	17.60	24.60	AB·4 + SB·5
25	3.06	8.77	SB·10	57	17.27	15.88	SB·5
25	3.03	8.16	"	57	17.25	14.28	" + SB·10
25	3.01	7.73	"	57	16.29	11.07	SB·10
25	2.97	6.26	"	65	18.62	29.00	AB·4
35	3.42	13.27	AB·4	65	19.36	28.94	" + SB·5
35	5.54	13.42	" + SB·10	65	19.25	22.01	SB·5
35	5.12	9.82	SB·10	65	18.70	10.70	"
35	4.63	3.29	"	65	18.30	5.33	"

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AB·4 =  $(\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$ ; SB·10 =  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ ; SB·5 =  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$ .

The cryohydric temperature of the system  $(\text{NH}_4)_2\text{B}_4\text{O}_7 + \text{Na}_2\text{B}_4\text{O}_7 + \text{Ice}$  is  $-1.22^\circ$  and 100 gms. of the saturated solution contain 3.472 gms. of  $(\text{NH}_4)_2\text{B}_4\text{O}_7$  and 0.6447 gm. of  $\text{Na}_2\text{B}_4\text{O}_7$ . (Sborgi and Gallichi, 1924.)

THE SYSTEM  $(\text{NH}_4)_2\text{B}_4\text{O}_7 + \text{Na}_2\text{SO}_4 = \text{Na}_2\text{B}_4\text{O}_7 + (\text{NH}_4)_2\text{SO}_4$   
(Sborgi, Bovalini and Medici, 1924; Sborgi, 1924)

The authors also give results for the solubility of the individual salts in water at these temperatures, and for mixtures of ammonium and sodium sulfates with the double salt  $(\text{NH}_4)\text{NaSO}_4$ . Determinations of the transformation temperatures in this system are given by Sborgi and Stefanini, 1924.

Results for aqueous solutions saturated with respect to:

(Cont.)



# N NITROGEN

THE SYSTEM  $(\text{NH}_4)_2\text{B}_4\text{O}_7 + \text{Na}_2\text{SO}_4 \rightleftharpoons \text{Na}_2\text{B}_4\text{O}_7 + (\text{NH}_4)_2\text{SO}_4$ —Cont.

t°	$(\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$ + $(\text{NH}_4)_2\text{SO}_4$ Gms. equiv. per 1000 gms. mols. $\text{H}_2\text{O}$		$(\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$ + $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ Gms. equiv. per 1000 gms. mols. $\text{H}_2\text{O}$		$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ + $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ Gms. equiv. per gms. mols. $\text{H}_2\text{O}$	
	$(\text{NH}_4)_2\text{SO}_4$	$(\text{NH}_4)_2\text{B}_4\text{O}_7$	$\text{Na}_2\text{B}_4\text{O}_7$	$(\text{NH}_4)_2\text{B}_4\text{O}_7$	$\text{Na}_2\text{B}_4\text{O}_7$	$\text{Na}_2\text{SO}_4$
-10	184.0	4.900				
0	189.0	5.00	1.657	6.594	1.789	12.67
+10	195.45	5.257	2.349	9.801	1.384	23.319
15	198.42	6.50	3.22	12.797	2.326	32.222
25	204.23	9.563	6.25	19.88	2.627	72.27
25.65	204.0	10.0	6.08	19.83	2.50	75.64
26	204.5	10.3	7.5	21.3	3.0	78.0
30	207.0	12.0	10.0	25.5	3.25	104.36
35	208.94	14.607	12.214	31.138	4.266	123.59b
38.7	212.98	18.5	16.6	37.5	5.50	119.72b
40	212.42	20.5	18.8	40.0	6.0	118.5b
41	214.0	20.5	19.0	41.0	6.25	118.0b
41.7	214.5	22.5	21.0	42.36	6.80	117.17b
45	218.0	26.5	25.0	49.0	8.381	114.57b
50	223.14	32.141	37.0	60.0	12.467	110.51c
55	228.0	38.0	52.86	74.73a	16.26	108.0c
55.7	229.0	40.0	53.25	76.26a	17.0	107.3c

a Solid Phase  $(\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O} + \text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$ .

b Solid Phase  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O} + \text{Na}_2\text{SO}_4$ .

c Solid Phase  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O} + \text{Na}_2\text{SO}_4$ .

t°	$(\text{NH}_4)\text{NaSO}_4 \cdot 4\text{H}_2\text{O} + \text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ + $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ Gms. equiv. per 1000 gms. mols. $\text{H}_2\text{O}$			$(\text{NH}_4)\text{NaSO}_4 \cdot 4\text{H}_2\text{O} + (\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O} + \text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ Gms. equiv. per 1000 gms. mols. $\text{H}_2\text{O}$		
	$(\text{NH}_4)_2\text{SO}_4$	$\text{Na}_2\text{SO}_4$	$\text{Na}_2\text{B}_4\text{O}_7$	$(\text{NH}_4)_2\text{SO}_4$	$\text{Na}_2\text{SO}_4$	$\text{Na}_2\text{B}_4\text{O}_7$
-10.5	157.67	14.44	3.09	166.15	10.68	2.76
-10	156.12	14.828	3.259	157.245	14.328	2.80
0	129.73	26.30	4.70	132.13	25.0	5.0
+10	106.39	42.54	5.25	116.494	37.148	7.577
15	93.0	59.0	5.50	113.56	43.80	9.35
25	62.630	104.573	5.884	114.0	53.182	14.979
25.65	62.13	108.76	6.0a	113.93	53.21	15.98
26	63.5	107.4	7.6b	113.5	54.5	15.5
26	61.0	110	3.5c	60.0	109	6.5d
30	73.0	101.5	11.0b	114.0	57.5	19.5
35	89.817	89.849	17.571b	116.786	60.219	28.187
38	118.45	63.73	36.49e (30°)	20.0	119.0	4.5d

a Solid Phase  $(\text{NH}_4)\text{NaSO}_4 \cdot 4\text{H}_2\text{O} + \text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O} + \text{Na}_2\text{SO}_4 + \text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ .

b " " " +  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$  + "

c " " " +  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$  + "

d "  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$  + " + "

e " " +  $(\text{NH}_4)\text{NaSO}_4 \cdot 4\text{H}_2\text{O}$  + " +  $(\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ .

(Cont.)

THE SYSTEM  $(\text{NH}_4)_2\text{B}_4\text{O}_7 + \text{Na}_2\text{SO}_4 \rightleftharpoons \text{Na}_2\text{B}_4\text{O}_7 + (\text{NH}_4)_2\text{SO}_4$ —Cont.

t°	$(\text{NH}_4)\text{NaSO}_4 \cdot 4\text{H}_2\text{O} + \text{Na}_2\text{SO}_4$ $+ (\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$ Gms. equiv. per 1000 gms. mols. $\text{H}_2\text{O}$			$(\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot \text{H}_2\text{O} + \text{Na}_2\text{SO}_4$ $+ \text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ Gms. equiv. per 1000 gms. mols. $\text{H}_2\text{O}$		
	$(\text{NH}_4)_2\text{SO}_4$	$\text{Na}_2\text{SO}_4$	$(\text{NH}_4)_2\text{B}_4\text{O}_7$	$(\text{NH}_4)_2\text{SO}_4$	$\text{Na}_2\text{SO}_4$	$\text{Na}_2\text{B}_4\text{O}_7$
40	135.09	79.81	27.75	119.50	62.25	42.25
41.7	152.42	74.45	28.65	111.78	69.65	48.43 <sup>a</sup>
45.0	165.76	76.42	33.25	121.44	58.80	52.90 <sup>b</sup>
50.0	171.08	84.99	43.63	128.54	42.46	67.29 <sup>b</sup>
55.0	168.61	99.26	60.53	140.63	26.78	94.09 <sup>b</sup>

<sup>a</sup> Solid Phase also contains  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$ .

<sup>b</sup> Solid Phase  $(\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O} + \text{Na}_2\text{SO}_4 + \text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$ .

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t°	$(\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$ $+ (\text{NH}_4)\text{NaSO}_4 \cdot 4\text{H}_2\text{O} + (\text{NH}_4)_2\text{SO}_4$ Gm. equiv. per 1000 gm. mols. $\text{H}_2\text{O}$			t°	$(\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$ $+ (\text{NH}_4)\text{NaSO}_4 \cdot 4\text{H}_2\text{O} + (\text{NH}_4)_2\text{SO}_4$ Gm. equiv. per 1000 gm. mols. $\text{H}_2\text{O}$		
	$(\text{NH}_4)_2\text{SO}_4$	$\text{Na}_2\text{SO}_4$	$(\text{NH}_4)_2\text{B}_4\text{O}_7$		$(\text{NH}_4)_2\text{SO}_4$	$\text{Na}_2\text{SO}_4$	$(\text{NH}_4)_2\text{B}_4\text{O}_7$
-10.5	177.52	9.71	2.60	35	195.54	44.41	17.54
-10	177.55	9.85	2.60	38.7	195.21	49.21	21.26
0	182.918	18.101	4.685	40	194.5	51.5	23.0
+10	187.654	23.778	6.047	41	192.98	54.0	24.62
15	189.25	27.0	7.25	41.7	192.80	54.9	25.7
25	193.89	34.0	10.11	45	190.65	63.0	31.0
25.65	193.68	34.69	11.15	50	184.06	78.13	42.40
26	193.0	35.0	11.5	55	170.22	98.42	60.37
30	195.0	38.5	13.0	55.7	168.28	101.28	62.84*

\* $\text{Na}_2\text{SO}_4$  also in Solid Phase.

THE SYSTEM  $(\text{NH}_4)_2\text{B}_4\text{O}_7 + 2\text{NaCl} \rightleftharpoons 2\text{NH}_4\text{Cl} + \text{Na}_2\text{B}_4\text{O}_7$   
 (Sborgi and Franco, 1921; see also S. & F., 1922)

Gms. equivalents per 1000 gms. mols. $\text{H}_2\text{O}$				Solid Phase
$\text{NH}_4\text{Cl}$	$\text{NaCl}$	$\text{Na}_2\text{B}_4\text{O}_7$	$(\text{NH}_4)_2\text{B}_4\text{O}_7$	
97.92	-	-	4.35	$(\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O} + \text{NH}_4\text{Cl}$
-	-	1.52	6.38	" $+ \text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
-	108.06	0.85	-	$\text{NaCl} + "$
49.33	85.79	1.58	-	" $+ \text{NH}_4\text{Cl}$
58.71	69.14	1.92	-	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O} + \text{NH}_4\text{Cl}$
68.87	48.82	1.97	-	" "
74.10	40.57	2.92	-	" "
87.14	21.22	3.77	-	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O} + \text{NH}_4\text{Cl} + (\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$
74.98	17.06	3.57	-	" $+ (\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$
48.71	10.84	3.22	-	" "

(Cont.)

# N NITROGEN

THE SYSTEM  $(\text{NH}_4)_2\text{B}_4\text{O}_7 + 2\text{NaCl} = 2\text{NH}_4\text{Cl} + \text{Na}_2\text{B}_4\text{O}_7$ —Cont.

		Gms. equivalents per 1000 gms. mols. $\text{H}_2\text{O}$			
		$\text{NH}_4\text{Cl}$	$\text{NaCl}$	$\text{Na}_2\text{B}_4\text{O}_7, (\text{NH}_4)_2\text{B}_4\text{O}_7$	Solid Phase
		at $10^\circ$			
Br			2.35	9.88	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O} + (\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$
	111.66	-	-	5.06	$\text{NH}_4\text{Cl} +$
	-	109.22	0.97		$\text{NaCl} + \text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
	39.20	91.52	2.25		" "
	61.38	80.33	2.34		" " $+ \text{NH}_4\text{Cl}$
	76.50	51.42	3.99		$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O} +$
	91.50	30.14	5.00		" "
	95.05	25.98	6.30		" " $+ (\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$
	73.94	18.09	5.71		" " $+ (\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$
	58.70	12.35	4.74		" "
	112.7	0.03	4.41		$\text{NH}_4\text{Cl} +$
		at $25^\circ$			
	132.10	-	-	10.40	" "
	-	-	6.25	19.96	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O} +$
	-	109.53	1.80		" "
	85.16	71.49	9.80		" " $+ \text{NaCl}$
	97.99	50.00	13.00		" " $+ \text{NH}_4\text{Cl}$
	105.52	38.32	14.83		" " $+ (\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$
	93.90	32.00	13.90		" " $+ (\text{NH}_4)_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$
	78.90	25.00	12.80		" "

## AMMONIUM STRONTIUM BOROTARTRATE

At  $15-16^\circ$  the solubility of  $(\text{NH}_4)_2\text{O} \cdot 2\text{SrO} \cdot \text{B}_2\text{O}_3 \cdot 2\text{C}_4\text{H}_4\text{O}_5 \cdot 10\text{H}_2\text{O}$  is 2.42 gms. per liter (Shvarcs and Ievins, 1957).

## Br AMMONIUM BROMIDE $\text{NH}_4\text{Br}$

### SOLUBILITY IN WATER

(Benrath and Schiffers, 1938; Benrath, Gjedebø, Schiffers and Wunderlich, 1937)

The earlier data of Smith and Eastlack, 1916, determined by the sealed tube method, are given in parentheses.

$t^\circ$	Gms. $\text{NH}_4\text{Br}$ per 100 gms. sat. sol.	$t^\circ$	Gms. $\text{NH}_4\text{Br}$ per 100 gms. sat. sol.	$t^\circ$	Gms. $\text{NH}_4\text{Br}$ per 100 gms. sat. sol.
-17*	-- (32.1)	70	52.8 (53.0)	200	71.5
0	37.3 (37.7)	80	54.4 (55.8)	225	74.2
10	40.0 (40.5)	90	56.0 (57.6)	250	76.5
20	42.6 (43.0)	100	57.4 (59.4)	275	78.2
25	43.9 --	120	61.5 (62.7)	300	81.0
30	45.0 (45.4)	140	64.5 (65.8)	350	84.5
40	47.3 (47.6)	160	67.0 (68.1)	400	87.5
50	49.4 (49.7)	180	69.5	480	91.5
60	51.2 (51.9)				

\*Eutectic

SOLUBILITY OF AMMONIUM BROMIDE IN AQUEOUS SOLUTIONS  
OF HYDROBROMIC ACID AT 25°  
(Scott and Durham, 1930)

Gms. per 100 gms. sat. solution

HBr	NH <sub>4</sub> Br
0.0	43.86
12.53	27.91
16.94	24.06
22.72	15.96

THE SYSTEM AMMONIUM BROMIDE - AMMONIUM CHLORIDE - WATER AT 25°  
(Flatt and Burkhardt, 1944)

Br

Moles per mole of Dissolved Salts		Mole % NH <sub>4</sub> Br in Solid	Moles per mole of Dissolved Salts		Mole % NH <sub>4</sub> Br in Solid
NH <sub>4</sub> Br	H <sub>2</sub> O		NH <sub>4</sub> Br	H <sub>2</sub> O	
0.0	7.47	0.0	54.3	5.91	52.7
16.2	6.92	3.8	59.8	5.95	72.0
24.9	6.64	6.2	63.0	5.94	75.6
34.5	6.38	11.0	78.2	6.30	90.7
42.3	6.12	17.2	100.0	6.92	100.0
48.3	5.89	33.2			

THE SYSTEM AMMONIUM BROMIDE - LEAD BROMIDE - WATER AT 25°  
(Wilkerson, Bathurst and Parton, 1937)

Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
PbBr <sub>2</sub>	NH <sub>4</sub> Br		PbBr <sub>2</sub>	NH <sub>4</sub> Br	
0.0	79.39	NH <sub>4</sub> Br	1.38	32.13	NH <sub>4</sub> Br·2PbBr <sub>2</sub>
4.3	82.56	"	0.392	19.26	"
8.93	84.37	"	0.232	13.58	"
16.26	88.80	" + 2NH <sub>4</sub> Br·PbBr <sub>2</sub>	0.155	6.688	"
14.89	81.87	2NH <sub>4</sub> Br·PbBr <sub>2</sub>	0.155	5.607	"
14.07	76.07	"	0.173	4.239	"
12.99	69.90	"	0.200	3.398	" + PbBr <sub>2</sub>
12.17	63.53	"	0.244	2.066	PbBr <sub>2</sub>
11.87	61.44	" + NH <sub>4</sub> Br·2PbBr <sub>2</sub>	0.273	1.444	"
11.49	60.75	NH <sub>4</sub> Br·2PbBr <sub>2</sub>	0.572	0.395	"
5.845	50.03	"	0.981	0.00	"

AMMONIUM CADMIUM BROMIDE (NH<sub>4</sub>)CdBr<sub>3</sub>·½H<sub>2</sub>O

100 parts water dissolve 137 parts of the salt; 100 parts of alcohol dissolve 18.8 parts and 100 parts of ether dissolve 0.36 part. (Eder, 1876.)

## N NITROGEN

### AMMONIUM PLATINUM BROMIDE $(\text{NH}_4)_2\text{PtBr}_6$

SOLUBILITY IN WATER  
(Archibald and Kern, 1917)

t°	Gms. $(\text{NH}_4)_2\text{PtBr}_6$ per 100 gms. $\text{H}_2\text{O}$	t°	Gms. $(\text{NH}_4)_2\text{PtBr}_6$ per 100 gms. $\text{H}_2\text{O}$	t°	Gms. $(\text{NH}_4)_2\text{PtBr}_6$ per 100 gms. $\text{H}_2\text{O}$
0.2	0.4165	29.7	0.8147	70.0	1.9265
7.3	0.5002	40.0	1.0355	80.0	2.3002
19.0	0.6438	50.0	1.2087	90.0	2.8370
25.0	0.7384,	60.0	1.5780	99.0	3.5866

SOLUBILITY IN AQUEOUS SOLUTIONS OF AMMONIUM BROMIDE AT 20°  
(Archibald and Kern, 1917)

Gms. mols. $\text{NH}_4\text{Br}$ per liter	Gms. $(\text{NH}_4)_2\text{PtBr}_6$ per 100 gms. solvent
0.10	0.0359
0.20	0.0168
1.00	0.0080
2.00	0.0032

### Br AMMONIUM TIN BROMIDES Mono, Di, Tetra

SOLUBILITY OF STANNOUS MONO AMMONIUM BROMIDE IN WATER  
(Rimbach and Fleck, 1916)

t°	Gms. per 100 gms. sat. sol.			Solid Phase
	Br	Sn	$\text{NH}_4$	
0.1	15.16	4.95	1.91	$\text{NH}_4 \cdot \text{SnBr}_3 \cdot \text{H}_2\text{O} + \text{SnBr}_2 \cdot \text{H}_2\text{O}$
17.7	19.23	7.03	2.29	" "
36.8	26.73	11.51	2.54	" "
56.7	40.84 +	20.30 +	3.06 = 64.2 gms.	$\text{NH}_4\text{SnBr} \cdot \text{H}_2\text{O}$
74.6	49.43 +	25.56 +	3.71 = 77.7 gms.	"

At temperatures below 56°.7 the atomic ratios of  $\text{Br}:\text{Sn}:\text{NH}_4$  did not correspond to the double salt hence in these cases the solid phase was a mixture of the double salt and stannous bromide.

SOLUBILITY OF STANNOUS DIAMMONIUM BROMIDE IN WATER  
(Rimbach and Fleck, 1916)

t°	Gms. per 100 gms. sat. sol.			Solid Phase
	Br	Sn	NH <sub>4</sub>	
0.2	21.57	1.99	4.26	(NH <sub>4</sub> ) <sub>2</sub> SnBr <sub>4</sub> ·H <sub>2</sub> O+SnBr <sub>2</sub> ·H <sub>2</sub> O
14.4	26.65	4.49	4.65	" "
36.6	38.87	10.19	5.69	" "
60.6	48.70	16.01	6.13	" "
80.5	52.21 +	19.36 +	5.91 = 77.4 gms.	(NH <sub>4</sub> ) <sub>2</sub> SnBr <sub>2</sub> ·H <sub>2</sub> O

The ratio of Br:Sn:NH<sub>4</sub> in solution, corresponding to the double salt, was reached only at temperatures above 60°.6.

Br

SOLUBILITY OF STANNOUS TETRA AMMONIUM BROMIDE IN WATER  
(Rimbach and Fleck, 1916)

t°	Gms. per 100 gms. sat. sol.			Solid Phase
	Br	Sn	NH <sub>4</sub>	
1.8	30.33	0.65	6.65	(NH <sub>4</sub> ) <sub>4</sub> SnBr <sub>6</sub> ·H <sub>2</sub> O+SnBr <sub>2</sub> ·H <sub>2</sub> O
16.0	34.62	2.00	7.21	" "
73.3	52.52	10.37	8.71	" "
91.6	56.66	13.53	8.68	" "

The atomic ratio Br:Sn:NH<sub>4</sub> corresponding to the double salt was not reached below 91°.6.

SOLUBILITY OF AMMONIUM BROMIDE IN ALCOHOLS  
(Bedwell, 1943)

t°	Gms. NH <sub>4</sub> Br per 100 gms. solvent		
	Methyl Alcohol	Ethyl Alcohol	n-Propyl Alcohol
0	10.62	2.968	0.9082
10	11.53	3.154	1.033
15	-	(3.06)*	-
19	(12.5)*	(3.22)*	-
20	12.33	3.356	1.158
30	13.09	3.583	1.269
40	14.07	4.260	1.357
50	14.88	4.412	1.397
60	15.63	4.552	1.476
70	-	4.709	1.501
78	-	(10.50)*	-
80	-	-	1.576
90	-	-	1.613

\*Eder; de Bruyn, 1892.

100 cc. ethyl alcohol of d<sub>15</sub> = 0.8352 (85 wt. %) dissolve 7.8 grams NH<sub>4</sub>Br at 15°, d<sub>15</sub> of sat. sol. = 0.8848. (Grenish, 1900.)

## N NITROGEN

SOLUBILITY OF AMMONIUM BROMIDE IN MIXTURES OF ALCOHOLS AT 25°  
(Herz and Kuhn, 1908)

	Methyl and Ethyl Alcohols			Propyl and Methyl Alcohols		
	Gms. CH <sub>3</sub> OH per 100 Gms. Solvent	d <sub>25</sub> <sup>°</sup> of Sat. Sol.	Gms. NH <sub>4</sub> Br per 100 cc. Sat. Sol.	Gms. CH <sub>3</sub> OH per 100 Gms. Solvent	d <sub>25</sub> <sup>°</sup> of Sat. Sol.	Gms. NH <sub>4</sub> Br per 100 cc. Sat. Sol.
	0	0.8065	2.55	0	0.8605	9.83
	4.37	0.8083	2.99	11.11	0.8524	8.51
	10.40	0.8117	3.21	23.8	0.8426	6.90
	41.02	0.8252	5.06	65.2	0.8184	3.08
	80.69	0.8501	8.13	91.8	0.8097	1.28
Br	84.77	0.8508	8.47	93.75	0.8089	1.25
	91.25	0.8551	9.34	100	0.8059	0.95
	100	0.8605	9.83			

Propyl and Ethyl Alcohols		
Gms. C <sub>3</sub> H <sub>7</sub> OH per 100 Gms. Solvent	d <sub>4</sub> <sup>25</sup> of Sat. Sol.	Gms. NH <sub>4</sub> Br per 100 cc. Sat. Sol.
0	0.8065	2.55
8.51	0.8062	2.51
17.85	0.8052	2.37
56.6	0.8048	1.63
88.6	0.8042	1.11
91.2	0.8049	1.05
95.2	0.8059	1.04
100	0.8059	0.95

[illegible]

100 gms. ethyl ether (sp. gr. 0.720) dissolve 0.123 gms.  $\text{NH}_4\text{Br}$  at  $19^\circ$ . (Eder; de Brun, 1892.)

## SOLUBILITY OF AMMONIUM BROMIDE IN LIQUID AMMONIA

Gms. $\text{NH}_4\text{Br}$ per 100			Gms. $\text{NH}_4\text{Br}$ per 100		
$t^\circ$	gms. $\text{NH}_3$	cc sat. sol. in $\text{NH}_3$	$t^\circ$	gms. $\text{NH}_3$	cc sat. sol. in $\text{NH}_3$
-50	-	47.1 (1)	-38.2	-	50.6 (1)
-44	-	48.2 (1)	-33.9	90.75	50.45 (d.=1.0608) (2)
-41.2	-	48.9 (1)	-31.8	-	52.0 (1)
-42.8	-	49.0 (1)	0	137.9	- (3)
-40.5	-	49.7 (1)	25	237.9	- (4)

(1) Scherer, 1931; (2) Johnson and Krumboltz, 1933; (3) Linhard and Stephan, 1933, 1934; (4) Hunt, 1932.

## SOLUBILITY OF AMMONIUM BROMIDE IN LIQUID SULFUR DIOXIDE

t°	Gms. $\text{NH}_4\text{Br}$ per 100 gms. sat. sol.	Author
0	0.059	(Jander and Wickert, 1936, 1937)
25	0.052	(Shatenstein and Viktorov, 1937)

100 cc. anhydrous hydrazine dissolve 110 gms.  $\text{NH}_4\text{Br}$  at room temp. with evolution of ammonia. (Welsh and Broderson, 1915.)

TETRA METHYL AMMONIUM BROMIDE  $(\text{CH}_3)_4\text{NBr}$ 

Br

100 cc. pure Ethyl urethan dissolve 0.22 gm.  $(\text{CH}_3)_4\text{NBr}$  at 60°. (Stuckgold, 1917.)

100 cc. acetonitrile dissolve 0.17 gm.  $(\text{CH}_3)_4\text{NBr}$  at 25°. (Walden, 1906.)

TETRA ETHYL AMMONIUM BROMIDE  $(\text{C}_2\text{H}_5)_4\text{NBr}$ SOLUBILITY OF TETRA ETHYL AMMONIUM BROMIDE IN VARIOUS SOLVENTS  
(Bjerrum and Josefowicz, 1932)

Solvent	Formula	t°	d. of sat. sol.	Gms. $\text{N}(\text{C}_2\text{H}_5)_4\text{Br}$ per 100 gms. sat. sol.
Water	$\text{H}_2\text{O}$	20	1.193	75.5
"	"	25	-	75.6 <sup>b</sup>
"	"	35	1.1935	76.7
Methyl Alcohol	$\text{CH}_3\text{OH}$	20	1.0225	58.3
"	"	35	1.0315	61.5
Ethyl Alcohol	$\text{C}_2\text{H}_5\text{OH}$	20	0.9151	34.6
"	"	35	0.9288	40.9
Acetone	$(\text{CH}_3)_2\text{CO}$	20	0.7903	0.193
"	"	35	0.7740	0.252
Acetonitrile	$\text{CH}_3\text{CN}$	25	-	9.59 <sup>a</sup>
Chloroform	$\text{CHCl}_3$	25	-	25.0 <sup>b</sup>

<sup>a</sup>Gms. per 100 ml. sat. sol. (Walden, 1906).

<sup>b</sup>Peddle and Turner, 1913.

## PROPYL BENZYL METHYL PHENYL AMMONIUM BROMIDE

Distribution results between water and chloroform at 25° are given by Wedekind and Paschke, 1910.



# N NITROGEN

## AMMONIUM POLYHALIDES

### SOLUBILITY OF AMMONIUM POLYHALIDES IN WATER AND IN CARBON TETRACHLORIDE AT 25° (Cremer and Duncan, 1931)

Compound	Gm. atoms halogen per liter	Gms. compd. per 100 gms. sat. sol. in H <sub>2</sub> O
	(1)	
NH <sub>4</sub> I Br <sub>2</sub>	0.0084	Very soluble
C <sub>3</sub> H <sub>7</sub> (a)NH <sub>3</sub> I Br <sub>2</sub>	0.0076	" "
C <sub>3</sub> H <sub>7</sub> (b)NH <sub>3</sub> I Br <sub>2</sub>	0.0025	" "
C <sub>2</sub> H <sub>5</sub> NH <sub>3</sub> I Br <sub>2</sub>	0.0066	Readily soluble
(CH <sub>3</sub> ) <sub>3</sub> NH I Br <sub>2</sub>	0.0025	Moderately soluble
CH <sub>3</sub> NH <sub>3</sub> I Br <sub>2</sub>	0.0013	" "
(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> NH <sub>2</sub> I Br <sub>2</sub>	0.0012	" "
C <sub>6</sub> H <sub>5</sub> N(CH <sub>3</sub> )I Br <sub>2</sub>	0.00023	1.33
C <sub>6</sub> H <sub>5</sub> NH I Br <sub>2</sub>	0.00018	1.27
(CH <sub>3</sub> ) <sub>2</sub> NH <sub>2</sub> I Br <sub>2</sub>	0.00004	3.0 at 0°
(CH <sub>3</sub> ) <sub>4</sub> N I Br <sub>2</sub>	0.00004	0.85
(CH <sub>3</sub> ) <sub>3</sub> N(C <sub>2</sub> H <sub>5</sub> )I Br <sub>2</sub>	0.00002	0.60
(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> N I Br <sub>2</sub>	0.00000	0.25

(1) The compounds as such were insoluble in CCl<sub>4</sub> and the units refer to the concentration of IBr in CCl<sub>4</sub> formed by their dissociation.

### SOLUBILITY OF SEVERAL POLYHALIDES IN ACETIC ACID AT 38° (McCombie and Reade, 1923)

Compound		Formula	Gms. compd. per liter
Phenyl trimethyl Ammonium Bromide	Di Chloride	N(C <sub>6</sub> H <sub>5</sub> )(CH <sub>3</sub> ) <sub>3</sub> BrCl <sub>2</sub>	50.0
"	"	N(C <sub>6</sub> H <sub>5</sub> )(CH <sub>3</sub> ) <sub>3</sub> BrBr <sub>2</sub>	8.0
"	"	N(C <sub>6</sub> H <sub>5</sub> )(CH <sub>3</sub> ) <sub>3</sub> BrI <sub>2</sub>	6.5
"	"	N(C <sub>6</sub> H <sub>5</sub> )(CH <sub>3</sub> ) <sub>3</sub> BrIBr	6.6
"	Chloride Iodo Chloride	N(C <sub>6</sub> H <sub>5</sub> )(CH <sub>3</sub> ) <sub>3</sub> CHCl	13.3
"	Iodide Iodo Iodide	N(C <sub>6</sub> H <sub>5</sub> )(CH <sub>3</sub> ) <sub>3</sub> I <sub>2</sub> I <sub>2</sub>	1.6

AMMONIUM FORMATE  $\text{HCOONH}_4$ 

CH

SOLUBILITY IN WATER  
(Groschuff - Ber. 36, 4351, '03)

t°	Gms. $\text{HCOONH}_4$ per 100 Gms.		Solid Phase	t°	Gms. per 100 Gms. Solution		Solid Phase
	Solution	Water			$\text{HCOONH}_2$	$\text{HCOOH}$	
-20	41.9	72	$\text{HCOONH}_4$	- 6.5	46.7	34.1	$\text{HCOONH}_4 \cdot \text{HCOOH}$
0	50.5	102	"	+ 1.5	49.6	36.2	"
20	58.9	143	"	6	51.3	37.4	"
40	67.1	204	"	8.5	52.1	38	"
60	75.7	311	"	- 7	49.6	36.2	$\text{HCOONH}_4$ labil.
80	84.2	531	"	+13	53	38.6	" stabil.
116 m. pt.				29	55.8	40.7	" "
				39	57.8	42.2	$\text{H}_2\text{O}$ free solution

SOLUBILITY OF AMMONIUM FORMATE IN FORMIC ACID SOLUTIONS  
(Groschuff)

30 grams of  $\text{HCOONH}_4$  dissolved in weighed amounts of anhydrous formic acid and cooled to the point at which a solid phase separated.

t°	Gms. $\text{HCOONH}_4$ per 100 Gms. Solution	G. M. $\text{HCOONH}_4$ per 100 G. M. $\text{HCOOH}$	Solid Phase
- 3	35.3	39.9	$\text{HCOONH}_4 \cdot \text{HCOOH}$
+ 8.5	40.6	49.9	"
21.5	50	73	"
11	50	73	$\text{HCOONH}_4$ labil.
39	57.8	100	" stabil.
78	73.1	199	" "
116 m. pt.	100		" "

100 gms. 95% Formic Acid dissolve 6.2 gms.  $\text{HCOONH}_4$  at 21°.  
(Aschan, 1913.)

Freezing-point data for mixtures of  $\text{NH}_4\text{HCOO} + \text{HCOOH}$  are given by Kendall and Adler, 1921.

AMMONIUM METHIONATE  $(\text{NH}_4)_2\text{CH}_2\text{O}_6\text{S}_2$ 

CH

100 gms.  $\text{H}_2\text{O}$  dissolve 32.01 gm.  $(\text{NH}_4)_2\text{CH}_2\text{O}_6\text{S}_2$  at 25°. (Backer and Terpstra, 1929.)

# N NITROGEN

## CH AMMONIUM ACETATE $\text{CH}_3\text{COONH}_4$

### SOLUBILITY IN AQUEOUS SOLUTIONS OF ACETIC ACID (Sugden, 1926)

t°	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{CH}_3\cdot\text{COOH}$	$\text{CH}_3\cdot\text{COONH}_4$	
0	3.7	63.8	$\text{CH}_3\text{COONH}_4$
0	15.8	61.1*	"
0	19.6	48.9	$\text{CH}_3\text{COONH}_4\cdot\text{CH}_3\text{COOH}$
0	61.6	28.1	"
16	0.91	67.8	$\text{CH}_3\text{COONH}_4$
16	7.73	64.4	"
16	16.0	62.6	"
16	19.7	61.1*	"
16	23.9	59.6*	"
16	17.1	61.1	$\text{CH}_3\text{COONH}_4\cdot\text{CH}_3\text{COOH}$
16	21.7	55.6	"
16	22.7	54.3	"
16	38.1	42.5	"
16	57.3	32.6	"
16	72.3	27.3	"
25	2.15	70.6	$\text{CH}_3\text{COONH}_4$
25	12.0	67.0	"
25	21.1	63.3	"
25	31.3	58.9*	"
25	23.2	60.7	$\text{CH}_3\text{COONH}_4\cdot\text{CH}_3\text{COOH}$
25	36.2	48.5	"
25	47.6	41.0	"
25	59.9	33.2	"

\*Indicates unstable equilibrium.

### MELTING POINTS IN THE SYSTEM AMMONIA - ACETIC ACID (Davidson, Sisler, and Stoenner, 1944)

t°	Mole % $\text{NH}_3$	Solid Phase	t°	Mole % $\text{NH}_3$	Solid Phase	t°	Mole % $\text{NH}_3$	Solid Phase
50.1	23.7	A	119.0	53.1	C	6.5	74.4	D
59.5	26.3	A	120.0	54.5	C	4.5	75.7	D
66.0	30.2	A	119.5	55.2	C	3.0	76.2	D
66.5	31.3	A	119.5	55.7	C	-1.0	78.0	D
67.0	32.6	A	119.5	56.0	C	-3.0	78.6	D
69.0	34.0	B	118.0	59.0	C	-7.0	80.2	D
73.5	34.9	B	116.4	61.4	C	-9.0	81.2	D
79.5	35.9	B	113.0	63.9	C	-20.5	84.6	D
96.5	39.6	B	109.5	66.0	C	-29.5	87.3	D
100.5	40.8	B	104.5	67.8	C	-35.5	88.8	E
106.5	43.3	B	100.0	69.2	C	-34.0	89.6	E
112.0	45.6	B	91.0	71.2	C	-34.5	90.9	E

(Cont.)

## MELTING POINTS IN THE SYSTEM AMMONIA - ACETIC ACID--Cont.

t°	Mole % NH <sub>3</sub>	Solid Phase	t°	Mole % NH <sub>3</sub>	Solid Phase	t°	Mole % NH <sub>3</sub>	Solid Phase
114.0	46.7	B	87.0	71.9	C	-40.5	92.6	E
115.5	48.0	B	85.0	72.2	C	-61.5	97.6	E
117.0	50.0	B	81.0	72.7	C	-64.0	98.0	E
117.0	51.0	B	78.0	73.2	C	-77.5	98.9	E
117.0	51.6	B	68.5	73.7	C	-78.5	99.3	F
			40.0	74.2	C	-77.5	100.0	F

A = NH<sub>3</sub>·2HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>      B = NH<sub>3</sub>·HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>      C = 5NH<sub>3</sub>·4HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>  
 D = 2NH<sub>3</sub>·HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>      E = 9NH<sub>3</sub>·HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>      F = NH<sub>3</sub>

CH

THE SYSTEM AMMONIUM ACETATE - ACETIC ACID  
(Davidson and McAllister, 1930)

t°	Mol. Percent NH <sub>4</sub> C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>	Solid Phase
16.5	0.0	HC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>
14.2	4.64	"
10.45	9.35	"
6.90	12.03	"
2.8	14.54	"
-3.0	17.08	"
-6.5	18.54	"
2.5	19.43	NH <sub>4</sub> C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ·HC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>
9.6	20.67	"
24.0	23.15	"
40.1	27.06	"
50.1	31.10	"
56.4	34.95	"
63.0	40.80	"
65.5	45.05	"
66.0	47.66	"
66.5 m. pt.	50.00	"
66.0	51.75	"
65.2	53.20	" + NH <sub>4</sub> C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>
68.5	54.83	NH <sub>4</sub> C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>
75.7	58.70	"
93.0	69.50	"
102.0	76.84	"
113.0	100.00	"

Data for equilibrium in the System Ammonium Acetate + Nickel Acetate + Acetic Acid at 30° are given by Davidson and Chappell, 1933.

100 gms. Methyl Alcohol (CH<sub>3</sub>OH) dissolve 7.89 gms. NH<sub>4</sub>C<sub>2</sub>H<sub>3</sub>O<sub>2</sub> at 15° and 131.24 gms. at 94.2° (b.pt.). (Henstock, 1934.)

100 cc. sat. solution of ammonium acetate in Acetone contain 0.27 gm. CH<sub>3</sub>COONH<sub>4</sub> at 19°. (Rshdestwensky and Lewis, 1912.)

100 gms. Liquid Ammonia (NH<sub>3</sub>) dissolve 253.16(?) gms. NH<sub>4</sub>C<sub>2</sub>H<sub>3</sub>O<sub>2</sub> at 25°. (Hunt and Boneyk, 1933.)

100 gms. Liquid Sulfur Dioxide (SO<sub>2</sub>) dissolve 1.09 gm. NH<sub>4</sub>C<sub>2</sub>H<sub>3</sub>O<sub>2</sub> at 0°. (Jander and Ruppolt, 1937.)

# N NITROGEN

## CH AMMONIUM complex ETHYLENEDIAMINE TETRA ACETATES $\text{NH}_4[\text{M C}_2\text{H}_2\text{N}(\text{CH}_2\text{COO})_4]$

THE SYSTEM  $\text{NH}_4[\text{La-EDTA}] - \text{NH}_4[\text{Sm-EDTA}] - \text{H}_2\text{O}$  AT  $0^\circ$   
(Brunisholz and Cahen, 1958)

Sat. Solution		Solid Phase	Sat. Solution		Solid Phase
Gm. atom % Sm in complex	Moles $\text{H}_2\text{O}$ per gm. atom La + Sm	Gm. atom % Sm in complex	Gm. atom % Sm in complex	Moles $\text{H}_2\text{O}$ per gm. atom La + Sm	Gm. atom % Sm in complex
0.0	99.2	0.0 <sup>a</sup>	50.0	176.7	94.9 <sup>a</sup>
9.8	90.9	0.0 <sup>a</sup>	565.	196.6	96.9 <sup>a</sup>
18.1	83.2	32.6 <sup>a+β</sup>	72.2	250.6	100.0 <sup>a</sup>
20.0	89.6	77.3 <sup>a</sup>	85.0	281.6	100.0 <sup>a</sup>
31.3	121.0	86.4 <sup>a</sup>	100.0	330.6	100.0 <sup>a</sup>

<sup>a</sup> = Solid solution of  $\text{NH}_4[\text{La-EDTA}]$  in  $\text{NH}_4[\text{Sm-EDTA}] \cdot 8\text{H}_2\text{O}$

<sup>β</sup> =  $\text{NH}_4[\text{La-EDTA}] \cdot 3\text{H}_2\text{O}$

THE SYSTEM  $\text{NH}_4[\text{Gd-EDTA}] - \text{NH}_4[\text{Y-EDTA}] - \text{H}_2\text{O}$  AT  $0^\circ$   
(Brunisholz and Randin, 1958)

Sat. Solution		Solid Phase	Sat. Solution		Solid Phase
Gm. atom % Gd in complex	Moles $\text{H}_2\text{O}$ per gm. atom Gd+Y	Gm. atom % Gd in complex	Gm. atom % Gd in complex	Moles $\text{H}_2\text{O}$ per gm. atom Gd+Y	Gm. atom % Gd in complex
0.0	314.6	0.0 <sup>β</sup>	32.36	170.4	91.88 <sup>a*</sup>
2.93	309.1	0.89 <sup>a</sup>	43.48	203.0	94.48 <sup>a*</sup>
5.35	303.7	1.67 <sup>a</sup>	51.29	226.6	- <sup>a+β</sup>
13.50	287.2	4.91 <sup>a</sup>	52.82	230.6	96.41 <sup>a</sup>
26.31	263.9	9.68 <sup>a</sup>	56.75	241.6	96.84 <sup>a</sup>
41.69	239.3	19.96 <sup>a</sup>	70.95	277.2	98.63 <sup>a</sup>
41.56	221.0	26.74 <sup>a</sup>	85.07	311.0	99.58 <sup>a</sup>
21.96	136.5	85.76 <sup>a*</sup>	100.0	338.45	100.0 <sup>a</sup>

\* metastable

<sup>a</sup> = Solid solution of  $\text{NH}_4[\text{Y-EDTA}]$  in  $\text{NH}_4[\text{Gd-EDTA}] \cdot 8\text{H}_2\text{O}$

<sup>β</sup> = " " "  $\text{NH}_4[\text{Gd-EDTA}]$  in  $\text{NH}_4[\text{Y-EDTA}] \cdot 6\text{H}_2\text{O}$

## CH AMMONIUM TARTRATE (d) $(\text{NH}_4)_2\text{C}_4\text{H}_4\text{O}_6$

SOLUBILITY OF AMMONIUM TARTRATE IN WATER  
(Timmermans and Dumont, 1931; Campbell and Slotin, 1933)

The results of the above named investigators, although differing somewhat, especially at  $20^\circ$  and  $30^\circ$ , gave a curve from which the following values were read.

## SOLUBILITY OF AMMONIUM TARTRATE IN WATER--Cont.

Gms. (NH <sub>4</sub> ) <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>6</sub> per 100 gms. t°      H <sub>2</sub> O      Solid Phase			Gms. (NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> H <sub>4</sub> O <sub>6</sub> per 100 gms. t°      H <sub>2</sub> O      Solid Phase		
-7.6*	40.0	Ice+(NH <sub>4</sub> ) <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>6</sub>	25	67.0	(NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> H <sub>4</sub> O <sub>6</sub>
0	45.0	(NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> H <sub>4</sub> O <sub>6</sub>	30	70.5	"
10	55.0	"	40	76.5	"
15	59.5	"	50	81.5	"
20	63.0	"	60	87.0	"

\*Eutectic

AMMONIUM HYDROGEN TARTRATE NH<sub>4</sub>HC<sub>4</sub>H<sub>4</sub>O<sub>6</sub>

CH

SOLUBILITY OF AMMONIUM ACID TARTRATE IN WATER  
(Timmermans and Dumont, 1931)

t°	Gms. NH <sub>4</sub> HC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> per 100 gms. H <sub>2</sub> O	Solid Phase
-0.3 Eutec.	1.0	Ice + NH <sub>4</sub> HC <sub>4</sub> H <sub>4</sub> O <sub>6</sub>
15	2.35	NH <sub>4</sub> HC <sub>4</sub> H <sub>4</sub> O <sub>6</sub>
20	2.70	"
25	3.24	"

Results for equilibrium in the following systems are also given by Timmermans and Dumont, 1931.

(d) Ammonium Acid Tartrate	+	(l) Ammonium Acid Malate + H <sub>2</sub> O
(l) " " "	+	(l) " " " + "
(d) " " "	+	(d) " " chlor succinate + H <sub>2</sub> O
(d) " " "	+	(l) " " " " + "
(d) " Neutral "	+	(d) " Neutral" " + "
(l) " " "	+	(d) " " " " + "
(l) " Acid Malate	+	(l) " Acid " " + "
(l) " " "	+	(d) " " " " + "

SOLUBILITY OF AMMONIUM ACID TARTRATE IN UREA AND DIOXANE SOLUTIONS  
(Pedersen, 1941)

17.85°		18.00°	
Moles Urea per liter of Solvent	Moles NH <sub>4</sub> HC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> per liter Sat. Sol.	Moles Dioxane per liter of Solvent	Moles NH <sub>4</sub> HC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> per liter Sat. Sol.
0.0	0.1494	0.0	0.1499
0.250	.1527	0.250	.1403
.500	.1558	.500	.1310
.750	.1590	.750	.1223
1.00	.1621		

# N NITROGEN

## CH AMMONIUM HYDROGEN MALATE (1) $\text{NH}_4\text{HC}_4\text{H}_4\text{O}_6$

### SOLUBILITY OF AMMONIUM ACID MALATE IN WATER (Timmermans and Dumont, 1931)

t°	Gms. $\text{NH}_4\text{HC}_4\text{H}_4\text{O}_6$ per 100 gms. $\text{H}_2\text{O}$	Solid Phase
- 4.0	20.0	(1) $\text{NH}_4\text{HC}_4\text{H}_4\text{O}_6$
+10	28.56	"
20	36.63	"
25	41.72	"

## AMMONIUM LACTATE $\text{NH}_4[\text{CH}_3\text{CHOHCOO}]$

### FREEZING POINTS OF AMMONIUM LACTATE SOLUTIONS (Dietz, Degering, and Schopmeyer, 1941)

Gms. per 100 gms. Sat. Sol.	Density $\frac{25}{4}$	Freezing Point
5	1.0092	- 1.9
10	1.0218	- 3.30
20	1.0461	- 7.6
30	1.0703	-14.8
40	1.0954	-21.1
60	1.1394	-51.8

Data are also given for the viscosities, densities, refractive indices, boiling points, and surface tensions of unsaturated solutions at 25°.

## CH AMMONIUM SUCCINATE $(\text{NH}_4)_2(\text{CH}_2)_2(\text{COO})_2$

### EQUILIBRIUM IN THE SYSTEM AMMONIUM SUCCINATE AMMONIUM CHLORIDE AND WATER AT 25°.2 (Lanzing, 1928)

Ammonium succinate is designated as  $\text{NH}_4\text{S}$  in the paper and no indication given as to whether this represents the neutral or acid salt. The mixtures were shaken for about three weeks at 25.2°.

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{NH}_4\text{Cl}$	$(\text{NH}_4)_2(\text{CH}_2)_2(\text{COO})_2(?)$	
0.0	50.74	$(\text{NH}_4)_2(\text{CH}_2)_2(\text{COO})_2(?)$
7.62	44.34	"
10.63	42.15	"
10.75	41.57	$\text{NH}_4\text{Cl}$
15.02	29.49	"
22.23	12.74	"
28.47	0.0	

100 gms. Methyl Alcohol,  $\text{CH}_3\text{OH}$ , dissolve 1.62 gms. Ammonium Succinate at  $15^\circ$  and 5.84 gms. at  $65.6^\circ$  (b.pt.).

100 gms. Acetone,  $(\text{CH}_3)_2\text{CO}$ , dissolve 0.47 gms. Ammonium Succinate at  $15^\circ$ . (Henstock, 1934.)

# AMMONIUM CHLORO SUCCINATES (d) $(\text{NH}_4)_2\text{CH}_2\text{CHCl}(\text{COO})_2 \cdot \text{NH}_4\text{HCH}_2\text{CHCl}(\text{COO})_2$

CH

## SOLUBILITY OF EACH IN WATER (Timmermans and Dumont, 1931)

Results for the:

### Neutral (d) Succinate

t°	Gms. $(\text{NH}_4)_2\text{CH}_2\text{CHCl}(\text{COO})_2$ per 100 gms. $\text{H}_2\text{O}$	Solid Phase
- 8.8 (Eutec.)	33.0	Ice + $(\text{NH}_4)_2\text{CH}_2\text{CHCl}(\text{COO})_2$
+15.0	61.30	$(\text{NH}_4)_2\text{CH}_2\text{CHCl}(\text{COO})_2$
20.0	69.03	"

### Acid (d) Succinate

t°	Gms. $\text{NH}_4\text{HCH}_2\text{CHCl}(\text{COO})_2$ per 100 gms. $\text{H}_2\text{O}$	Solid Phase
- 5.0	27.5	Ice + $\text{NH}_4\text{HCH}_2\text{CHCl}(\text{COO})_2$
+20.0	53.14	$\text{NH}_4\text{HCH}_2\text{CHCl}(\text{COO})_2$

# AMMONIUM URATE (PRIMARY) $\text{C}_5\text{H}_3\text{N}_4\text{O}_3\text{NH}_4$

CH

## SOLUBILITY OF THE LACTAM AND LACTIM FORMS IN WATER (Gudzeit, 1908-09)

t°	Gms. of Each per 1000 cc. Sat. Solution		
	Lactam	Lactim	Mixture of the Two
18	0.456	0.304	0.414
37	0.817	0.540	0.741



# N NITROGEN

## CH AMMONIUM CITRATES

SOLUBILITY IN AQUEOUS SOLUTIONS OF CITRIC ACID AT 30°  
(van Itallie, 1908)

(Data read from curve plotted from original results.)

Gms. per 100 Gms. Sat. Sol.		Solid Phase
C <sub>6</sub> H <sub>8</sub> O <sub>7</sub>	NH <sub>3</sub>	
65	0	C <sub>6</sub> H <sub>8</sub> O <sub>7</sub> ·H <sub>2</sub> O
68	0.5	"
72	1.3	"
75	2.3	C <sub>6</sub> H <sub>8</sub> O <sub>7</sub> ·H <sub>2</sub> O + C <sub>6</sub> H <sub>7</sub> O <sub>7</sub> ·NH <sub>4</sub>
70	2.4	C <sub>6</sub> H <sub>7</sub> O <sub>7</sub> ·NH <sub>4</sub>
65	2.5	"
60	2.7	"
55	2.8	"
52	2.8	"
50	3.6	"
49.2	5.1	"
50	6.2	"
53	7.5	"
56	8.2	"
59.1	8.5	C <sub>6</sub> H <sub>7</sub> O <sub>7</sub> NH <sub>4</sub> + C <sub>6</sub> H <sub>6</sub> O <sub>7</sub> (NH <sub>4</sub> ) <sub>2</sub>
54	8.5	C <sub>6</sub> H <sub>6</sub> O <sub>7</sub> (NH <sub>4</sub> ) <sub>2</sub>
50	7.9	"
45.8	8.4	"
47	11.1	"
50	12.9	"
54.5	14.5	C <sub>6</sub> H <sub>6</sub> O <sub>7</sub> (NH <sub>4</sub> ) <sub>2</sub> + C <sub>6</sub> H <sub>6</sub> O <sub>7</sub> (NH <sub>4</sub> ) <sub>2</sub> ·?H <sub>2</sub> O
52	15	C <sub>6</sub> H <sub>5</sub> O <sub>7</sub> (NH <sub>4</sub> ) <sub>3</sub> ·?H <sub>2</sub> O
50	16	"
48.4	17.9	"

## CH AMMONIUM PICRATE C<sub>6</sub>H<sub>2</sub>(NO<sub>2</sub>)<sub>3</sub>ONH<sub>4</sub>

100 cc. H<sub>2</sub>O dissolve 1.1 gm. Am. picrate at room temp. (Squire and Caines, 1905.)

100 cc. 90% alcohol dissolve 1.2 gm. Am. picrate at room temp. (Squire and Caines, 1905.)

AMMONIUM BENZOATE  $C_6H_5COONH_4$ 

CH

## SOLUBILITY IN WATER

t°	Gms. $C_6H_5COONH_4$ per 100 gms. sat. sol.		Author
14.5	16.4	( $d_{14} = 1.042$ )	(Greenish and Smith, 1901)
25	18.6	( $d_{25} = 1.043$ )	(Seidell, 1910)
boiling pt.	45.4		(U.S.P.)

## SOLUBILITY OF AMMONIUM BENZOATE IN AQUEOUS ETHANOL

SOLUTIONS AT 25°  
(Seidell, 1910)

Results in good agreement with these are given by Gregg, Wilson and Wright, 1928.

Gms. $C_2H_5OH$ per 100 Gms. Solvent	d <sub>25</sub> of Sat. Sol.	Gms. $C_6H_5COONH_4$ per 100 Gms. Sat. Sol.	Gms. $C_2H_5OH$ per 100 Gms. Solvent	d <sub>25</sub> of Sat. Sol.	Gms. $C_6H_5COONH_4$ per 100 Gms. Sat. Sol.
0	1.043	18.6	60	0.930	15
10	1.027	18	70	0.901	12.2
20	1.012	18	80	0.864	8.3
30	0.997	18.1	90	0.828	4.2
40	0.979	18	95	0.810	2.7
50	0.956	17	100	0.796	1.6

100 gms. glycerol dissolve 10 gms.  $C_6H_5COONH_4$  at room temp.  
(Hager.)

100 gms. methyl alcohol  $CH_3OH$ , dissolve 6.39 gms.  $NH_4C_6H_5COO$  at 15° and 13.07 gms. at 66° (b.pt.). A methyl alcoholate of the composition  $NH_4(C_6H_5COO) \cdot 1\frac{1}{2}CH_3OH$  was prepared from hot methyl alcohol. (Henstock, 1934.)

# N NITROGEN

## CH AMMONIUM PHENOXY ACETATE p-NITROPHENYL ACETATE o-iodo benzoate o-METHOXY BENZOATE 2,4 DINITRO BENZOATE 2,5 DINITRO BENZENE SULFONATE 4 NITRO CHLOROBENZENE SULFONATE

SOLUBILITY OF EACH IN WATER, METHYL ALCOHOL AND IN ETHYL ALCOHOL AT 20°  
(McMaster and Pratte, 1922)

Salt and Formula	Gms. salt per 100 gms.		
	Water	CH <sub>3</sub> OH	C <sub>2</sub> H <sub>5</sub> OH
Ammonium Phenoxyacetate C <sub>6</sub> H <sub>5</sub> O·CH <sub>3</sub> COONH <sub>4</sub>	13.03	3.97	0.44
Ammonium p Nitrophenylacetate p NO <sub>2</sub> ·C <sub>6</sub> H <sub>4</sub> CH <sub>2</sub> ·COONH <sub>4</sub>	7.41	15.14	1.82
Ammonium o Iodo Benzoate o I·C <sub>6</sub> H <sub>4</sub> COONH <sub>4</sub>	67.11	184.10	63.37
Ammonium o Methoxy Benzoate o CH <sub>3</sub> O·C <sub>6</sub> H <sub>4</sub> ·COONH <sub>4</sub>	38.25	17.85	4.82
Ammonium 2,4 Dinitro Benzoate 2,4 (NO <sub>2</sub> ) <sub>2</sub> C <sub>6</sub> H <sub>3</sub> COONH	62.70	21.39	3.85
Ammonium 2,5 Dichlorobenzene Sulfonate C <sub>6</sub> H <sub>3</sub> Cl <sub>2</sub> ·SO <sub>3</sub> ·NH <sub>4</sub>	11.30	20.15	2.59
Ammonium 4 Nitrochlorobenzene-2-Sulfonate C <sub>6</sub> H <sub>3</sub> ·NO <sub>2</sub> ·ClSO <sub>3</sub> NH <sub>4</sub>	4.72	2.76	0.96

## CH AMMONIUM SALICYLATE C<sub>6</sub>H<sub>4</sub>·OH·COONH<sub>4</sub>

SOLUBILITY IN AQUEOUS ETHANOL SOLUTIONS AT 25°  
(Seidell, 1909, 1910)

Results in good agreement with these are given by Gregg, Wilson and Wright, 1928.

Gms. C <sub>2</sub> H <sub>5</sub> OH per 100 Gms. Sat. Sol.	Sp. Gr. of Sat. Sol.	Gms. C <sub>6</sub> H <sub>4</sub> · OHCOONH <sub>4</sub> per 100 Gms. Sat. Sol.	Gms. C <sub>2</sub> H <sub>5</sub> OH per 100 Gms. Sat. Sol.	Sp. Gr. of Sat. Sol.	Gms. C <sub>6</sub> H <sub>4</sub> · OHCOONH <sub>4</sub> per 100 Gms. Sat. Sol.
0	1.148	50.8	70	1.015	42
20	1.122	50.3	80	0.979	38
40	1.088	48.3	90	0.936	31.6
50	1.067	46.7	95	0.907	27.8
60	1.042	44.7	100	0.875	22.3

100 gms. Methyl Alcohol, CH<sub>3</sub>OH, dissolve 71.55 gms. NH<sub>4</sub>C<sub>6</sub>H<sub>4</sub>OHCOO at 15° and 163.78 gms. at 72.8° (b.pt.). (Henstock, 1934.)

SOLUBILITY OF AMMONIUM SALICYLATE IN ACETONE  
(Henstock, 1934)

t°	Gms. $\text{NH}_4\text{C}_6\text{H}_4\text{OHCOO}$ per 100 gms. $\text{CH}_3\text{COCH}_3$	Solid Phase	t°	Gms. $\text{NH}_4\text{C}_6\text{H}_4\text{OHCOO}$ per 100 gms. $\text{CH}_3\text{COCH}_3$	Solid Phase
15	69.65	$\text{NH}_4\text{C}_6\text{H}_4\text{OHCOO}$	45	37	(?)
25	24.0	"	55	46	"
35	28.8	" (?)	65	67	"

100 cc. ethyl ether (U.S.P.) dissolve 0.67 gm.  $\text{NH}_4\text{C}_6\text{H}_4\text{OHCOO}$  at about 20°. (E'we, 1920.)

AMMONIUM MANDELATE  $\text{NH}_4\text{C}_6\text{H}_5\text{CHOHCOO}$  (dl) and (l)

CH

THE SYSTEM (dl) AMMONIUM MANDELATE - (dl)  
MANDELIC ACID - WATER AT 25°  
(Ross and Morrison, 1936)

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{C}_6\text{H}_5\text{CHOHCOOH}$	$\text{NH}_4\text{C}_6\text{H}_5\text{CHOHCOO}$	
17.02	56.2	$\text{NH}_4\text{C}_6\text{H}_5\text{CHOHCOO} \cdot \text{C}_6\text{H}_5\text{CHOHCOOH}$
20.7	50.9	"
25.4	45.7	"
28.3	42.1	"
35.2	36.1	"
41.1	33.9	"
47.2	32.2	"
47.0	32.3	$\text{NH}_4\text{C}_6\text{H}_5\text{CHOHCOO} \cdot 3\text{C}_6\text{H}_5\text{CHOHCOOH}$
49.7	28.7	"
50.5	27.4	"
50.9	26.3	" + $\text{C}_6\text{H}_5\text{CHOHCOOH}$
51.2	25.4	$\text{C}_6\text{H}_5\text{CHOHCOOH}$
50.8	24.5	"
47.9	19.8	"
44.2	15.9	"
31.1	8.9	"
22.7	4.5	"
16.95	0.0	"

THE SYSTEM (l) AMMONIUM MANDELATE - (l) MANDELIC  
ACID - WATER AT 25°

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{C}_6\text{H}_5\text{CHOHCOOH}$	$\text{NH}_4\text{C}_6\text{H}_5\text{CHOHCOO}$	
18.7	61.5	$\text{NH}_4\text{C}_6\text{H}_5\text{CHOHCOO} \cdot \text{C}_6\text{H}_5\text{CHOHCOOH}$
22.2	55.5	"
24.7	51.9	"
29.0	48.0	"
37.0	42.6	"

(Cont.)

# N NITROGEN

## THE SYSTEM (1) AMMONIUM MANDELATE - (1) MANDELIC ACID - WATER AT 25°--Cont.

Gms. per 100 gms. sat. sol.		Solid Phase
$C_6H_5CHOHCOOH$	$NH_4C_6H_5CHOHCOO$	
43.9	36.4	$NH_4C_6H_5CHOHCOO \cdot C_6H_5CHOHCOOH$
46.9	36.0	$C_6H_5CHOHCOOH$
47.2	35.4	"
46.5	34.0	"
45.8	30.6	"
39.1	25.9	"
31.1	19.5	"
18.8	13.1	"
12.9	7.8	"
10.1	0.0	"

CH AMMONIUM 2,4 DINITRO PHEATE  $[C_6H_3(OH)(NO_2)_2]NH_4$   
 AMMONIUM 2,4 DINITRO CRESYLATE  $[C_6H_2(OH)(CH_3)(NO_2)_2]NH_4$

Between 0.25 and 0.5 gms.  $NH_4$  D.N.P. dissolve in 100 gms. sat. sol. at 4°. Between 0.8 and 1.0 gms.  $NH_4$  D.N.P. dissolve in 100 gms. sat. sol. at 15°. Between 0.5 and 1.0 gms.  $NH_4$  D.N.C. dissolve in 100 gms. sat. sol. at 15°. (Pastac and Lecrivain, 1948.)

## AMMONIUM NITROSALICYLATE 5.2.1 $NO_2C_6H_3(OH)COONH_4$

SOLUBILITY IN WATER AND IN METHYL AND ETHYL ALCOHOLS AT 20°  
 (McMaster and Prattle, 1923; 1924)

		Gms. compound per 100 gms.		
		$H_2O$	$CH_3OH$	$C_2H_5OH$
Ammonium Nitrosalicylate 5.2.1	$NO_2C_6H_3(OH)COONH_4$	4.43	4.41	1.96

## AMMONIUM 2.5 di-iodobenzene SULFONATE $C_6H_3I_2SO_3(NH_4)$

100 gms.  $H_2O$  dissolve 4.35 gms. salt at 20°. (Boyle, 1909.)

AMMONIUM N-Phenyl  $\beta$ -Aminoethyl Hydrogen Sulfate  $C_6H_5NH \cdot C_2H_4 \cdot O \cdot SO_3 \cdot NH_4$   
 (m. pt. 123°)

100 cc. sat. solution in water contain 70 gms. of the salt at 15°. (Saunders, 1922.)

AMMONIUM GLUCONATE  $\text{NH}_4\text{C}_6\text{H}_{11}\text{O}_7$ 

CH

100 cc. sat. solution of ammonium gluconate in water contain 29.9 gms.  $\text{NH}_4\text{C}_6\text{H}_{11}\text{O}_7$  at 25°. (May, Weisberg and Herrick, 1929.)

AMMONIUM LAURATE  $\text{C}_{11}\text{H}_{23}\text{COONH}_4$ 

100 cc. of ethylene trichloride dissolve 0.23 gms. ammonium laurate at 0°, 0.57 gm. at 10° and 1.46 gm. at 20°. (Strauß, 1918, 1926.)

AMMONIUM CALCIUM MECONATE  $\text{NH}_4 \cdot \text{CaC}_7\text{HO}_7 \cdot 2\text{H}_2\text{O}$ 

1 liter of a saturated solution of ammonium calcium meconate in aqueous 0.1 N ammonia contains 1.2783 gm.  $\text{NH}_4\text{CaC}_7\text{HO}_7 \cdot 2\text{H}_2\text{O}$  at 18°. (Heiduschka and Faul, 1917.)

AMMONIUM NAPHTHALENE SULFONATES  $\alpha$  and  $\beta$   $\text{C}_{10}\text{H}_7\text{SO}_3\text{NH}_4$ 

CH

## SOLUBILITY IN VARIOUS SOLVENTS

(1) McMaster and Prattle, 1923; 1924)

(2) Witt, 1915

	t°	Gms. per 100 gms.			
		$\text{H}_2\text{O}$	$\text{CH}_3\text{OH}$	$\text{C}_2\text{H}_5\text{OH}$	Ref
Ammonium $\alpha$ -Naphthalene sulfonate $\text{C}_{10}\text{H}_7\text{SO}_3\text{NH}_4$	20	45.91	34.45	9.22	(1)
Ammonium $\beta$ -Naphthalene sulfonate $\text{C}_{10}\text{H}_7\text{SO}_3\text{NH}_4$	20	11.71	8.33	2.53	(1)
" " "	25	12.62*	-	-	(2)

\*density = 1.034

AMMONIUM NAPHTHYLAMINE DISULFONATES 2.6.8 and 2.5.7,  $\text{C}_{12}\text{H}_9(\text{NH}_2)(\text{SO}_3\text{NH}_4)_2$ 

100 gms. sat. solution in water contain 70.35 gms. of the 2.6.8 salt at 15°. 100 gms. sat. solution in water contain 68.1 gms. of the 2.5.7 salt at 15°. (Braunschweig, 1922, 1926.)

# N NITROGEN

## CH AMMONIUM PHENANTHRENE SULFONATES $C_{14}H_9SO_3NH_4$ (2), (3), and (10)

SOLUBILITY IN WATER AT 20°  
(Sandquist, 1912)

100 gms.  $H_2O$  dissolve 0.37 gms.  $C_{14}H_9SO_4NH_4$  (2).  
100 gms.  $H_2O$  dissolve 0.26 gms.  $C_{14}H_9SO_3NH_4$  (3).  
100 gms.  $H_2O$  dissolve 4.41 gms.  $C_{14}H_9SO_3NH_4$  (10).

## AMMONIUM 10-CHLOROPHENANTHRENE 3 or 6 SULFONATE $C_{14}H_8Cl \cdot SO_3NH_4 \cdot H_2O$

100 gms.  $H_2O$  dissolve 0.442 gms. of the anhydrous salt at about 20°. (Sandqvist, 1917.)

## AMMONIUM ANTHRAQUINONE SULFONATES

SOLUBILITY OF EACH SEPARATELY IN WATER  
(Fierz-David, Krebsner and Anderan, 1927)

Compound	Formula	t°	Gms. Compound per 100 cc. $H_2O$
Ammonium:			
Anthraquinone 1.5 DiSulfonate	$(NH_4)_2C_{14}H_6O_2(SO_3)_2$	18	2.27
" " "	" "	100	7.70
" 1.8 " "	$(NH_4)_2C_{14}H_6O_2(SO_3)_2 \cdot 2H_2O$	18	1.00
" " "	" "	100	14.3
" 1.6 " "	$(NH_4)_2C_{14}H_6O_2(SO_3)_2$	18	5.26
" " "	" "	100	33.3
" 1.7 " "	$(NH_4)_2C_{14}H_6O_2(SO_3)_2 \cdot 2H_2O$	18	8.33
" " "	" "	100	50.00

The results are given in terms of cc.  $H_2O$  to dissolve 1.0 gm. (anhydrous or hydrated ?) compound.

## CH AMMONIUM HELIANTHATE $C_{14}H_4H_3SO_3NH_4 \cdot 2H_2O$

1000 cc. of water saturated at 20°-25° with respect to ammonium helianthate contain 6.0 gms.  $C_{14}H_{14}N_3SO_3 \cdot NH_4 \cdot 2H_2O$ . (Stark and Dehn, 1918.)

AMMONIUM PALMITATE  $C_{16}H_{31}O_2NH_4$ 

CH

SOLUBILITY IN SEVERAL SOLVENTS  
(Falciola, 1910)Gms.  $C_{16}H_{31}O_2 \cdot NH_4$  per 100 c.c. of:

t°	Gms. $C_{16}H_{31}O_2 \cdot NH_4$ per 100 c.c. of:				Acetone
	Absolute Alcohol	75% Alcohol	50% Alcohol	Mixture of 1 Pt. Alcohol + 2 Parts Ether	
0	0.5	-	-	-	-
10	0.7	1.78	-	0.37 (13°)	0.2 (13°)
20	1.4	4.33	5.33	0.29	
30	-	11.02	-		
40	4.5	14.84	6.69		
50	11	-	-		

AMMONIUM OLEATE  $C_{17}H_{33}COONH_4$ SOLUBILITY IN SEVERAL SOLVENTS  
(Falciola, 1910)

Solvent	Gms. $C_{17}H_{33}COONH_4$ dissolved per 100 cc. solvent:			
	31 at 0°	59 at 10°	100 at 50°	
Absolute Alcohol	--	8.2 at 20°	10.86 at 30°	
75 percent Alcohol	--	9.45 at 15°	16.9 at 20°	
1 part Alcohol + 2 parts Ether	--	4.7 at 15°	--	
Acetone	--			

AMMONIUM STEARATE  $C_{18}H_{35}O_2NH_4$ 

CH

SOLUBILITY IN SEVERAL SOLVENTS  
(Falciola, 1910)Gms.  $C_{18}H_{35}O_2NH_4$  per 100 cc. of:

t°	Absolute Alcohol	75% Alcohol	50% Alcohol	Ether	Acetone
0	0.1	-	-	-	-
10	0.3	0.56	0.25	-	0.08 (13°)
20	0.5	-	0.51	0.1	
30	0.9	1.83	1.16		
40	1.8	5	3.21		
50	5.5	-	-		

100 cc. ethylene trichloride dissolve 0.04 gm. ammonium stearate at 0°, 0.12 gm. at 10° and 0.31 gm. at 20°. (Strauli, 1918, 1926.)



# N NITROGEN

## CN AMMONIUM FERROCYANIDE $(\text{NH}_4)_4\text{Fe}(\text{CN})_6$

THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM FERROCYANIDE - WATER  
(Irving and Cherry, 1941)

t°	Gms. per 100 gms. Sat. Sol.		Solid Phase	t°	Gms. per 100 gms. Sat. Sol.		Solid Phase
	$\text{NH}_4\text{Cl}$	$(\text{NH}_4)_4\text{Fe}(\text{CN})_6$			$\text{NH}_4\text{Cl}$	$(\text{NH}_4)_4\text{Fe}(\text{CN})_6$	
0	13.6	9.7	2:1	40.05	31.6	0.0	$\text{NH}_4$
	8.7	18.9	"		29.9	0.8	"
	7.0	21.9	"		29.6	1.3	"
25.1	28.3	0.0	$\text{NH}_4$		28.4	1.8	$\text{NH}_4 + 2:1$
	28.0	0.3	"		28.4	1.6	" + "
	27.8	0.4	$\text{NH}_4 + 2:1$		24.3	4.5	2:1
	27.3	1.2	" + "		23.6	5.2	"
	27.3	1.0	2:1		15.9	13.9	"
	25.3	2.3	"		9.5	25.2	"
	17.1	10.3	"		3.7	41.2	"
	14.7	14.0	"		1.0	54.6	2:1 + Fe
	8.5	24.7	"		1.1	53.3	" "
	6.2	30.0	"		1.0	64.6	Fe
	3.7	36.7	"		0.6	54.1	"
	0.8	44.6	"		0.9	54.9	"
	0.6	53.8	2:1 + Fe		0.0	54.7	"
	1.0	53.6	" + "				
	0.3	51.7	Fe				
	0.0	51.3	"				

$\text{NH}_4 = \text{NH}_4\text{Cl}$

$\text{Fe} = (\text{NH}_4)_4\text{Fe}(\text{CN})_6$

2:1 =  $2\text{NH}_4\text{Cl} \cdot (\text{NH}_4)_4\text{Fe}(\text{CN})_6$

## CN AMMONIUM LEAD COBALTICYANIDE $\text{NH}_4\text{PbCo}(\text{CN})_6 \cdot 3\text{H}_2\text{O}$

100 grams.  $\text{H}_2\text{O}$  dissolve 12 grams of the salt at 18°. (Schuler, 1879.)

## SCN AMMONIUM THIOCYANATE $\text{NH}_4\text{SCN}$

SOLUBILITY IN WATER  
(Shnidman, 1934; Foote, 1921)

Earlier data, averaging somewhat higher than these are given by Rüdorff, 1868 and 1872; Wassilijew, 1910; Smits and Kettner, 1912. The eutectic occurs at about -25°, 42%  $\text{NH}_4\text{SCN}$ . Other freezing-point data for mixtures of ammonium thiocyanate and water are given by Vasiliev, 1917.

## SOLUBILITY IN WATER--Cont.

t°	Gms. NH <sub>4</sub> SCN per 100 gms. sat. sol.	Solid Phase	t°	Gms. NH <sub>4</sub> SCN per 100 gms. sat. sol.	Solid Phase
10	58.23 F	NH <sub>4</sub> SCN	39.44	70.05	NH <sub>4</sub> SCN
13.0	59.57	"	46.92	72.86	"
18.99	62.20	"	51.37	74.53	"
20	62.54 F	"	52.50	74.94	"
26.33	64.95	"	57.23	76.63	"
28.82	65.93	"	62.46	78.53	"
30	66.26 F	"	67.21	80.18	"
36.36	68.86	"	71.53	81.73	"

SOLUBILITY OF AMMONIUM THIOCYANATE IN AQUEOUS SOLUTIONS OF AMMONIA SCN  
(Foote, 1921)

t° = 10° Gms. per 100 gms. sat. sol.		t° = 10° Gms. per 100 gms. sat. sol.		t° = 10° Gms. per 100 gms. sat. sol.		Solid Phase in all cases
NH <sub>3</sub>	NH <sub>4</sub> CNS	NH <sub>3</sub>	NH <sub>4</sub> CNS	NH <sub>3</sub>	NH <sub>4</sub> CNS	
0.0	58.23	0.0	62.54	0.0	66.26	NH <sub>4</sub> CNS
3.49	59.40	3.53	63.57	2.85	67.28	"
6.86	61.03	6.23	64.99	5.79	68.30	"
9.22	62.61	8.57	66.20	8.38	69.48	"
12.33	65.29	11.19	67.57	12.18	71.84	"
14.53	66.67	12.54	69.06	14.46	74.00	"
17.12	69.50	15.65	71.89	17.04	76.63	"
19.78	72.84	18.07	74.15	20.01	79.99	"
22.70	77.30	21.35	78.65			

THE SYSTEM AMMONIUM THIOCYANATE - AMMONIUM NITRATE - WATER  
(Ravich, Ketkovich and Rassninskaya, 1949)

Continuous solid solutions occur in the binary system NH<sub>4</sub>NO<sub>3</sub> - NH<sub>4</sub>SCN above 70°, and the 80° and 90° isotherms in the aqueous system exhibit a region saturated with the solid solution phase.

N = NH <sub>4</sub> NO <sub>3</sub>		S = NH <sub>4</sub> SCN		I = ICE		α = solid solution		
mole %		Solid Phase	solution mole %		solid mole %		Solid Phase	
S	N		S	N	S	N		
at -30.0°			at 68°					
12.9	5.7	N+S+I	39.5	38.4	--	--	N+S+	
at 0°			at 80°					
5.6	16.4	N	12.0	51.0	8.0	66.7	N	
11.1	14.3	N	23.5	45.8	13.0	70.7	N	
18.4	12.0	N+S	33.2	44.7	22.1	63.3	N	
19.8	8.7	S	36.9	43.9	33.5	54.6	α	
20.8	3.6	S	38.0	41.5	38.5	45.2	α	

(Cont.)

(Cont.)

# N NITROGEN

## THE SYSTEM AMMONIUM THIOCYANATE - AMMONIUM NITRATE - WATER--Cont.

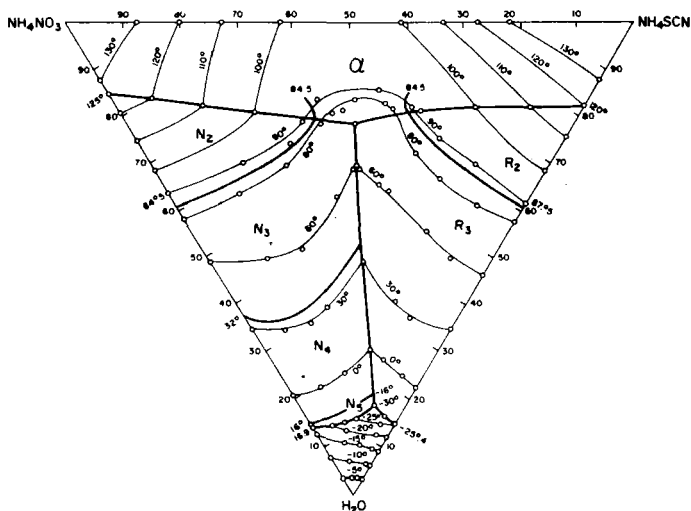
N =  $\text{NH}_4\text{NO}_3$

S =  $\text{NH}_4\text{SCN}$

I = ICE

$\alpha$  = solid solution

mole %		Solid Phase	solution mole %		solid mole %		Solid Phase
S	N		S	N	S	N	
at 30°							
5.0	29.5	N	44.1	38.5	46.1	41.0	$\alpha$
10.7	25.1	N	48.0	35.1	54.4	34.7	$\alpha$
15.5	24.4	N	48.0	33.3	61.5	26.8	$\alpha$
26.4	22.1	N+S	47.1	24.3	71.0	12.9	S
28.4	12.2	S	48.7	17.8	64.5	12.0	S
SCN 28.5	8.4	S	52.8	8.6	70.3	5.5	S
at 60°						at 90°	
10.0	39.6	N	16.7	53.5	9.6	73.5	N
17.0	34.2	N	25.9	47.5	15.6	68.4	N
28.4	33.8	N	30.6	47.8	24.7	58.6	N
34.9	33.5	N	35.7	47.5	31.3	56.2	$\alpha$
35.5	34.0	N+S	42.6	40.5	43.4	44.6	$\alpha$
35.8	32.1	S	47.7	37.6	50.2	37.2	$\alpha$
37.9	27.3	S	51.5	30.4	59.8	31.9	$\alpha$
38.5	25.1	S	52.7	28.1	73.3	16.0	S
40.8	14.1	S	52.7	22.2	73.6	13.0	S
41.9	7.4	S	56.8	12.8	74.2	7.1	S



$\alpha$  = solid solution of  $\text{NH}_4\text{SCN}$  +  $\text{NH}_4\text{NO}_3$

$N_2$  = trigonal  $\text{NH}_4\text{NO}_3$

$N_3$  =  $\alpha$ -rhombic  $\text{NH}_4\text{NO}_3$

$N_4$  =  $\beta$ -rhombic  $\text{NH}_4\text{NO}_3$

$N_5$  = hexagonal  $\text{NH}_4\text{NO}_3$

$R_2$  = rhombic  $\text{NH}_4\text{SCN}$

$R_3$  = monoklinic  $\text{NH}_4\text{SCN}$

THE SYSTEM AMMONIUM THIOCYANATE - PHENOL - WATER  
(Merclin, 1940)

The system was studied at 20°, 30°, 40°, and 50° and contains an immiscibility gap between the solutions of ammonium thiocyanate rich in water and those rich in phenol. The two liquids become more miscible as the temperature is increased, and at 50° there is only one liquid phase in the system. The separate smaller miscibility gaps remain, instead of the one large gap at lower temperatures. The author gives data for the composition of solutions which are in equilibrium with a second liquid layer, but does not indicate which phases are coexistent. The maximum solubility of  $\text{NH}_4\text{SCN}$  in each layer is given below. These are the compositions of the liquid phases which are in equilibrium with each other, and with excess solid  $\text{NH}_4\text{SCN}$ .

t°	Water-Rich Layer Wt. %		Phenol-Rich Layer Wt. %		SCN
	$\text{C}_6\text{H}_5\text{OH}$	$\text{NH}_4\text{SCN}$	$\text{C}_6\text{H}_5\text{OH}$	$\text{NH}_4\text{SCN}$	
20	4.0	61.0	77.0	11.4	
30	4.0	64.5	77.3	12.5	
40	3.0	69.7	77.7	13.0	
50	2.1	73.5	77.6	14.0	

Data for the system ammonium thiocyanate, ethyl ether and water at 20° are given by Nesterow and Petine, 1932. See also Bock, 1951.

Data for the system ammonium thiocyanate, thiourea and water at 25° are given by Smits and Kettner (1912) in the form of a triangular diagram, but the numerical results are omitted. The diagram confirms the freezing-point lowering results in showing that the molecular compound  $\text{NH}_4\text{SCN} \cdot 4(\text{NH}_4)_2\text{CS}$  is formed.

SOLUBILITY OF AMMONIUM THIOCYANATE IN METHYL AND ETHYL ALCOHOL  
(Shnidman, 1934)

Results for Methyl Alcohol

t°	Gms. $\text{NH}_4\text{SCN}$ per 100 gms. sat. solution
24.58	37.11
32.94	40.05
44.80	44.70
54.76	49.30
64.55	54.55

Results for Ethyl Alcohol

t°	Gms. $\text{NH}_4\text{SCN}$ 100 gms. sat. solution
18.45	19.07
33.25	21.54
36.93	22.16
43.36	23.46
57.62	26.72

100 gms. acetonitrile dissolve 7.52 gms.  $\text{NH}_4\text{SCN}$  at 18°. (Naumann and Schier, 1914.)

100 gms. liquid ammonia ( $\text{NH}_3$ ) dissolve 312.0 gms.  $\text{NH}_4\text{SCN}$  at 25°. (Hunt, 1932.)

100 gms. liquid sulfur dioxide ( $\text{SO}_2$ ) dissolve 46.8 gms.  $\text{NH}_4\text{SCN}$  at 0°. (Jander and Ruppolt, 1937.)

## N NITROGEN

Freezing-point data are given for:

Ammonium Thiocyanate	+	Ammonia (Bradley and Alexander, 1912)
"	"	+ Potassium Thiocyanate (Wrzesnewsky, 1912)
"	"	+ Thiocarbamide (Thiourea) (Renolds and Werner, 1903; Findlay, 1904; Atkins and Werner, 1912; Smits and Kettner, 1912; Wrzesnewsky, 1912; Kettner, 1919)
"	"	+ Ammonium Nitrate (Ravich, Ketkovich and Rassonskaya, 1949)

CO AMMONIUM CARBONATE  $(\text{NH}_4)_2\text{CO}_3$

HCO AMMONIUM BICARBONATE  $\text{NH}_4\text{HCO}_3$

### THE SYSTEM AMMONIA - CARBON DIOXIDE - WATER (Janecke, 1929a)

The synthetic sealed tube method was used for determination of the temperatures of complete solution or appearance of immiscible layers in all possible mixtures of the three components. The mixtures were prepared from weighed amounts of either ammonium bicarbonate or carbamate and aqueous ammonia solutions of given concentrations. In those mixtures containing a large excess of ammonia, liquid  $\text{NH}_3$  was distilled at very low temperature into the tubes containing the salt and water. On account of the danger of explosion in these cases the tubes were incased in a metal cylinder and observed by light transmitted through protected windows. For observation of the point of complete solution at low temperatures the tubes were first cooled in a mixture of liquid  $\text{CO}_2$  and acetone until a solid phase separated and then allowed to warm to the temperature at which this solid phase just disappeared. More than 300 such observations were made and from the diagram plotted from them the values for isotherms and the invariant points were obtained. The solid phases were identified analytically and microscopically.

The previous results of Terres and Weiser, 1921, and Terres and Behrens, 1928, are shown to be in error due to imperfections in the method employed, except at temperatures below  $60^\circ$  and when the solid phase is bicarbonate or sesquicarbonate. The two solid phases reported by Terres in addition to the four here mentioned are shown not to exist.

In the following table (1) designates ammonium bicarbonate,  $\text{NH}_4\text{HCO}_3$ , (2) ammonium carbonate,  $(\text{NH}_4)_2\text{CO}_3 \cdot \text{H}_2\text{O}$ , (3) ammonium carbamate  $\text{NH}_4\text{COONH}_2$  and 1.2 ammonium sesquicarbonate  $(\text{NH}_4)_2\text{CO}_3 \cdot 2\text{NH}_4\text{HCO}_3$ .

## THE SYSTEM AMMONIA - CARBON DIOXIDE - WATER--Cont.

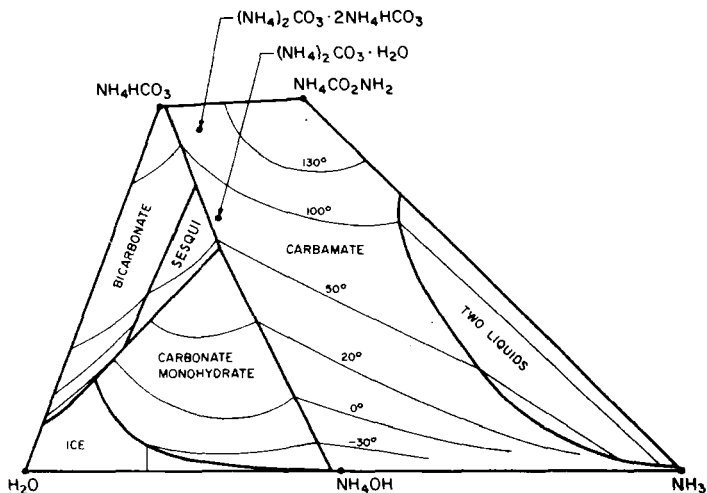
t°	Gms. per 100 gms. sat. sol.		Solid Phase	t°	Gms. per 100 gms. sat. sol.		Solid Phase	
	NH <sub>3</sub>	CO <sub>2</sub>			NH <sub>3</sub>	CO <sub>2</sub>		
-95	81.0	0.5(?)	(3)+NH <sub>3</sub> +(NH <sub>4</sub> ) <sub>2</sub> O	20	60	10.5	(3)	
-85	59.0	0.5(?)	(3)+NH <sub>4</sub> OH+ "	"	70	6.0	"	
-80	47.0	0.5(?)	(3)+ " + (2)	"	16	21.0	(1)+(1.2)	
-95	34.0	0.5(?)	Ice+ " + (2)	30	10	16.2	(1)	
-13	11.0	14.5	" + (1) + (2)	"	17	23.0	" +(1.2)	
-10	11.5	15.5	(3)+ (1)	"	20	25	(1.2)	
-10	9.5	12.5	Ice+ (1)	"	25	26	(2)	
- 5	6.0	9.0	" + "	"	30	26.5	"	
0	14.0	18.0	(3)+ (1)	"	33.5	27.0	" +(3)	CO
"	5.0	8.5	(1)	"	35	26	(3)	HCO
"	10.0	13.7	"	"	40	23	"	
"	15.0	17.0	(2)	"	45	20.3	"	
"	20.0	19.5	"	"	50	17.5	"	
"	25	9.0	"	"	60	13.0	"	
"	30	8.0	"	"	70	8.5	"	
"	35	8.5	"	40	10	17.3	(1)	
"	40	10	"	"	15	22	"	
"	42	11	" + (3)	"	17.5	25	" +(1.2)	
"	45	10	(3)	"	20	26.7	(1.2)	
"	50	8.5	"	"	25	29.5	"	
"	60	6.0	"	"	30	32.0	(2)	
"	70	4.0	"	"	31.5	32	" +(3)	
5	15	19.5	(1)+(1.2)+(2)	"	35	29	(3)	
10	5	9.6	(1)	"	40	26	"	
"	10	14.3	"	"	45	23.2	"	
"	15	19	"	"	50	21	"	
"	20	17.5	(2)	"	60	15.5	"	
"	25	15.8	"	"	70	10.5	"	
"	30	15.3	"	43	30	33	" +(2)+(1.2)	
"	35	16.0	"	50	10	19.2	(1)	
"	39	17.0	" +(3)	"	15	23	"	
"	40	17.0	(3)	"	18	27	" +(1.2)	
"	45	14.3	"	"	20	27.7	(1.2)	
"	50	12.0	"	"	25	32	"	
"	60	8.5	"	"	29	35	" +(3)	
"	70	5.0	"	"	30	35	(3)	
"	15.5	20.0	(1)+(1.2)	"	40	29	"	
20	5	10.8	(1)	"	45	26.5	"	
"	10	15.0	"	"	50	23.7	"	
"	15	20.0	"	"	60	19.0	"	
"	20	22.5	(2)	"	70	15.0	"	
"	25	21.0	"	60	19	29.0	(1)+(1.2)	
"	30	21.5	"	"	28	38	(3)+ "	
"	35	22.8	"	70	22	33.5	(1)+ "	
"	36	23.0	" +(3)	"	27.5	40	(3)+ "	
"	40	20.3	(3)	80	24.5	39	(1)+ "	
"	45	17.5	"	"	27	42	(3)+ "	
"	50	14.7	"	85	27	44	" + " +(1)	

## N NITROGEN

Above 50° two liquid layers are formed. The compositions of these, as derived from the diagram, are as follows.

t°	Liquid Layer I		Liquid Layer II	
	NH <sub>3</sub>	CO <sub>2</sub>	NH <sub>3</sub>	CO <sub>2</sub>
50	80	3.5	70	15
60	85	2.5	65	20
70	58	2.0	63	26
80	91	1.5	59	32
90	93	1.5	57.5	35
100	95	0.5	57	37.5
110	97	0.5	57	40.5

CO  
HCO



In continuation of his studies upon the system ammonium, carbon dioxide and water, Jänecke, 1930, and Jänecke and Rahlfs, 1932, give freezing-point, solubility and vapor pressure determinations of the following systems.

CO(NH <sub>2</sub> ) <sub>2</sub> (urea)	+ NH <sub>4</sub> HCO <sub>3</sub>
"	+ NH <sub>4</sub> CO <sub>2</sub> NH <sub>2</sub>
"	+ CN <sub>2</sub> NH <sub>2</sub>
"	+ H <sub>2</sub> O
"	+ NH <sub>3</sub>
"	+ NH <sub>3</sub> + H <sub>2</sub> O
"	+ " + NH <sub>4</sub> CO <sub>2</sub> NH <sub>2</sub>
"	+ "
(CN <sub>2</sub> H <sub>2</sub> ) <sub>2</sub>	+ NH <sub>3</sub>
NH(CONH <sub>2</sub> ) <sub>2</sub> (Biuret)	+ CO(NH <sub>2</sub> ) <sub>2</sub>
"	+ NH <sub>4</sub> HCO <sub>3</sub>
"	+ " + CO(NH <sub>2</sub> ) <sub>2</sub>

AMMONIUM BICARBONATE  $\text{NH}_4\text{HCO}_3$ SOLUBILITY OF AMMONIUM BICARBONATE IN WATER  
(Janecke, 1929)

The usual method of solubility determination could not be employed since the vapor with which the solutions are in equilibrium is not that of  $\text{H}_2\text{O}$  alone or of  $\text{CO}_2$  and  $\text{NH}_3$  in the molecular ratio of ammonium bicarbonate but contains relatively more  $\text{CO}_2$ . The solution therefore contains more  $\text{NH}_3$  than corresponds to  $\text{NH}_4\text{HCO}_3$ . The synthetic sealed tube method was used and the temperatures determined at which complete solution occurred in known mixtures of  $\text{NH}_4\text{HCO}_3$  and  $\text{H}_2\text{O}$ . At temperatures above  $60^\circ$  very small tubes were used and in order to avoid danger of explosion these were placed in an electrically heated metal block with a hole, protected by glass plates, through which the tube could be observed by transmitted light. The determinations were plotted and the following values taken from the curve. They agree with previous determinations except at the higher temperatures.

(The results in parentheses are the averages of the previous determinations of Fedotieff, 1904; Nishizawa, 1920; Toparescu, 1922; and Fedotieff and Kolossoff, 1923.)

$t^\circ$	Gms. $\text{NH}_4\text{HCO}_3$ per 100 gms. sat. sol.	Solid Phase	$t^\circ$	Gms. $\text{NH}_4\text{HCO}_3$ per 100 gms. sat. sol.	Solid Phase
- 3.9*	9.5 (10.6)	Ice + $\text{NH}_4\text{HCO}_3$	50	31.6	$\text{NH}_4\text{HCO}_3$
0	10.6 (13.8)	$\text{NH}_4\text{HCO}_3$	60	37.2	"
10	13.9 (17.3)	"	70	44.0	"
20	17.8 (17.3)	"	80	52.2	"
25	19.9 (19.2)	"	90	63.0	"
30	22.1 (21.3)	"	100†	78.0	"
40	26.8 (24.9)	"	108	100.0	"

\*Eutectic

†m. pt.

SOLUBILITY OF AMMONIUM BICARBONATE IN AMMONIA SOLUTIONS  
AT ONE ATMOSPHERE PRESSURE  
(Guyer and Piechowicz, 1944)

$t^\circ$	Gms. per 100 gms. Sat. Sol.		$t^\circ$	Gms. per 100 gms. Sat. Sol.	
	$\text{NH}_4\text{HCO}_3$	$\text{NH}_3$		$\text{NH}_4\text{HCO}_3$	$\text{NH}_3$
20	17.4	0.26	40	28.0	2.27
25	19.2	0.57	45	32.2	3.29
30	21.6	0.96	50	36.8	4.48
35	24.4	1.55			

Data for the solubility of  $\text{NH}_4\text{HCO}_3$  in water saturated with  $\text{CO}_2$  from  $30^\circ$  to  $70^\circ$  and from 10 to 70 atm. pressure is given by Utida, 1940, 1942.



# N NITROGEN

## THE SYSTEM $\text{NH}_4\text{HCO}_3 - \text{NH}_4\text{Cl} - \text{H}_2\text{O}$

### SOLUBILITY OF AMMONIUM BICARBONATE IN AQUEOUS SOLUTIONS OF AMMONIUM CHLORIDE SATURATED WITH $\text{CO}_2$ (Fedotieff, 1904)

t°	den- sity	Per 1000 cc. Solution				Per 1000 Grams $\text{H}_2\text{O}$			
		moles	moles	Gms.	Gms.	moles	moles	Gms.	Gms.
		$\text{NH}_4\text{Cl}$	$\text{NH}_4\text{HCO}_3$	$\text{NH}_4\text{Cl}$	$\text{NH}_4\text{HCO}_3$	$\text{NH}_4\text{Cl}$	$\text{NH}_4\text{HCO}_3$	$\text{NH}_4\text{Cl}$	$\text{NH}_4\text{HCO}_3$
0									
	1.077	4.41	0.37	235.9	29.2	5.42	1.22	0.0	119.0
	1.064	0.0	2.12	0.0	167.2	0.0	0.46	290.8	36.0
15	1.063	0.5	1.84	26.8	145.2	0.56	2.36	0.0	186.4
	1.062	1.0	1.59	53.5	125.5	1.13	2.06	29.9	162.9
	1.062	1.41	1.42	75.4	112.2	1.59	1.80	60.6	142.2
	1.062	1.41	1.42	75.4	112.2	1.59	1.60	85.1	126.9
	1.065	1.89	0.79	100.8	101.1	2.18	1.48	116.8	116.8
	1.069	2.87	0.99	153.3	78.2	3.42	1.18	183.0	93.3
	1.076	3.84	0.79	205.2	62.5	5.03	0.98	269.3	77.3
	1.085	4.82	0.65	257.9	51.4	6.21	0.84	332.5	66.4
	1.085	4.95	0.62	264.8	48.9	6.40	0.81	343.5	64.2
30						0.0	3.42	0.0	270.0
						7.4	1.15	397.0	91.0

### Results of Neumann and Domke, 1928 under 1.2 atm. $\text{CO}_2$

at 20°				at 40°			
Gms. per 1000 cc. sat. sol.		Gms. per 1000 cc. sat. sol.		Gms. per 1000 cc. sat. sol.		Gms. per 1000 cc. sat. sol.	
$\text{NH}_4\text{Cl}$	$\text{NH}_4\text{HCO}_3$	$\text{NH}_4\text{Cl}$	$\text{NH}_4\text{HCO}_3$	$\text{NH}_4\text{Cl}$	$\text{NH}_4\text{HCO}_3$	$\text{NH}_4\text{Cl}$	$\text{NH}_4\text{HCO}_3$
294.2	0.0	315.7	0.0	290.1	85.0	260.1	91.4
288.8	15.7	290.1	85.0	260.1	91.4	210.6	107.4
276.1	55.9	260.1	91.4	210.6	107.4	163.3	125.2
167.2	83.8	210.6	107.4	163.3	125.2	74.5	177.2
93.3	117.9	163.3	125.2	74.5	177.2	24.2	216.9
0.0	183.2	24.2	216.9				

At 15° a solution saturated with  $\text{NH}_4\text{HCO}_3 + \text{NH}_4\text{Cl}$  contains 7.02 gms.  $\text{NH}_4\text{HCO}_3$  and 35.4 gms.  $\text{NH}_4\text{Cl}$  per 100 gms.  $\text{H}_2\text{O}$ . (Fedotieff and Kolossof, 1923.)

### THE SYSTEM $\text{NH}_4\text{HCO}_3 + \text{NaCl} \rightleftharpoons \text{NH}_4\text{Cl} + \text{NaHCO}_3$ (Neumann and Domke, 1928)

The authors mention that few previous studies of the equilibrium in the ammonia-soda process have been made under conditions resembling closely those of the actual manufacturing process. This consists in saturating natural or artificial sodium chloride brine with ammonia and treating this with 30-40 vol. percent  $\text{CO}_2$  under pressure. The authors have therefore made determinations at 20° to 40° and under 1.2 and 2.5 atmospheres pressure of  $\text{CO}_2$  with results which permit the calculation of the yield of sodium and ammonium for each varying composition of the solution. Results for the binary systems involved may be found separately.

THE SYSTEM  $\text{NH}_4\text{HCO}_3 + \text{NaCl} \rightleftharpoons \text{NH}_4\text{Cl} + \text{NaHCO}_3$ --Cont.At 1.2 Atmospheres Pressure of  $\text{CO}_2$ 

t°	Gms. per 1000 cc. sat. sol.			t°	Gms. per 1000 cc. sat. sol.		
	$\text{NaHCO}_3$	$\text{NH}_4\text{Cl}$	$\text{NaCl}$		$\text{NaHCO}_3$	$\text{NH}_4\text{HCO}_3$	$\text{NH}_4\text{Cl}$
20	21.8	213.5	125.7	20	68.1	67.2	109.1
"	25.2	220.4	112.2	"	68.9	68.8	106.5
"	29.4	230.3	93.5	"	62.2	94.1	74.4
30	49.6	271.2	60.8	30	68.9	127.3	95.8
"	31.1	243.4	110.5	"	66.4	136.0	85.6
"	30.4	241.8	112.8	"	65.5	148.6	71.2
"	27.1	231.7	130.4	"	64.7	157.3	63.7

HCO

Solid Phase  $\text{NaHCO}_3 + \text{NH}_4\text{Cl} + \text{NaHCO}_3$  Solid Phase  $\text{NaHCO}_3 + \text{NH}_4\text{Cl} + \text{NaCl}$ 

Gms. per 1000 cc. sat. sol.				Gms. per 1000 cc. sat. sol.			
t°	NaHCO <sub>3</sub>	NH <sub>4</sub> Cl	NaHCO <sub>3</sub>	t°	NaHCO <sub>3</sub>	NH <sub>4</sub> Cl	NaCl
at 1.2 atm. CO <sub>2</sub>							
20	68.8	273.9	17.5	20	14.2	169.0	206.6
30	80.7	301.5	15.8	30	19.3	193.1	192.3
				40	27.7	218.8	178.7

at 2.5 atm.  $\text{CO}_2$ 

20	63.0	268.6	18.7	20	12.6	32.1	196.4
			( $\text{NaCl?}$ )	30	19.3	55.2	181.2
30	83.2	302.8	7.1	40	25.2	78.1	164.9
			( $\text{NaCl?}$ )				

Results of Fedotieff, 1904 in water saturated with  $\text{CO}_2$ 

t°	density	Gram Mols. per 1000 Gms. $\text{H}_2\text{O}$			Gms. per 1000 Gms. $\text{H}_2\text{O}$			Solid Phase
		$\text{NaHCO}_3$	$\text{NaCl}$	$\text{NH}_4\text{Cl}$	$\text{NaHCO}_3$	$\text{NaCl}$	$\text{NH}_4\text{Cl}$	
0	1.114	0.59	0.96	4.92	49.61	56.16	263.4	a + b + c
	1.187	0.12	4.83	2.74	10.09	282.6	146.7	"
15	1.116	0.93	0.51	6.28	78.18	29.84	336.2	"
	1.178	0.18	4.44	3.73	15.13	259.8	199.6	"
	1.151	0.30	3.09	4.56	25.22	180.8	244.1	a + c
	1.128	0.51	1.68	5.45	42.87	98.28	291.7	"
	1.112	0.99	0.35	5.65	83.22	20.47	302.4	a + b
	1.108	1.07	0.20	5.21	89.95	11.70	278.9	"
	1.106	1.12	0.11	4.92	94.14	6.44	263.4	"
	1.101	1.16	0.14	4.00	97.52	8.19	214.1	"
	1.090	0.93	0.95	2.03	78.18	55.58	108.6	"

a =  $\text{NaHCO}_3$ b =  $\text{NH}_4\text{HCO}_3$ c =  $\text{NH}_4\text{Cl}$

# N NITROGEN

## Results of Toporescu, 1922 at 15°

Gms. per 100 gms. H <sub>2</sub> O				Solid Phase
NH <sub>4</sub>	Na	HCO <sub>3</sub>	Cl	
11.2	3.4	5.9	24.5	NH <sub>4</sub> HCO <sub>3</sub> + NaHCO <sub>3</sub> + NH <sub>4</sub> Cl
6.6	10.5	1.2	29.3	NaCl + " + "

## Results at High Pressures

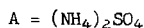
Equilibrium data in the quaternary system NaCl - NH<sub>4</sub>HCO<sub>3</sub> - H<sub>2</sub>O were determined at 30° (10 and 40 atm.), 40° (10, 20, 40, 60 atm.), 50° (40 and 60 atm.), 60° (40 and 60 atm.), and 70° (40, 60, 70 atm.) by Utida, HCO 1940.

## SOLUBILITY OF AMMONIUM BICARBONATE IN AQUEOUS SOLUTIONS OF AMMONIUM NITRATE (Fedotieff and Koltunoff, 1914)

t°	d of Sat. Sol.	Gms. per 100 Gms. H <sub>2</sub> O		t°	d of Sat. Sol.	Gms. per 100 Gms. H <sub>2</sub> O	
		NH <sub>4</sub> NO <sub>2</sub>	NH <sub>4</sub> HCO <sub>3</sub>			NH <sub>4</sub> NO <sub>3</sub>	NH <sub>4</sub> HCO <sub>3</sub>
0		0	11.90	15	1.242	103.4	8.25
0	1.265	118	4.52	15	1.269	128.9	7.79
15	1.064	0	18.64	15	1.302	166.9	7.46
15	1.113	23.26	12.91	30	--	0	26.96
15	1.164	49.82	10.33	30	--	231.9	12.57

## THE SYSTEM AMMONIUM BICARBONATE - AMMONIUM SULFATE - WATER

- 0° - (Belopolski, Shpunt, and Serebrenikova, 1934)  
 7° - (Belopolski and Shpunt, 1935)  
 -5° - (Belopolski and Shpunt, 1935a)  
 15°, 30°, 40° - (Nishizawa, 1920); other data of 15° are given by Wolfkowitzsch, Belokolski and Lebedew, 1931.  
 35° - (Fedotieff and Kolossof, 1923)



Gms. per 100 gms. Sat. Sol.			Solid Phase	Gms. per 100 gms. Sat. Sol.			Solid Phase
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	NH <sub>4</sub> HCO <sub>3</sub>	Density		(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	NH <sub>4</sub> HCO <sub>3</sub>	Density	
Results at -5°				Results at 0°			
15.00	-	-	Ice	41.26	0.28	-	A
40.80	-	-	A	39.93	0.65	-	A
38.22	1.72	1.214	A + B	39.49	0.56	1.234	A
29.41	2.73	-	B	39.05	1.36	-	A
17.93	4.34	-	B	39.30	1.23	-	A
9.86	5.36	-	B	38.38	2.37	1.228	A + B
3.01	6.51	1.041	B + Ice	36.96	2.19	-	B

(Cont.)



# N NITROGEN

THE SYSTEM  $2\text{NH}_4\text{HCO}_3 + \text{Na}_2\text{SO}_4 \rightleftharpoons (\text{NH}_4)_2\text{SO}_4 + 2\text{NaHCO}_3$ ---Cont.

Results of Belopolski and Urussov, 1935 at 32.5°

HCO	Gms. per 100 gms. Sat. Sol.			Solid Phase
	$\text{Na}_2\text{SO}_4$	$(\text{NH}_4)_2\text{CO}_3$	$(\text{NH}_4)_2\text{SO}_4$	
	33.62	0.0	0.0	
	32.64	1.81	0.0	
	31.70	3.52	0.0	
	30.53	5.19	0.0	
	29.80	7.15	0.0	
	28.00	10.44	0.0	
	25.90	14.80	0.0	
	24.57	18.54	0.0	
	24.16	19.21	0.10	$\text{Na}_2\text{SO}_4 + \text{NaHCO}_3$
	23.26	19.24	1.13	"
	22.60	21.25	1.03	"
	21.41	23.80	1.45	"

THE SYSTEM AMMONIUM BICARBONATE - SODIUM BICARBONATE - WATER

Results of Neumann and Domke, 1928 at 1.2 atm.  $\text{CO}_2$

at 20°		at 30°	
Gms. per 1000 cc. sat. sol.		Gms. per 1000 cc. sat. sol.	
$\text{NaHCO}_3$	$\text{NH}_4\text{HCO}_3$	$\text{NaHCO}_3$	$\text{NH}_4\text{HCO}_3$
90.8	0.0	104.2	0.0
68.9	89.4	88.1	64.0
55.4	171.0	64.2	200.3
0.0	183.2	60.7	228.6
		0.0	241.4

Results of Nishizawa, 1920 at 15°, 30°, 40°

t°	Gm. mols. per 1000 gm. mols. $\text{H}_2\text{O}$		Solid Phase
	$\text{NaHCO}_3$	$\text{NH}_4\text{HCO}_3$	
15	12.79	38.92	$\text{NaHCO}_3 + \text{NH}_4\text{HCO}_3$
30	12.38	37.96	" "
40	15.87	70.83	" "

Results of Fedotieff and Kolossof, 1923

$d_{25}$ of Sat. Sol.	Gms. per 100 gms. $\text{H}_2\text{O}$		Solid Phase
	$\text{NaHCO}_3$	$\text{NH}_4\text{HCO}_3$	
	at 15°		
	6.2	19.6	$\text{NH}_4\text{HCO}_3 + \text{NaHCO}_3$

(Cont.)

Results of Fedotieff and Kolossof, 1923--Cont.

d <sub>35</sub> of Sat. Sol.	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
	NaHCO <sub>3</sub>	NH <sub>4</sub> HCO <sub>3</sub>	
	at 35°		
1.11	0.0	31.08	NH <sub>4</sub> HCO <sub>3</sub>
1.16	7.12	29.32	" + NaHCO <sub>3</sub>
1.15	7.38	28.72	NaHCO <sub>3</sub>
1.11	9.51	9.78	"
1.11	10.59	3.99	"
1.08	11.66	0.00	"

NH<sub>4</sub>HCO<sub>3</sub> SOLUBILITY: RESULTS OF FEDOTIEFF IN SOLUTIONS SATURATED WITH CO<sub>2</sub>

t°	density	Per 1000 cc. Solution				Per 1000 Grams H <sub>2</sub> O			
		moles NaHCO <sub>3</sub>	moles NH <sub>4</sub> HCO <sub>3</sub>	Gms. NaHCO <sub>3</sub>	Gms. NH <sub>4</sub> HCO <sub>3</sub>	moles NaHCO <sub>3</sub>	moles NH <sub>4</sub> HCO <sub>3</sub>	Gms. NaHCO <sub>3</sub>	Gms. NH <sub>4</sub> HCO <sub>3</sub>
0	-	-	-	-	-	0.0	1.51	0.0	119.0
0	1.072	0.53	1.28	44.6	101.4	0.58	1.39	48.2	109.4
15	1.064	0.0	2.12	0.0	167.2	0.0	2.36	0.0	186.4
15	1.090	0.63	1.92	52.5	151.3	0.71	2.16	59.2	170.6
30	-	-	-	-	-	0.0	3.42	0.0	270.0
30	-	-	-	-	-	0.83	2.91	70.0	230.0

Results for the system  $\text{NH}_4^+, \text{Na}^+ || \text{HCO}_3^-, \text{OH}^-, \text{SO}_4^{2-} + \text{H}_2\text{O}$  at 35° are given by Urazov, Sedel'nikov and Titova, 1954.

AMMONIUM CARBONATE (NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub>

CO

SOLUBILITY OF AMMONIUM CARBONATE IN AMMONIA SOLUTIONS  
(Guyer, Bieler, and Orelli, 1940)

The results are reported in the form of diagrams only, and the following data were read from the curves:

% NH <sub>3</sub> in Solvent	Gms. (NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub> per 100 gms. Solvent			
	-30°	-10°	0°	20°
10	-	9	22	29.5
20	1	3	15	23
30	1	1.5	10	13.5
40	1	1.5	7.5	9
60	1	1.5	6.5	8
70	1	1.5	7.5	3.5
80	1	1.5	7	0.5
90	1	1.5	4	-

# N NITROGEN

## THE SYSTEM AMMONIUM CARBONATE - AMMONIUM CHLORIDE - WATER (Mondain Monval, 1922)

Results at 0°			Results at 15°		
Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
NH <sub>4</sub> Cl	$\frac{1}{2}(\text{NH}_4)_2\text{CO}_3$		NH <sub>4</sub> Cl	$\frac{1}{2}(\text{NH}_4)_2\text{CO}_3$	
0.00	55.8	(NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub>	10.1	62.0	(NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub>
26.4	56.7	" + NH <sub>4</sub> Cl	14.5	61.2	"
27.2	13.0	NH <sub>4</sub> Cl	31.3	61.0	" + NH <sub>4</sub> Cl
29.2	0.0	"	31.7	17.6	NH <sub>4</sub> Cl

CO

## THE SYSTEM (NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub> + 2NaCl ⇌ 2NH<sub>4</sub>Cl + Na<sub>2</sub>CO<sub>3</sub> (Mondain Monval, 1922)

<u>Results at 0°:</u>				<u>Results at 15°:</u>				Solid Phase at both temperatures
Gms. per 100 gms. H <sub>2</sub> O				Gms. per 100 gms. H <sub>2</sub> O				
Na	NH <sub>4</sub>	Cl	$\frac{1}{2}\text{CO}_3$	Na	NH <sub>4</sub>	Cl	$\frac{1}{2}\text{CO}_3$	
11.0	6.5	27.0	2.5	9.4	7.2	27.8	0.8	NH <sub>4</sub> Cl+NaCl
11.7	10.9	23.1	14.1	13.6	10.8	30.2	10.2	" + " +Na <sub>2</sub> CO <sub>3</sub>
14.6	1.7	21.1	4.2	13.3	6.0	23.3	7.7	NaCl+Na <sub>2</sub> CO <sub>3</sub>
9.7	11.0	21.7	12.6	12.7	14.3	28.2	16.6	NH <sub>4</sub> Cl+ "
9.2	38.4	22.6	56.6	18.5	39.4	38.5	57.2	" + " +(NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub>
6.2	34.8	19.9	49.4	10.3	35.4	31.2	46.0	" +(NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub>
1.8	31.1	17.5	39.3	2.3	31.7	21.4	37.7	" + "
6.8	24.5	4.8	45.4	10.9	38.8	21.4	60.8	NaCO <sub>3</sub> + "
2.3	10.1	19.9	31.1	4.1	12.0	23.7	5.4	NH <sub>4</sub> Cl
7.0	6.4	12.6	9.1	10.6	10.7	21.7	13.8	NaCO <sub>3</sub>
7.1	4.2	8.3	9.3	7.9	2.3	4.6	10.3	"
3.5	1.5	3.0	4.5	-	-	-	-	"

## THE SYSTEM AMMONIUM CARBONATE - SODIUM CARBONATE - WATER (Mondain Monval, 1922)

Results at 0°			Results at 15°		
Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
$\frac{1}{2}\text{Na}_2\text{CO}_3$	$\frac{1}{2}(\text{NH}_4)_2\text{CO}_3$		$\frac{1}{2}\text{Na}_2\text{CO}_3$	$\frac{1}{2}(\text{NH}_4)_2\text{CO}_3$	
18.0	64.2	(NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub> +Na <sub>2</sub> CO <sub>3</sub>	4.3	59.2	(NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub>
10.3	12.9	Na <sub>2</sub> CO <sub>3</sub>	15.9	65.2	" + Na <sub>2</sub> CO <sub>3</sub>
6.9	0.5	"	27.6	16.3	"
7.1	0.0	"	27.6	16.5	"

## SOLUBILITY OF AMMONIUM CARBONATE IN ORGANIC SOLVENTS

Solvent	t°	Solubility
Ethyl Alcohol, U.S.P.	25	2.12 gms $(\text{NH}_4)_2\text{CO}_3$ per 100 cc sat. sol. (E'we, 1920)
Glycerol	15	20.00 gms $(\text{NH}_4)_2\text{CO}_3$ per 100 gms solvent (Ossendowski, 1907)
Furfural	25	1.7 gms $(\text{NH}_4)_2\text{CO}_3 \cdot \text{H}_2\text{O}$ per 100 gms sat. sol. (Trimble, 1941)

AMMONIUM URANYL CARBONATE  $2(\text{NH}_4)_2\text{CO}_3 \cdot \text{UO}_2\text{CO}_3$ 

CO

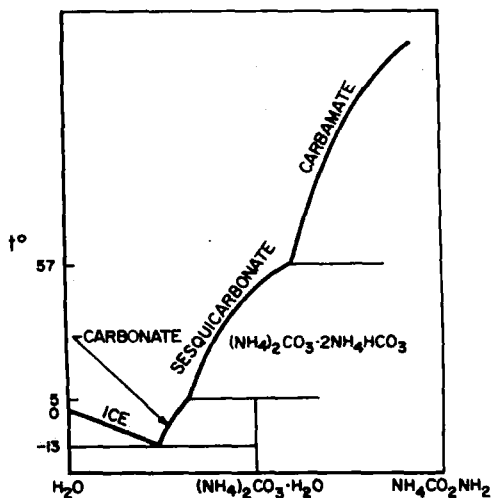
100 grams  $\text{H}_2\text{O}$  dissolve 5 grams of the salt at 15°. (Ebelmen.)

AMMONIUM CARBAMATE  $\text{NH}_4\text{CO}_2\text{NH}_2$ 

CON

## SOLUBILITY IN WATER

The equilibrium relations in the system  $\text{NH}_4\text{CO}_2\text{NH}_2 - \text{H}_2\text{O}$  were determined as part of the system  $\text{NH}_3 - \text{CO}_2 - \text{H}_2\text{O}$  by Jänecke, 1929a (see p. 638).  $\text{NH}_4\text{CO}_2\text{NH}_2$  is stable in contact with water only above 57°. Between 57° and 5° decomposition to the sesquicarbonate occurs, and from 5° to -13° (eutectic) to the carbonate. The diagram below is given by Jänecke.



The System Ammonium Carbamate - Water



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### THE SYSTEM AMMONIUM CARBAMATE - AMMONIUM SULFATE - AMMONIA - WATER (Schutze and Piechowicz, 1943)

t°	Moles per 1000 moles of water			Solid Phase
	$\text{NH}_4\text{CO}_2\text{NH}_2$	$(\text{NH}_4)_2\text{SO}_4$	$\text{NH}_3$	
20	234	-	400	$\text{NH}_4\text{CONH}_2$
	230	29	400	$\text{NH}_4\text{CO}_2\text{NH}_2 + (\text{NH}_4)_2\text{SO}_4$
	-	15.3	498	$(\text{NH}_4)_2\text{SO}_4$
30	283	-	285	$\text{NH}_4\text{CO}_2\text{NH}_2$
	279	35	285	$\text{NH}_4\text{CO}_2\text{NH}_2 + (\text{NH}_4)_2\text{SO}_4$
	-	41.3	331	$(\text{NH}_4)_2\text{SO}_4$
40	331	-	187	$\text{NH}_4\text{CO}_2\text{NH}_2$
	325	40	187	$\text{NH}_4\text{CO}_2\text{NH}_2 + (\text{NH}_4)_2\text{SO}_4$
	-	64.0	214	$(\text{NH}_4)_2\text{SO}_4$
50	382	-	100	$\text{NH}_4\text{CO}_2\text{NH}_2$
	375	45	100	$\text{NH}_4\text{CO}_2\text{NH}_2 + (\text{NH}_4)_2\text{SO}_4$
	-	83.8	138	$(\text{NH}_4)_2\text{SO}_4$
60	-	100.7	88	"
70	-	114.6	54	"
80	-	125.7	33	"

### CO AMMONIUM OXALATE $(\text{NH}_4)_2\text{C}_2\text{O}_4$

#### SOLUBILITY OF AMMONIUM OXALATE IN WATER (Hill and Distler, 1935; above 100°; Benrath, 1942)

The solid phase is  $(\text{NH}_4)_2\text{C}_2\text{O}_4 \cdot \text{H}_2\text{O}$  in all cases. The results in parentheses are densities of the saturated solution determined by Flottmann, 1928. In addition to the above very careful determinations, results for the solubility of ammonium oxalate in water at temperatures up to 50° are also given by Engel, 1888; Foote and Andrew, 1905; Wandstra, 1912; Colani, 1916; Koenig, 1922 and Guigues, 1927.

t°	Gms. $(\text{NH}_4)_2\text{C}_2\text{O}_4$ per 100 gms. sat. sol.	t°	Gms. $(\text{NH}_4)_2\text{C}_2\text{O}_4$ 100 gms. sat. sol.
0	2.314	90	21.84
10	(1.0169) 3.112	100	25.73
20	(1.0169) 4.259	114	30
25	(1.0188) 4.953	130	35
30	5.738	144	40
40	7.565	157	45
50	9.735	171	50
60	12.25	186	55
70	15.10	195	60
80	18.30		

SOLUBILITY OF AMMONIUM OXALATE IN AQUEOUS SOLUTIONS OF OXALIC ACID  
(Woudstra, 1912)

Results at 30°. (Interpolated from Original.)

Gms. per 100 Gms. Sat. Sol.

$(\text{COONH}_4)_2$	$(\text{COOH})_2$	Solid Phase
0.14	12.36	A
0.28	12.78	A + T
0.30	12	T
0.39	10	"
0.47	8	"
0.52	7	"
0.68	6	"
1	5	"
2	3.96	"
3	3.61	"
4	3.60	"
5	3.81	"
5.98	4.21	T + A.O.
7	3.63	A.O.
8.19	3.36	A.O. + N.O.
7	2.32	N.O.
6	1.02	"
5.53	0.22	"

CO

Results at 45°

0.22	21.22	A
0.31	21.31	"
0.53	20.54	A + T
0.56	21.23	T
0.61	20.55	"
0.54	20.92	"
0.79	16.44	"
1.23	12.88	"
7.16	7.98	"
3.54	5.83	"
5.65	5.67	"
6.72	5.95	"
8.74	6.53	T + A.O.
8.93	6.27	A.O.
9.04	6.14	"
12.38	5	A.O. + N.O.
8.31	3.04	N.O.
9.59	1.45	"

A. = Oxalic Acid  $(\text{COOH})_2 \cdot \text{H}_2\text{O}$ .

A.O. = Acid Ammonium Oxalate  $(\text{COO})_2\text{HNH}_4 \cdot \text{H}_2\text{O}$

T = Ammonium tetroxalate  $(\text{COOH})_2(\text{COO})_2\text{HNH}_4 \cdot \text{H}_2\text{O}$ .

N.O. = Neutral Ammonium Oxalate  $(\text{COONH}_4)_2 \cdot \text{H}_2\text{O}$ .

Additional data for this system at 25° are given by Walden (1905), and at 0°, by Engel (1888).

100 gms. 95% formic acid dissolve 6.2 gms.  $(\text{NH}_4)_2\text{C}_2\text{O}_4$  at 21°. (Aschan, 1913.)

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## SIMULTANEOUS SOLUBILITY OF MIXTURES OF AMMONIUM OXALATE WITH OTHER SALTS

Both salts in excess in every case. No double salts formed.

Other Oxalates at 25° (Foote and Andrew, 1905)			Other Ammonium Salts (Colani, 1916)		
Gms. per 100 Gms. Sat. Solution	t°		Gms. per 100 Gms Sat. Solution	t°	
2.79 (COONH <sub>4</sub> ) <sub>2</sub> H <sub>2</sub> O+25.96 (COOK) <sub>2</sub> H <sub>2</sub> O	15		0.14 (COONH <sub>4</sub> ) <sub>2</sub> +26.35NH <sub>4</sub> Cl		
4.8 " + 5.75 (COOLi) <sub>2</sub>	50		0.67 " +32.55 "		
5.45 " +0.59 (COO) <sub>2</sub> Mg2H <sub>2</sub> O	18		0.11 " +42.43 (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>		
6.19 " +1.45 (COO) <sub>2</sub> Zn2H <sub>2</sub> O	50		0.05 " +45.92 "		
5.06 " +0.28 (COO) <sub>2</sub> Cd <sub>3</sub> H <sub>2</sub> O	19		0.085 " +62.26NH <sub>4</sub> NO <sub>3</sub>		
	50		0.35 " +72.11 "		

CO

## THE SYSTEM AMMONIUM OXALATE-SODIUM OXALATE-WATER (Rivett and O'Conner, 1919)

Results at 25°

d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	
1.028	0.89	4.88	(NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O
1.035	1.82	4.81	"
1.043	2.85	4.75	"
1.047	3.41	4.74	" + Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>
1.043	3.46	3.77	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>
1.039	3.51	2.89	"
1.037	3.51	2.48	"
1.033	3.65	1.49	"
1.030	3.63	0.74	"
1.027	3.73	0.00	"

Results at 50°

d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	
1.042	1.25	9.46	(NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O
1.051	2.45	9.32	"
1.059	3.57	9.21	"
1.063	4.05	9.19	" + Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>
1.056	4.13	7.86	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>
1.049	4.29	6.12	"
1.044	4.28	4.64	"
1.036	4.37	3.14	"
1.031	4.46	1.59	"
1.023	4.54	0.00	"

THE SYSTEM AMMONIUM OXALATE - THORIUM OXALATE - WATER AT 25°  
(James, Whitemore and Holden, 1914)

The mixtures were constantly agitated for periods varying from many weeks to several months.

Gms. per 100 Gms. H <sub>2</sub> O			Gms. per 100 Gms. H <sub>2</sub> O		
(NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	Th(C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub>	Solid Phase	(NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	Th(C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub>	Solid Phase
5.25	0	(NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	29.47	39.10	2.1.7+2.1.2
6.04	1.54	"	23.04	29.87	2.1.2
7.78	4.51	"	16.84	21.18	"
10.37	8.87	"	13.27	15.96	"
15.46	16.89	"	8.13	9.13	"
21.47	26.37	"	5.36	5.63	"
28.18	36.54	" + 2.1.7	1.70	1.42	"

2.1.7 = 2Th(C<sub>2</sub>O<sub>4</sub>)<sub>2</sub> · (NH<sub>4</sub>)<sub>2</sub>C<sub>2</sub>O<sub>4</sub> · 7H<sub>2</sub>O; 2.1.2 = 2Th(C<sub>2</sub>O<sub>4</sub>)<sub>2</sub> · (NH<sub>4</sub>)<sub>2</sub>C<sub>2</sub>O<sub>4</sub> · 2H<sub>2</sub>O.

THE SYSTEM AMMONIUM OXALATE - ZIRCONIUM OXALATE - WATER  
(Boulanger, 1936)

Results at 19°		Results at 39°		Solid Phase at each Temp.
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
(NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	ZrOC <sub>2</sub> O <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	ZrOC <sub>2</sub> O <sub>4</sub>	
4.33	0.0	6.95	0.0	(NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub> · H <sub>2</sub> O
4.72	0.52	6.90	1.26	"
5.25	0.82	6.84	1.35	"
5.39	0.96	6.60	1.40	(?)
5.70	1.30	6.20	1.70	(?)
6.05	1.74	6.15	1.97	2(NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub> · ZrC <sub>2</sub> O <sub>4</sub> · H <sub>2</sub> C <sub>2</sub> O <sub>4</sub> · 2H <sub>2</sub> O(?)
5.53	1.34	5.46	1.80	"
5.10	1.25	4.91	1.76	"
4.43	1.21	4.61	1.60	"
3.05	0.8	3.95	1.45	"

Unfilterable gels

SOLUBILITY OF AMMONIUM OXALATE IN AQUEOUS SOLUTIONS OF ACETONE AT 17.6°  
(Hartley, 1931)

Mol. (CH <sub>3</sub> ) <sub>2</sub> CO per 1.0 mol. (CH <sub>3</sub> ) <sub>2</sub> CO + H <sub>2</sub> O	Mol. NH <sub>4</sub> C <sub>2</sub> O <sub>4</sub> per 1.0 mol. sat. sol.
0.0000	0.00604
0.0136	0.00488
0.0273	0.00395
0.0344	0.00352
0.0544	0.00261
0.0668	0.00219

100 cc. anhydrous hydrazine dissolve 44 gms. (NH<sub>4</sub>)<sub>2</sub>C<sub>2</sub>O<sub>4</sub> at room temp. with evolution of ammonia. (Welsh and Broderson, 1915)

# N NITROGEN

## CO AMMONIUM IRON OXALATES

SOLUBILITY OF EACH SEPARATELY IN METHYL ALCOHOL  
(Henstock, 1934)

Salt	Formula	t°	Gms. salt per 100 gms. CH <sub>3</sub> OH
Ammonium Ferrous Oxalate	(NH <sub>4</sub> ) <sub>2</sub> Fe(C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub>	15	0.47
" "	" "	66(b.pt.)	0.78
" Ferric "	(NH <sub>4</sub> ) <sub>3</sub> Fe(C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub>	15	0.42
" "	" "	66(b.pt.)	0.72

## CI AMMONIUM CHLORIDE NH<sub>4</sub>Cl

SOLUBILITY IN WATER

(Mulder, 1864; below 0°, Meerbert, 1903; for the ice curve, Rodebush, 1918; above 120°, Benrath, Gjeddebo, Schiffers and Wunderlich, 1937)

More recent results in excellent agreement with these are given by Polosin, 1946; Alexandrov, 1941; Gerassimow, 1930; Benrath, 1927; Aronowa and Lunskaia, 1931; Klein and Svanberg, 1920; etc. Data for the solubility of ammonium chloride in water at 0° under pressures up to 500 atmospheres are given by Stackelberg, 1896.

N = NH <sub>4</sub> Cl				I = Ice			
Gms. NH <sub>4</sub> Cl per 100 gms.				Gms. NH <sub>4</sub> Cl per 100 gms.			
t°	Sat. Sol.	H <sub>2</sub> O	Solid	t°	Sat. Sol.	H <sub>2</sub> O	Solid
- 5.73	8.49	9.28	I	50	33.5	50.4	N
- 7.63	10.92	12.27	I	60	35.6	55.2	N
- 8.60	12.09	13.76	I	70	37.6	60.2	N
-10.58	14.45	16.89	I	80	39.6	65.6	N
-11.80	15.85	18.80	I	90	41.6	71.3	N
-12.60	16.60	19.93	I	100	43.6	77.3	N
-14.03	18.3	22.40	I	110	45.6	83.8	N
-15.10	19.4	23.13	I	115.6	46.6	87.3	N
-15.36	19.7	24.5	N+I	120	48.0	92.3	N
-15	19.7	24.5	N	140	50.7	102.8	N
-10.9	20.3	25.5	N	160	54.0	117.4	N
- 5.7	21.7	27.7	N	180	57.3	134.1	N
0	22.7	29.4	N	200	60.5	153.3	N
+ 5	23.8	31.2	N	225	64.5	181.7	N
10	24.9	33.3	N	250	68.0	212.5	N
15	26.0	35.2	N	275	71.5	251	N
20	27.1	37.2	N	300	75.3	305	N
25	28.2	39.3	N	350	82.2	462	N
30	29.3	41.4	N	400	89.0	809	N
40	31.4	45.8	N				

## SOLUBILITY OF AMMONIUM CHLORIDE IN HYDROCHLORIC ACID SOLUTIONS

## Results at 0°

(Engel, 1888; Seidel and Fischer, 1941)

(Figures in parentheses are densities)

Gms. per 100 gms Sat. Sol.		Gms. per 100 gms. Sat. Sol.		Gms. per 100 Gms. Sat. Sol.	
HCl	NH <sub>4</sub> Cl	HCl	NH <sub>4</sub> Cl	HCl	NH <sub>4</sub> Cl
0.0	22.9 (1.076)	17.33	5.23E(1.106)	33.8	2.01
0.98	21.7 E(1.069)	19.82	4.19E(1.114)	36.8	2.24
1.86	20.33E(1.070)	20.7	3.61	37.3	2.32
3.66	18.02E(1.073)	23.0	2.81	39.7	2.55
7.18	13.50E(1.078)	27.3	2.21	42.4	3.15
13.2	8.02	32.3	2.00	44.8	4.17
16.9	5.37				

Cl

## Results at 25°

(Armstrong and Eyré, 1910-11)

Additional data at 25° are given by Berecz, 1958.

Gms. HCl per 100 Gms. H <sub>2</sub> O	d <sub>25</sub> <sup>25</sup> Sat. Sol.	Gms. NH <sub>4</sub> Cl per 100 Gms. Sat. Sol.
0	1.080	28.3
0.91	1.079	27.4
1.82	1.082	26.4
3.65	1.083	24.6
18.25	1.099	11.3

## COMPARATIVE RESULTS AT SEVERAL TEMPERATURES

(Morozov and Ustavshikova, 1944, 1945)

The data were read from curves drawn by the authors.

Gms. HCl per 100 gms. Sat. Sol.	Gms. NH <sub>4</sub> Cl per 100 gms. Sat. Sol.				
	0°	25°	50°	80°	100°
5	16	20	26.5	31.5	36
10	11	14	20.5	25	31
15	7.5	10.5	14.5	21	25
20	5.5	7.5	11	16.5	21.35*
27.5	-	-	-	11.52*	
30	3	4.5	7		
35	-	-	6.28*		
39.5	-	4.34*			
43.5	3.0*				

\*Indicates the gms. NH<sub>4</sub>Cl in a solution saturated with NH<sub>4</sub>Cl and HCl, as given by the authors.Data for the solubility of NH<sub>4</sub>Cl in water saturated with CO<sub>2</sub> from 30° to 30° to 70° and from 10 to 70 atm. pressure is given by Utida, 1940.Data for the reciprocal system  $2\text{NH}_4\text{Cl} + \text{H}_2\text{SO}_4 \rightleftharpoons (\text{NH}_4)_2\text{SO}_4 + 2\text{HCl}$  in water at 25° is given by Blumberg and Zdanovskii, 1939.Data for the system  $\text{NH}_4\text{Cl} + \text{As}_2\text{O}_3 + \text{H}_2\text{O}$  at 30° are given by Schreinemakers and de Baat, 1915.

# N NITROGEN

## SOLUBILITY OF AMMONIUM CHLORIDE IN AQUEOUS AMMONIA SOLUTIONS (Alexandrov, 1941; also see tables following)

Gms. NH <sub>3</sub> per 100 gms. H <sub>2</sub> O in Sat. Sol.	Gms. NH <sub>4</sub> Cl per 100 gms. H <sub>2</sub> O							
	-20°	-10°	0°	10°	20°	30°	40°	50°
0	-	25.9	29.6	33.0	37.4	41.5	45.8	50.4
10	24.5	27.9	32.0	36.0	40.0	44.1	48.3	53.2
20	28.1	31.6	35.9	39.8	43.7	47.8	52.4	57.2
25	30.4	33.9	38.6	42.0	45.5	50.2	55.0	-
30	32.6	36.5	41.0	44.5	48.4	53.0	58.2	-
40	38.0	41.9	46.5	50.7	55.6	60.8	66.5	-

Cl

### Results at 0° (Engel, 1891)

Sp. Gr. of Solution	Gms. per 100 cc. Solution		Sp. Gr. of Solution	Gms. per 100 cc. Solution	
	NH <sub>4</sub> OH	NH <sub>4</sub> Cl		NH <sub>4</sub> OH	NH <sub>4</sub> Cl
1.067	0.92	24.52	0.993	13.66	23.09
1.054	2.05	24.35	0.992	15.36	23.56
1.031	6.48	23.82	0.983	16.29	23.75
1.025	8.02	23.56	0.953	22.18	26.63
1.017	9.30	23.35	0.931	28.97	32.14

### At 17.5° (Stromholm, 1908)

Gms. per 1000 cc. Solution	
NH <sub>3</sub>	NH <sub>4</sub> Cl
0	290.8
2.55	290.0
81.0	271.9

### At 25° (Hill and Loucks, 1937)

Gms. per 100 gms. Sat. Sol.		Saturating Phases
NH <sub>3</sub>	NH <sub>4</sub> Cl	
19.16	35.59	NH <sub>4</sub> Cl + NH <sub>3</sub>

## SOLUBILITY OF AMMONIUM CHLORIDE IN AQUEOUS AMMONIUM BICARBONATE SOLUTIONS SATURATED WITH CO<sub>2</sub> (Fedotieff, 1904)

t°	Wt of 1 cc. Sol.	Per 1000 cc. Solution				Per 1000 Gms. H <sub>2</sub> O			
		Moles NH <sub>4</sub> HCO <sub>3</sub>	Moles NH <sub>4</sub> Cl	Gms. NH <sub>4</sub> HCO <sub>3</sub>	Gms. NH <sub>4</sub> Cl	Moles NH <sub>4</sub> HCO <sub>3</sub>	Moles NH <sub>4</sub> Cl	Gms. NH <sub>4</sub> HCl	Gms. NH <sub>4</sub> Cl
0	1.069	0.0	4.60	0.0	246.1	0.0	5.57	0.0	298.0
0	1.077	0.37	4.41	29.2	235.9	0.46	5.42	36.0	290.8
15	1.077	0.0	5.29	0.0	283.1	0.0	6.64	0.0	355.0
15	1.085	0.62	4.95	48.9	264.8	0.81	6.40	64.2	343.5
30	...	...	...	...	...	0.0	7.78	0.0	416.4
30	...	...	...	...	...	1.15	7.40	91.0	397.0

THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM DICHROMATE - WATER  
(Gerassimow, 1930)

t°	Gms. per 100 gms. sat. sol.		Solid Phase
	$(\text{NH}_4)_2\text{Cr}_2\text{O}_7$	$\text{NH}_4\text{Cl}$	
0	0.0	22.9	$\text{NH}_4\text{Cl}$
"	0.948	24.42	" + $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$
"	3.58	15.52	$(\text{NH}_4)_2\text{Cr}_2\text{O}_7$
"	15.37	0.0	"
19.8	1.940	26.69	$\text{NH}_4\text{Cl}$
"	1.964	26.60	" + $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$
"	7.489	17.31	$(\text{NH}_4)_2\text{Cr}_2\text{O}_7$
"	8.687	15.10	"
"	14.362	8.414	"
"	19.54	4.219	"
"	26.23	0.0	"
50	0.0	33.5	$\text{NH}_4\text{Cl}$
"	5.771	31.22	" + $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$
"	25.13	11.96	$(\text{NH}_4)_2\text{Cr}_2\text{O}_7$
"	32.06	6.46	"
"	42.03	0.0	"
75	0.0	38.64	$\text{NH}_4\text{Cl}$
"	1.619	37.43	"
"	2.984	36.84	"
"	11.406	33.17	" + $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$
"	17.21	25.77	$(\text{NH}_4)_2\text{Cr}_2\text{O}_7$
"	31.45	16.68	"
"	39.84	9.41	"
"	47.36	2.59	"
"	52.13	0.0	"

Cl

THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM FLUOSILICATE - WATER AT 25°  
(Ricci and Skarulis, 1951)

Sat. Sol. wt %		Solid Phase	Sat. Sol. wt %		Solid Phase
$\text{NH}_4\text{Cl}$	$(\text{NH}_4)_2\text{SiF}_6$		$\text{NH}_4\text{Cl}$	$(\text{NH}_4)_2\text{SiF}_6$	
27.97	0.78	$\text{NH}_4\text{Cl}$	26.17	3.00	$(\text{NH}_4)_2\text{SiF}_6$
27.81	1.47	"	19.73	4.32	"
27.52	2.21	"	13.73	6.30	"
27.39	2.63	" + $(\text{NH}_4)_2\text{SiF}_6$	7.36	10.21	"

THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM FLUORIDE - WATER AT 25°  
(Ricci and Skarulis, 1951)

Sat. Sol. wt %		Solid Phase	Sat. Sol. wt %		Solid Phase
$\text{NH}_4\text{F}$	$\text{NH}_4\text{Cl}$		$\text{NH}_4\text{F}$	$\text{NH}_4\text{Cl}$	
45.12	0.0	$\text{NH}_4\text{F}$	38.18	13.61	$\text{NH}_4\text{Cl}$
42.73	5.36	"	30.94	15.43	"
40.42	10.32	"	19.62	19.16	"
38.97	13.48	$\text{NH}_4\text{F} + \text{NH}_4\text{Cl}$	10.30	23.14	"
			0.0	28.37	"



# N NITROGEN

## THE SYSTEM $\text{NH}_4\text{Cl} - \text{NH}_4\text{F} - (\text{NH}_4)_2\text{SiF}_6 - \text{H}_2\text{O}$ AT $25^\circ$ (Ricci and Skarulis, 1951)

	Sat. Sol. wt %			Solid Phases	Sat. Sol. wt %			Solid Phases
	$\text{NH}_4\text{F}$	$\text{NH}_4\text{Cl}$	$(\text{NH}_4)_2\text{SiF}_6$		$\text{NH}_4\text{F}$	$\text{NH}_4\text{Cl}$	$(\text{NH}_4)_2\text{SiF}_6$	
C1	18.06	5.66	6.19	C+D	41.32	6.85	1.24	A+D
	17.17	10.97	4.46	C+D	38.58	13.34	1.07	A+B+D
	16.33	15.77	3.39	C+D	38.52	13.40	1.07	A+B+D
	4.88	24.67	3.12	B+C	45.12	-	-	A
	(11.9?)	21.15	(3.5?)	B+C	38.97	13.48	-	A+B
	13.13	20.88	3.19	B+C	-	28.37	-	B
	14.06	20.55	2.98	B+C	-	27.39	2.63	B+C
	15.47	19.92	2.73	B+C+D	-	-	18.75	C
	15.43	19.96	2.73	B+C+D	20.13	-	8.18	C+D
	15.69	19.88	2.73	B+C+D	44.64	-	1.54	D+A
	17.41	19.34	2.44	B+D	15.53	19.92	2.73	B+C+D
	34.30	14.16	1.20	B+D	38.55	13.37	1.07	A+B+D
	42.90	3.58	1.37	A+D				

A =  $\text{NH}_4\text{F}$       B =  $\text{NH}_4\text{Cl}$       C =  $(\text{NH}_4)_2\text{SiF}_6$       D =  $\text{NH}_4\text{F} \cdot (\text{NH}_4)_2\text{SiF}_6$

## THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM BIFLUORIDE - WATER AT $25^\circ$ (Zhdanov, 1956)

Sat. Sol. wt %				Sat. Sol. wt %			
$\text{NH}_4\text{HF}_2$	$\text{NH}_4\text{Cl}$	density	Solid Phase	$\text{NH}_4\text{HF}_2$	$\text{NH}_4\text{Cl}$	density	Solid Phase
43.73	0.0	1.1273	$\text{NH}_4\text{HF}_2$	13.84	21.89	1.0647	$\text{NH}_4\text{Cl}$
40.65	4.52	1.1281	"	8.67	24.41	1.0487	"
36.75	10.51	1.1296	" + $\text{NH}_4\text{Cl}$	5.87	25.56	1.0388	"
34.31	12.17	1.1243	$\text{NH}_4\text{Cl}$	3.96	26.68	1.0291	"
21.74	18.90	1.0919	"	4.11	26.63	1.0292	"
21.22	19.05	1.0868	"	0.0	28.30	1.0761	"

## THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM IODIDE - WATER AT $25^\circ$ (Zhdanov, 1947)

Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
$\text{NH}_4\text{I}$	$\text{NH}_4\text{Cl}$		$\text{NH}_4\text{I}$	$\text{NH}_4\text{Cl}$		$\text{NH}_4\text{I}$	$\text{NH}_4\text{Cl}$	
0.0	28.20	C	24.82	17.88	C	37.65	13.42	C
3.88	26.25	C	25.56	17.46	C	39.68	12.84	C
6.31	25.29	C	28.14	16.51	C	40.21	12.71	C
7.93	24.58	C	29.91	16.10	C	44.68	10.98	C
10.60	23.85	C	31.14	15.39	C	47.83	9.75	C
14.41	22.22	C	33.85	14.76	C	51.07	8.66	C
17.11	20.84	C	34.52	14.35	C	54.43	7.74	C+I
18.94	20.52	C	36.55	13.42	C	56.10	7.30	C+I
22.37	19.06	C	37.25	13.36	C	56.10	7.30	C+I
						63.86	0.0	I

C =  $\text{NH}_4\text{Cl}$       I =  $\text{NH}_4\text{I}$

THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM NITRATE - WATER  
(See also the data of Jänecke in the table following)

N =  $\text{NH}_4\text{NO}_3$ Cl =  $\text{NH}_4\text{Cl}$ Results of Pavlov, Bulovich, and  
Bergman, 1943Results of Prutton,  
Broscheer and Maron, 1935

Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.		
$\text{NH}_4\text{Cl}$ $\text{NH}_4\text{NO}_3$		Solid Phase	$\text{NH}_4\text{Cl}$ $\text{NH}_4\text{NO}_3$		Solid Phase	$\text{NH}_4\text{Cl}$ $\text{NH}_4\text{NO}_3$		Solid Phase
Results at $-20^\circ$			Results at $0^\circ$			Results at $0.4^\circ$		
14.4	16.4	Cl+Ice	23.0	0	Cl	23.09	0.0	Cl
11.2	23.6	Ice	20.4	8.0	"	20.58	8.01	"
7.6	31.6	"	19.4	11.2	"	18.39	15.52	"
6.2	34.4	N+Ice	18.2	15.4	"	15.81	24.39	"
10.2	30.6	N	16.2	22.2	"	13.51	32.71	"
11.2	29.6	Cl+N	14.0	29.4	"	11.75	39.44	"
13.0	21.2	Cl	12.6	35.0	"	10.39	54.59	Cl+N
			10.4	38.4	Cl+N	6.35	47.90	N
						3.39	50.53	"
						0.0	54.26	"
Results at $-15^\circ$			Results at $10^\circ$			Results at $25^\circ$		
18.9	0	Ice	25.2	0	Cl	28.33	0.0	Cl
13.8	8.4	"	23.6	7.8	"	25.21	9.14	"
12.2	12.0	"	21.4	10.8	"	21.81	19.05	"
16.6	10.0	"	18.2	15.4	"	18.20	29.57	"
6.0	25.0	"	16.0	22.4	"	13.60	44.50	"
2.2	33.4	"	14.2	29.4	"	11.08	53.49	"
0	38.6	"	12.6	35.0	"	9.36	60.37	N+Cl
			11.0	45.0	"	5.58	62.24	N
Results at $-10^\circ$			Results at $20^\circ$			3.82	64.73	"
13.8	0	Ice	27.5	0	Cl	0.0	67.73	"
8.2	9.2	"	24.5	7.8	"	Results at $50^\circ$		
6.6	13.0	"	23.8	10.6	"	33.50	0.0	Cl
4.0	16.2	"	22.4	14.4	"	29.36	11.22	"
0	26.2	"	20.0	21.2	"	26.20	18.99	"
0	48.5	N	19.4	28.0	"	22.24	29.54	"
10.4	48.8	N+Cl	15.8	33.8	"	14.27	53.03	"
11.4	35.6	Cl	13.0	44.0	"	12.98	56.54	"
12.8	29.8	"	9.8	56.9	"	9.24	70.77	Cl+N
14.2	22.8	"	9.6	57.4 <sup>a</sup>	Cl+N	7.08	72.09	N
16.2	15.8	"	Results at $30^\circ$			3.90	74.07	"
17.0	11.4	"				0.0	77.39	"
18.4	8.0	"				Results at $100^\circ$		
19.0	0	"	29.6	0	Cl	8.12	83.53 <sup>b</sup>	Cl+N
			26.4	7.4	"			
			25.2	10.4	"			
			23.8	14.0	"			
			21.6	20.5	"			
			19.4	27.4	"			
			17.6	31.2	"			
			14.2	41.4	"			
			11.0	55.4	"			
Results at $-5^\circ$								
7.5	0	Ice						
1.6	9.9	"						
0	13	N						

<sup>a</sup>Rudorff<sup>b</sup>Wurmser, 1922

# N NITROGEN

## THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM NITRATE - WATER--Cont.

Results of Janecke, 1928

The results are given in terms of the Janecke method of expressing such results, and the author found that the solid phases in contact with solutions containing the two salts, were composed of the salts and mixed crystals varying in content of  $\text{NH}_4\text{Cl}$  from 2 to 4 mols. per 100 mols.

t°	Mol. % $\text{NH}_4\text{Cl}$ in dissolved salt mixture	Mols. $\text{H}_2\text{O}$ to dissolve 100 mols. salt mixture	Solid Phase
0	100	1000	$\text{NH}_4\text{Cl}$
"	80	790	"
"	60	620	"
"	40	450	"
Cl	22	310	" + $\text{NH}_4\text{NO}_3$
"	20	300	$\text{NH}_4\text{NO}_3$
"	0	340	"
20	100	800	$\text{NH}_4\text{Cl}$
"	80	650	"
"	60	500	"
"	40	350	"
"	23	200	" + $\text{NH}_4\text{NO}_3$
"	20	190	$\text{NH}_4\text{NO}_3$
"	0	210	"
40	100	650	$\text{NH}_4\text{Cl}$
"	80	530	"
"	60	410	"
"	40	280	"
"	20	280	"
"	19	140	" + $\text{NH}_4\text{NO}_3$
"	0	150	$\text{NH}_4\text{NO}_3$
60	100	540	$\text{NH}_4\text{Cl}$
"	80	420	"
"	60	320	"
"	40	220	"
"	20	100	"
"	18	95	" + $\text{NH}_4\text{NO}_3$
"	0	105	$\text{NH}_4\text{NO}_3$
80	100	450	$\text{NH}_4\text{Cl}$
"	17.5	60	" + $\text{NH}_4\text{NO}_3$
"	0.0	70	$\text{NH}_4\text{NO}_3$
100	100	390	$\text{NH}_4\text{Cl}$
"	17	35	" + $\text{NH}_4\text{NO}_3$
"	0	50	$\text{NH}_4\text{NO}_3$
184	100	200	$\text{NH}_4\text{Cl}$
169	0	0	$\text{NH}_4\text{NO}_3$

## THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM NITRATE - AQUEOUS AMMONIA (Alexandrov, 1946)

Gms. per 100 gms. H <sub>2</sub> O			Density	Solid Phase
NH <sub>3</sub>	NH <sub>4</sub> Cl	NH <sub>4</sub> NO <sub>3</sub>		
Results at -10°				
10.0	27.9	0.0	1.027	NH <sub>4</sub> Cl
10.0	22.0	78.0	1.176	NH <sub>4</sub> Cl + NH <sub>4</sub> NO <sub>3</sub>
10.0	0.0	96.0	1.197	NH <sub>4</sub> NO <sub>3</sub>

(Cont.)

THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM NITRATE -  
AQUEOUS AMMONIA--Cont.

Gms. per 100 gms. H <sub>2</sub> O			Density	Solid Phase
NH <sub>3</sub>	NH <sub>4</sub> Cl	NH <sub>4</sub> NO <sub>3</sub>		
<u>Results at -10°</u>				
25.0	33.9	0.0	0.989	NH <sub>4</sub> Cl
25.0	23.8	92.5	1.144	NH <sub>4</sub> Cl + NH <sub>4</sub> NO <sub>3</sub>
25.0	0.0	114.5	-	NH <sub>4</sub> NO <sub>3</sub>
40.0	41.9	0.0	0.970	NH <sub>4</sub> Cl
39.8	25.4	117.0	1.129	NH <sub>4</sub> Cl + NH <sub>4</sub> NO <sub>3</sub>
40.0	0.0	141.0	1.142	NH <sub>4</sub> NO <sub>3</sub>
<u>Results at 0°</u>				
10.0	32.0	0.0	1.032	NH <sub>4</sub> Cl
10.0	28.0	41.2	1.113	"
10.0	26.4	76.4	1.166	"
10.0	23.7	110.5	1.208	NH <sub>4</sub> Cl + NH <sub>4</sub> NO <sub>3</sub>
10.0	0.0	128.0	1.224	NH <sub>4</sub> NO <sub>3</sub>
25.0	38.6	0.0	0.998	NH <sub>4</sub> Cl
24.9	32.9	41.5	1.068	"
24.8	28.0	80.0	1.123	"
25.3	25.7	134.5	1.171	NH <sub>4</sub> Cl + NH <sub>4</sub> NO <sub>3</sub>
25.0	0.0	149.5	1.186	NH <sub>4</sub> NO <sub>3</sub>
40.0	46.5	0.0	0.977	NH <sub>4</sub> Cl
39.9	39.9	41.9	1.035	"
40.0	32.1	91.0	1.096	"
40.3	27.4	164.0	1.162	NH <sub>4</sub> Cl + NH <sub>4</sub> NO <sub>3</sub>
40.0	0.0	180.0	1.167	NH <sub>4</sub> NO <sub>3</sub>
<u>Results at 20°</u>				
10.0	40.0	0.0	1.040	NH <sub>4</sub> Cl
10.0	35.1	49.9	1.130	"
10.0	29.7	146.0	1.243	"
10.1	29.2	185.5	1.270	NH <sub>4</sub> Cl + NH <sub>4</sub> NO <sub>3</sub>
10.0	0.0	201.0	1.277	NH <sub>4</sub> NO <sub>3</sub>
25.0	45.5	0.0	1.000	NH <sub>4</sub> Cl
25.0	38.7	50.3	1.061	"
25.0	32.7	151.0	1.194	"
24.9	31.0	216.0	1.242	NH <sub>4</sub> Cl + NH <sub>4</sub> NO <sub>3</sub>
25.4	31.4	222.0	1.241	"
25.0	0.0	230.0	1.247	NH <sub>4</sub> NO <sub>3</sub>
40.0	55.2	0.0	0.975	NH <sub>4</sub> Cl
40.0	40.0	101.6	1.105	"
40.1	34.1	204.5	1.193	"
40.6	33.7	263.0	1.220	NH <sub>4</sub> Cl + NH <sub>4</sub> NO <sub>3</sub>
40.0	0.0	268.0	1.224	NH <sub>4</sub> NO <sub>3</sub>
<u>Results at 40°</u>				
10.0	48.3	0.0	1.037	NH <sub>4</sub> Cl
9.9	41.8	101.5	1.191	"
10.0	39.1	307.0	1.312	NH <sub>4</sub> Cl + NH <sub>4</sub> NO <sub>3</sub>
10.0	39.1	305.0	1.316	"

(Cont.)

# N NITROGEN

## THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM NITRATE - AQUEOUS AMMONIA--Cont.

Gms. per 100 gms. H <sub>2</sub> O			Density	Solid Phase
NH <sub>3</sub>	NH <sub>4</sub> Cl	NH <sub>4</sub> NO <sub>3</sub>		
Results at 40° (Cont.)				
10.0	0.0	315.0	1.312	NH <sub>4</sub> NO <sub>3</sub>
25.0	55.0	0.0	0.969	NH <sub>4</sub> Cl
25.0	42.4	149.0	1.183	"
24.6	41.2	346.0	1.293	NH <sub>4</sub> Cl + NH <sub>4</sub> NO <sub>3</sub>
25.2	41.5	352.0	1.286	"
25.0	0.0	353.0	1.275	NH <sub>4</sub> NO <sub>3</sub>
Cl 40.0	65.3	0.0	-	NH <sub>4</sub> Cl
39.8	43.6	390.0	1.265	NH <sub>4</sub> Cl + NH <sub>4</sub> NO <sub>3</sub>
40.0	0.0	405.0	1.260	NH <sub>4</sub> NO <sub>3</sub>

Results for the system  $\text{NH}_4\text{Cl} + \text{NaNO}_3 \rightleftharpoons \text{NH}_4\text{NO}_3 + \text{NaCl}$  in H<sub>2</sub>O at 100° are given by Mlle. Wurmser, 1922. Diagrams at -33° and 0° in the presence of NH<sub>3</sub> are given by Zdanovskii, 1949.

## THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM DIHYDROGEN PHOSPHATE - WATER (Polosin, 1946)

Gms. per 100 gms. Sat. Sol.			Solid Phase	Gms. per 100 gms. Sat. Sol.			Solid Phase
NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>	NH <sub>4</sub> Cl	NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>		NH <sub>4</sub> Cl			
Results at -15°				Results at 20°			
0.0	19.0	Ice	26.3	0.0	NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>		
2.95	17.75	"	19.5	4.02	"		
3.05	18.25	NH <sub>4</sub> Cl	14.2	8.57	"		
0.0	19.5	"	9.6	14.46	"		
			6.9	18.62	"		
			5.2	23.7	"		
			0.0	27.1	NH <sub>4</sub> Cl		
Results at 0° (also see table following)				Results at 25°			
18.6	0.0	NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>					
12.3	4.38	"	29.2	0.0	NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>		
8.6	9.14	"	21.7	3.91	"		
5.2	15.17	"	16.2	8.38	"		
3.9	19.22	"	11.1	14.22	"		
3.5	21.3	NH <sub>4</sub> Cl	8.1	18.38	"		
0.0	22.8	"	6.1	23.48	"		
			0.0	28.2	NH <sub>4</sub> Cl		
Results at 10°				Results at 35°			
22.1	0.0	NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>					
15.6	4.22	"	32.8	0.0	NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>		
10.8	8.92	"	36.4	3.7	"		
7.0	14.88	"	20.8	7.92	"		
5.1	18.98	"	14.4	13.69	"		
3.9	23.5	NH <sub>4</sub> Cl	10.9	17.82	"		
0.5	24.88	"	8.0	23.0	"		
0.0	24.9	"	0.0	30.2	NH <sub>4</sub> Cl		
(Cont.)							

(Cont.)

THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM DIHYDROGEN  
PHOSPHATE - WATER--Cont.

The eutectic temperature is  $-15.6^{\circ}$  and the solution contains 3.9%  $\text{NH}_4\text{H}_2\text{PO}_4$  and 17.8%  $\text{NH}_4\text{Cl}$ .

$\text{NH}_4\text{Cl} - \text{NH}_4\text{H}_2\text{PO}_4 - \text{H}_2\text{O}$  AT  $0^{\circ}$   
(Askenasy and Nessler, 1930)  
(see also table above)

d. of sat. sol.	Mol. % $\text{NH}_4\text{Cl}$ in dissolved salts	Mols. $\text{H}_2\text{O}$ to dissolve 100 mols. salt mixture	Solid Phase	Ck
1.0655	100.0	1000	$\text{NH}_4\text{Cl}$	
1.0831	98.3	990	"	
1.0846	92.2	955	" + $\text{NH}_4\text{H}_2\text{PO}_4$	
1.0872	78.6	1490	$\text{NH}_4\text{H}_2\text{PO}_4$	
1.0887	62.9	2060	"	
1.0955	44.6	2270	"	
1.0990	20.2	2450	"	
1.1043	0.0	2815	"	

THE SYSTEM  $2\text{NH}_4\text{Cl} + \text{Na}_2\text{HPO}_4 \rightleftharpoons (\text{NH}_4)_2\text{HPO}_4 + 2\text{NaCl} (+ \text{H}_2\text{O})$   
(Lauffenburger and Brodsky, 1938)

[additional data at  $25^{\circ}$  are given by Lauffenburger, 1941]

Results for solutions saturated with two salts:

t°	Gm. Mols. per 1000 gms. $\text{H}_2\text{O}$				Solid Phase
	$\text{NH}_4\text{Cl}$	$\text{NaCl}$	$(\text{NH}_4)_2\text{HPO}_4$	$\text{Na}_2\text{HPO}_4$	
0	2.73	4.89	-	-	$\text{NH}_4\text{Cl} + \text{NaCl}$
"	6.22	-	3.47	-	" + $(\text{NH}_4)_2\text{HPO}_4$
"	-	-	3.14	0.08	$\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O} + (\text{NH}_4)_2\text{HPO}_4$
"	-	-	0.48	0.25	"
"	-	5.95	-	1.00	" + $\text{NaCl}$
25	3.85	4.41	-	-	$\text{NH}_4\text{Cl} + \text{NaCl}$
"	6.65	-	1.53	-	" + $(\text{NH}_4)_2\text{HPO}_4$
"	-	-	5.14	0.14	$\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O} + (\text{NH}_4)_2\text{HPO}_4$
"	-	-	0.33	1.00	"
"	-	5.70	-	0.50	" + $\text{NaCl}$

Results for Solutions Saturated with three salts:

t°	Gm. ions per 1000 gms. $\text{H}_2\text{O}$				Solid Phase
	$\text{Na}^+$	$\text{NH}_4^+$	$\text{HPO}_4^-$	$\text{Cl}^-$	
0	4.90	2.80	0.08	7.55	$\text{NH}_4\text{Cl} + \text{NaCl} + \text{Na}(\text{NH}_4)\text{HPO}_4 \cdot 4\text{H}_2\text{O}$
"	0.30	10.1	2.65	5.1	" + $(\text{NH}_4)_2\text{HPO}_4$ + "
25	4.34	4.67	0.23	8.55	" + $\text{NaCl}$ + "
"	6.51	0.40	0.46	5.99	$\text{NaCl} + \text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O} + "$
"	0.45	9.04	1.64	6.21	$\text{NH}_4\text{Cl} + (\text{NH}_4)_2\text{HPO}_4$

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THE SYSTEM  $2\text{NH}_4\text{Cl} + \text{H}_2\text{SO}_4 \rightleftharpoons (\text{NH}_4)_2\text{SO}_4 + 2\text{HCl}$  (+  $\text{H}_2\text{O}$ ) AT  $25^\circ$   
(Blumberg and Zdanovsky, 1939)

The authors also give results for solutions simultaneously saturated with ammonium chloride and the neutral and acid ammonium sulfates as well as all other mixtures required to complete the diagram for the  $25^\circ$  isotherm.

	Mols. percent composition of dissolved components				Mols. $\text{H}_2\text{O}$ per 100 mols. of dissolved components	Solid Phase
	$2\text{NH}_4\text{Cl}$	$(\text{NH}_4)_2\text{SO}_4$	$\text{H}_2\text{SO}_4$	$2\text{HCl}$		
	-	100	-	-	964	$(\text{NH}_4)_2\text{SO}_4$
CI	16.92	83.08	-	-	945	"
	31.24	68.76	-	-	931	"
	43.57	56.43	-	-	915	" + $\text{NH}_4\text{Cl}$
	62.82	37.18	-	-	1115	$\text{NH}_4\text{Cl}$
	80.34	19.66	-	-	1295	"
	100.0	-	-	-	1516	"
	76.47	-	-	23.53	1490	"
	22.15	-	-	77.85	1166	"
	8.29	-	-	91.71	801	"
	6.39	-	-	93.61	565	" + (HCl)
	-	-	-	100.0	578	(HCl)
	-	-	99.30	0.70	0	" in $(\text{H}_2\text{SO}_4)$
	-	31.60	68.40	-	0	$(\text{NH}_4)\text{HSO}_4$ in $(\text{H}_2\text{SO}_4)$
	-	48.48	51.52	-	184	$(\text{NH}_4)\text{HSO}_4 + (\text{NH}_4)_3\text{H}(\text{SO}_4)_2$
	-	69.90	30.10	-	459	$(\text{NH}_4)_2\text{SO}_4 +$ "

THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM SULFITE - WATER  
(Labash and Lusby, 1955)

## Results at $20^\circ$

Sat. Sol. wt. %			Solid Phase
$\text{NH}_4\text{Cl}$	$(\text{NH}_4)_2\text{SO}_3$	$(\text{NH}_4)_2\text{SO}_4$	
27.26	0.0	0.0	$\text{NH}_4\text{Cl}$
24.70	5.25	0.45	"
22.45	10.00	1.06	"
20.08	15.52	-	"
18.39	19.13	-	"
16.61	23.57	1.20	" + $(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O}$
16.57	23.64	1.15	" + "
15.36	24.55	0.90	$(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O}$
9.66	28.85	-	"
5.13	32.63	-	"
0.0	37.34	0.49	"

## Results at $60^\circ$

Sat. Sol. wt. %		
$\text{NH}_4\text{Cl}$	$(\text{NH}_4)_2\text{SO}_3$	$\text{NH}_4\text{HSO}_4$
35.37	0.0	0.0
32.04	6.95	-
	(Cont.)	

## THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM SULFITE - WATER--Cont.

## Results at 60°

## Sat. Sol. wt. %

$\text{NH}_4\text{Cl}$	$(\text{NH}_4)_2\text{SO}_3$	$\text{NH}_4\text{HSO}_4$
28.56	13.97	0.23
25.35	20.75	0.09
22.98	25.75	0.22
19.82	32.06	0.43 <sup>b</sup>
17.84	37.72	(0.91) <sup>b</sup>
17.82	37.86	(0.99) <sup>b</sup>
(16.74) <sup>a</sup>	(35.82)	-
17.71	37.7	0.17
16.90	37.6	(0.22) <sup>c</sup>
13.82	39.6	(0.02) <sup>c</sup>
15.64	38.5	-
12.29	40.7	(0.89) <sup>b</sup>
9.05	43.1	(0.02) <sup>c</sup>
5.35	46.2	(0.05) <sup>c</sup>
3.41	48.6	0.51
0.0	50.48	0.13

Cl

aZilberman and Ivanov, 1941

b%  $(\text{NH}_4)_2\text{SO}_4$ c%  $\text{NH}_3$ 

## THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM SULFATE - WATER

Cl =  $\text{NH}_4\text{Cl}$ S =  $(\text{NH}_4)_2\text{SO}_4$ 

## Results at 20°

(Dolique and Pauc, 1947)

Gms. per 100 gms. $\text{H}_2\text{O}$		Density 20° 4°	Solid Phase	Gms. per 100 gms. $\text{H}_2\text{O}$		Density 20° 4°	Solid Phase
$\text{NH}_4\text{Cl}$	$(\text{NH}_4)_2\text{SO}_4$			$\text{NH}_4\text{Cl}$	$(\text{NH}_4)_2\text{SO}_4$		
37.4	0.0	1.076	Cl	26.97	48.52	1.191	Cl+S
35.58	7.7	1.100	Cl	21.0	54.05	1.202	S
33.8	13.52	1.113	Cl	9.9	64.74	1.223	S
32.33	20.0	1.134	Cl	0.0	73.95	1.245	S
31.05	39.2	1.179	Cl				

## Results at 30°

(Dolique and Pauc, 1948)

Gms. per 100 gms. $\text{H}_2\text{O}$		Solid Phase	Gms. per 100 gms. $\text{H}_2\text{O}$		Solid Phase
$\text{NH}_4\text{Cl}$	$(\text{NH}_4)_2\text{SO}_4$		$\text{NH}_4\text{Cl}$	$(\text{NH}_4)_2\text{SO}_4$	
41.6	0.0	Cl	31.5	44.7	Cl+S
36.6	9.7	Cl	29.1	46.06	S
33.3	19.7	Cl	19.3	56.4	S
32.7	32.5	Cl	0.0	74.55	S
31.7	40.2	Cl	(Cont.)		



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## THE SYSTEM AMMONIUM CHLORIDE - AMMONIUM SULFATE - WATER--Cont.

### Results at 30° (Cont.)

(Wibaut, 1909; Schreinemakers, 1910)

	Gms. per 100 Gms. Sat. Sol		Solid Phase
	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	NH <sub>4</sub> Cl	
	0	29.5	Cl
	5	28.5	Cl
	10	25.7	Cl
	15	23.2	Cl
	20	20.2	Cl
	25	18.3	Cl+S
	30	13.2	S
	35	8.5	S
	40	2.8	S
	42	0	S

Results for the system  $2\text{NH}_4\text{Cl} + \text{Na}_2\text{SO}_4 = (\text{NH}_4)_2\text{SO}_4 + \text{Na}_2\text{SO}_4$  in H<sub>2</sub>O at 0°, 25°, 40°, 60°, and 80° are given by Rivett, 1922.

A solution saturated at 25° with ammonium chloride + ammonium sulfamate in the system  $\text{NH}_4\text{Cl} - \text{NH}_4\text{SO}_3\text{NH}_2 - \text{H}_2\text{O}$  contains 60.06%  $\text{NH}_4\text{SO}_3\text{NH}_2$ , 9.26%  $\text{NH}_4\text{Cl}$  and has a density of 1.372. (Ricci and Selikson, 1952)

## THE SYSTEM AMMONIUM CHLORIDE - SODIUM CHLORIDE - WATER

(Jarlykoff, 1934)

- |                                                                    |                    |
|--------------------------------------------------------------------|--------------------|
| a) Gerassimow, 1930 (data given at 0°, 20°, 50°, 70° in original). | d) Toporescu, 1922 |
| b) Sborgi and Franco, 1921, 1922                                   | e) Wurmser, 1922   |
| c) Mondain Monval, 1922                                            | f) Fedotieff, 1904 |

t°	Gms. per 100 gms. H <sub>2</sub> O		Density	Solid Phase
	NaCl	NH <sub>4</sub> Cl		
-10	33.06	0.0	1.1898	NaCl
	27.5	12.2	1.1785	NaCl + NH <sub>4</sub> Cl
	14.9	18.45	1.1284	NH <sub>4</sub> Cl
	0.0	26.3	1.060	"
0	35.2	0.0	1.2020	NaCl
	27.86	14.32	1.1788	NaCl + NH <sub>4</sub> Cl
	(28.25	14.65) <sup>a</sup>	-	" + "
	(27.86	14.55) <sup>b</sup>	-	" + "
	(26.1	15.7) <sup>c</sup>	-	" + "
	(28.64	14.61) <sup>f</sup>	1.185	" + "
	17.80	19.28	1.1405	NH <sub>4</sub> Cl
	0.0	29.9	1.066	"
10	35.3	0.0	1.1994	NaCl
	28.6	13.8	1.1788	"
	26.9	18.35	1.1719	NaCl + NH <sub>4</sub> Cl
	(26.33	18.03) <sup>b</sup>	-	" + "
	16.7	23.7	1.1363	NH <sub>4</sub> Cl
	0.0	33.2	1.072	"

(Cont.)

## THE SYSTEM AMMONIUM CHLORIDE - SODIUM CHLORIDE - WATER--Cont.

t°	Gms. per 100 gms. H <sub>2</sub> O		Density	Solid Phase
	NaCl	NH <sub>4</sub> Cl		
15	(24.7	20.3) <sup>c</sup>	-	NaCl + NH <sub>4</sub> Cl
	(27.2	20.3) <sup>d</sup>	-	" + "
	(26.68	19.88) <sup>f</sup>	1.175	" + "
20	35.6	0.0	1.201	NaCl
	34.4	2.74	1.1983	"
	28.7	15.5	1.1789	"
	25.8	21.5	1.1724	NaCl + NH <sub>4</sub> Cl
	(25.9	21.8) <sup>a</sup>	-	" + "
	23.9	22.2	1.1591	NH <sub>4</sub> Cl
	11.40	30.3	1.1181	"
	0.0	37.5	1.076	"
25	(25.04	24.09) <sup>b</sup>	-	NaCl + NH <sub>4</sub> Cl
35	36.1	0.0	1.1910	NaCl
	23.9	27.7	1.1644	NaCl + NH <sub>4</sub> Cl
	19.94	30.7	1.1490	NH <sub>4</sub> Cl
	0.0	43.4	1.081	"
50	36.8	0.0	1.1900	NaCl
	34.2	5.75	1.1850	"
	30.2	11.5	1.1965	"
	31.02	15.0	1.1704	"
	23.9	33.0	1.1585	NaCl + NH <sub>4</sub> Cl
	(22.5	35.6) <sup>a</sup>	-	" + "
	15.6	39.1	1.1415	NH <sub>4</sub> Cl
	9.09	43.1	1.0876	"
	5.9	45.64	1.1243	"
	0.0	49.0	1.086	"
65	37.2	0.0	1.1920	NaCl
	25.2	30.5	1.1640	"
	20.69	42.7	1.1546	NaCl + NH <sub>4</sub> Cl
	13.4	47.4	1.1243	NH <sub>4</sub> Cl
	0.0	56.5	1.086	"
75	(23.4	44.9) <sup>a</sup>	-	NaCl + NH <sub>4</sub> Cl
80	37.4	0.0	1.1926	NaCl
	36.7	1.63	1.1916	"
	19.7	50.7	1.1434	NaCl + NH <sub>4</sub> Cl
	16.9	52.0	1.1415	NH <sub>4</sub> Cl
	0.0	64.4	1.0876	"
100	(19.5	61.5) <sup>e</sup>	-	NaCl + NH <sub>4</sub> Cl

Cl

THE SYSTEM NH<sub>4</sub>Cl - NaCl - H<sub>2</sub>O UNDER 1.2 ATM. CO<sub>2</sub>  
(Neumann and Domke, 1928)

at 20°		at 30°		at 40°	
Gms. per 1000 cc sat. sol.		Gms. per 1000 cc sat. sol.		Gms. per 1000 cc sat. sol.	
NH <sub>4</sub> Cl	NaCl	NH <sub>4</sub> Cl	NaCl	NH <sub>4</sub> Cl	NaCl
294.2	0.0	315.7	0.0	337.8	0.0
241.6	82.3	291.5	36.2	307.2	44.5
202.8	150.5	236.1	127.3	263.3	115.7
172.1	206.0	199.9	191.7	228.2	177.1
52.4	279.8	116.5	243.1	77.2	268.7
37.5	289.3	63.6	274.5	0.0	316.0
0.0	312.3	0.0	314.4		

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## SOLUBILITY OF AMMONIUM CHLORIDE IN AQUEOUS SOLUTIONS OF SODIUM CHLORIDE SATURATED WITH CO<sub>2</sub> (Fedotieff)

t°	Wt. of 1 cc. Sol.	Per 1000 cc. Solution				Per 1000 Gms. H <sub>2</sub> O			
		Moles NaCl	Moles NH <sub>4</sub> Cl	Gms. NaCl	Gms. NH <sub>4</sub> Cl	Moles NaCl	Moles NH <sub>4</sub> Cl	Gms. NaCl	Gms. NH <sub>4</sub> Cl
0	1.069	0.0	4.60	0.0	246.1	0.0	5.57	0.0	298.0
0	1.185	4.04	2.26	236.5	121.0	4.89	2.73	286.4	146.1
15	1.977	0.0	5.29	0.0	283.1	0.0	6.64	0.0	355.0
15	1.097	0.81	4.71	47.5	252.1	1.02	5.91	59.8	316.4
15	1.120	1.68	4.13	98.0	221.7	2.09	5.18	122.4	277.0
15	1.153	2.87	3.38	168.0	180.7	3.57	4.20	208.9	224.7
Cl 15	1.175	3.65	2.98	213.5	159.4	4.55	3.72	266.8	198.8
30	...	...	...	...	...	0.0	7.78	0.0	416.4
30	1.166	3.30	3.70	193.0	198.0	4.26	4.77	249.0	255.4
45	...	...	...	...	...	0.0	9.03	0.0	483.7
45	...	...	...	...	...	4.0	6.02	233.9	322.1

## THE SYSTEM AMMONIUM CHLORIDE - NICKEL CHLORIDE - WATER

### Results at 25°

(Foote, 1912)

Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
NH <sub>4</sub> Cl	NiCl <sub>2</sub>		NH <sub>4</sub> Cl	NiCl <sub>2</sub>	
26.07	3.10	Mixed Crystals of NH <sub>4</sub> Cl and NiCl <sub>2</sub> ·2H <sub>2</sub> O	7.98	37.41	Mixed crystals and NiCl <sub>2</sub> ·6H <sub>2</sub> O
22.27	8.04		8.07	37.73	
20.68	10.32		8.23	37.45	
17.43	15.01		8.17	37.64	
11.22	26.93		7.51	37.19	NiCl <sub>2</sub> ·6H <sub>2</sub> O
10.21	30.56		3.06	37.98	
9.16	35.70		0	37.53	

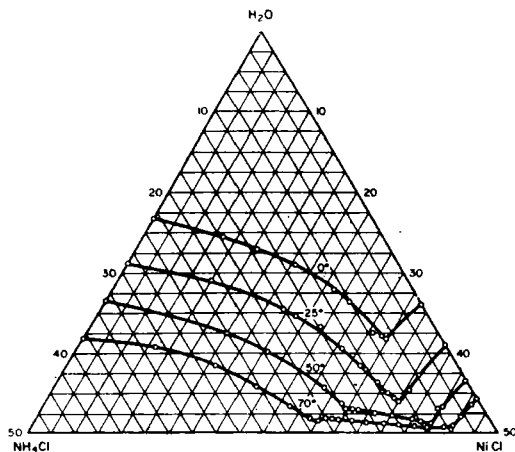
### Results at 70°

(Glendinnen, 1922)

Gms. per 100 d of gms. sat. sol.			Per cent NH <sub>4</sub> Cl in mixed crystals (extrapolated)	Gms. per 100 d of gms. sat. sol.			Per cent NH <sub>4</sub> Cl in mixed crystals (extrapolated)
NH <sub>4</sub> Cl	NiCl <sub>2</sub>			NH <sub>4</sub> Cl	NiCl <sub>2</sub>		
1.162	30.92	8.59	98.3	1.469	13.56	33.22	39.3
1.234	26.09	15.83	94.6	1.492	11.74	36.99	34.8
1.294	22.91	21.29	93.9	1.510	10.09	38.88	31.4
1.355	20.47	26.28	84.6	1.530	8.43	40.43	28.1
1.386	19.01	28.96	75.1	1.552	6.96	42.05	25.9
1.401	18.37	30.03	68.8	-	5.35	43.87	21.8
1.411	17.54	30.69	62.5	1.591	4.62	44.70	0.9
1.409	17.57	30.70	57.2	1.587	2.79	44.99	0.4
1.421	16.93	31.31	52.5	1.589	1.24	45.60	0.1
1.446	15.05	33.54	45.1	1.592	0.0	45.8	0.0

## THE SYSTEM AMMONIUM CHLORIDE - NICKEL CHLORIDE - WATER--Cont.

Results of Kurnakov and Egorov, 1936



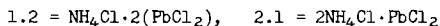
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Distributions in mixed crystals in the systems  $\text{NH}_4\text{Cl} - \text{CdCl}_2 - \text{H}_2\text{O}$  and  $\text{NH}_4\text{Cl} - \text{NiCl}_2 - \text{H}_2\text{O}$  are reported by Ioffe, 1956.

A study of the lower boundary of "true" vs. "anomalous mixed crystal formation in the systems  $\text{NH}_4\text{Cl} + \text{FeCl}_3$ , or  $\text{CrCl}_3$ ,  $\text{CuCl}_2$ ,  $\text{MnCl}_2$ ,  $\text{NiCl}_2$ ,  $\text{CoCl}_2$ ,  $\text{CdCl}_2 + \text{H}_2\text{O}$  is given by Ioffe, 1958. Data in the system  $\text{Ba}(\text{NO}_3)_2 + \text{methylene blue}$  are also reported.

## THE SYSTEM AMMONIUM CHLORIDE - LEAD CHLORIDE - WATER

(At 17°, 50° and 100° Demassieux (1913) at 25° Foote and Levy, 1907)



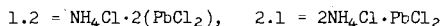
At 17°		At 25° *		At 50°		At 100°		Solid Phase in Each Case
Gms. per 100 Gms. Sol.		Gms. per 100 Gms. Sol.		Gms. per 100 Gms. Sol.		Gms. per 100 Gms. Sol.		
PbCl <sub>2</sub>	NH <sub>4</sub> Cl	PbCl <sub>2</sub>	NH <sub>4</sub> Cl	PbCl <sub>2</sub>	NH <sub>4</sub> Cl	PbCl <sub>2</sub>	NH <sub>4</sub> Cl	
0.30	27.03	...	...	0.32	34.14	1.61	43.42	NH <sub>4</sub> Cl
0.52	26.68	...	...	2.65	33.62	4.21	42.91	"
0.64	26.49	1.20	28.15	3.96	33.56	...	...	" + 1.2
...	...	...	...	...	...	9.26	41.90	" + 2.1
...	...	...	...	...	...	9.88	40.22	2.1
...	...	...	...	...	...	11.60	38.32	"
...	...	...	...	...	...	12.67	37.62	" + 1.2
0.34	22.32	0.93	27.45	3.31	31.90	11.40	36.29	1.2
0.098	12.36	0.35	21.59	1.76	27.16	8.32	32.64	"

\*See below for further data at 25° and 22°.

(Cont.)

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## THE SYSTEM AMMONIUM CHLORIDE - LEAD CHLORIDE - WATER--Cont.



	At 17°		At 25°		At 50°		At 100°		Solid Phase in Each Case
	Gms. per 100 Gms. Sol.		Gms. per 100 Gms. Sol.		Gms. per 100 Gms. Sol.		Gms. per 100 Gms. Sol.		
	PbCl <sub>2</sub>	NH <sub>4</sub> Cl	PbCl <sub>2</sub>	NH <sub>4</sub> Cl	PbCl <sub>2</sub>	NH <sub>4</sub> Cl	PbCl <sub>2</sub>	NH <sub>4</sub> Cl	
	0.078	4.93	0.29	17.97	0.71	19.42	4.54	26.08	1.2
	0.078	4.23	0.11	10.25	0.49	12.45	1.98	13.12	"
	0.076	3.48	0.03	2.77	0.48	4.86	1.76	8.59	" + PbCl <sub>2</sub>
	0.16	1.43	...	...	0.67	1.45	1.85	5.33	PbCl <sub>2</sub>
	0.21	0.96	...	...	1.08	0.51	2.02	1.32	"
Cl	0.89	0	...	...	1.69	0	3.10	0	"

See below for further data at 25° and 22°.

Data of Wilkerson and Bathurst, 1937 at 25°

Gms. per 1000		Solid Phase	Gms. per 1000		Solid Phase
PbCl <sub>2</sub>	NH <sub>4</sub> Cl		PbCl <sub>2</sub>	NH <sub>4</sub> Cl	
0.0	397.8	NH <sub>4</sub> Cl	1.21	102.1	NH <sub>4</sub> Cl · 2PbCl <sub>2</sub>
5.40	400.6	"	1.22	86.12	"
7.28	401.1	"	1.21	65.61	"
10.42	403.9	"	1.44	43.62	" + PbCl <sub>2</sub>
14.46	403.3	" + NH <sub>4</sub> Cl · 2PbCl <sub>2</sub>	1.76	34.19	PbCl <sub>2</sub>
13.63	394.5	NH <sub>4</sub> Cl · 2PbCl <sub>2</sub>	1.97	26.22	"
12.27	384.7	"	2.00	22.34	"
4.58	270.0	" "	2.15	20.97	"
3.31	233.5	"	2.75	13.42	"
1.97	171.3	"	3.04	9.62	"
1.57	146.5	"	10.91	0.0	"

Data of Bronsted, 1909 at 22°

Gm. Equiv. NH <sub>4</sub> Cl per 100 Gms. H <sub>2</sub> O	Gm. Equiv. PbCl <sub>2</sub> per 100 Gms. Sat. Sol.	Solid Phase
0	7.49 x 10 <sup>-3</sup>	PbCl <sub>2</sub>
0.1	3.10 x 10 <sup>-3</sup>	"
0.2	1.916 x 10 <sup>-3</sup>	"
0.4	1.348 x 10 <sup>-3</sup>	"
0.5	1.263 x 10 <sup>-3</sup>	"
0.55	1.189 x 10 <sup>-3</sup>	2PbCl <sub>2</sub> · NH <sub>4</sub> Cl
0.6	1.092 x 10 <sup>-3</sup>	"
0.7	0.956 x 10 <sup>-3</sup>	"
0.8	0.837 x 10 <sup>-3</sup>	"
1	0.758 x 10 <sup>-3</sup>	"
2	0.695 x 10 <sup>-3</sup>	"
3	0.968 x 10 <sup>-3</sup>	"
4	1.502 x 10 <sup>-3</sup>	"
5	2.338 x 10 <sup>-3</sup>	"
6	3.580 x 10 <sup>-3</sup>	"
7.29 sat.	6.46 x 10 <sup>-3</sup>	" + NH <sub>4</sub> Cl

The two curves intersect at 0.52 normal NH<sub>4</sub>Cl.

AMMONIUM PLATINUM CHLORIDE  $(\text{NH}_4)_2\text{PtCl}_6$ 

Cl

SOLUBILITY IN WATER  
(Archibald and Kern, 1917)

t°	Gms. $(\text{NH}_4)_2\text{PtCl}_6$ per 100 gms. $\text{H}_2\text{O}$	t°	Gms. $(\text{NH}_4)_2\text{PtCl}_6$ per 100 gms. $\text{H}_2\text{O}$	t°	Gms. $(\text{NH}_4)_2\text{PtCl}_6$ per 100 gms. $\text{H}_2\text{O}$
0.0*	0.2900	30.0	0.6370	70.0	1.7440
5.0	0.3550	40.0	0.8050	80.0	2.1605
10.0	0.3745	50.0	1.0250	90.0	2.6150
20.0	0.5000	60.0	1.4405	100.0	3.3650

SOLUBILITY IN HCl AND HCl +  $\text{NH}_4\text{Cl}$  SOLUTIONS AT 25°  
(Belonogov, 1939)

Solvent:	Water	0.7% NCl	28.36% $\text{NH}_4\text{Cl}$	28.2% $\text{NH}_4\text{Cl}$
Gms. $(\text{NH}_4)_2\text{PtCl}_6$ per 100 cc Solvent:	0.5530	0.5983	0.0082	0.0026

SOLUBILITY IN  $\text{NH}_4\text{Cl}$  SOLUTIONS AT 20°  
(Archibald and Kern, 1917)

Gms. Mols $\text{NH}_4\text{Cl}$ per liter	Gms. $(\text{NH}_4)_2\text{PtCl}_6$ per 100 gms. solvent	Gms. Mols $\text{NH}_4\text{Cl}$ per liter	Gms. $(\text{NH}_4)_2\text{PtCl}_6$ per 100 gms. solvent
0.10	0.0423	1.00	0.0028
0.20	0.0186	2.00	0.0024

AMMONIUM STANNOUS CHLORIDES  $\text{NH}_4\text{SnCl}_3$   
 $(\text{NH}_4)_2\text{SnCl}_4$   
 $(\text{NH}_4)_4\text{SnCl}_6$ 

Cl

SOLUBILITY OF EACH IN WATER  
(Rimbach and Fleck, 1916)

## Monoammonium Stannous Chloride

t°	Gms. $\text{NH}_4\text{SnCl}_3$ per 100 gms. sat. sol.	Solid Phase
1.2*	57.0	$\text{NH}_4 \cdot \text{SnCl}_3 \cdot \text{H}_2\text{O} + \text{SnCl}_2$
15.9*	63.1	"
36.9	71.8	$\text{NH}_4\text{SnCl}_3 \cdot \text{H}_2\text{O}$
61.7	80.0	"
81.2	85.8	"

\*At these temperatures the atomic ratios of  $\text{Cl}:\text{Sn}:\text{NH}_4$  in solution do not correspond to the double salt, hence in these cases the solid phase is a mixture of the double salt and stannous chloride.

(Cont.)

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## SOLUBILITY OF EACH IN WATER--Cont.

### Diammonium Stannous Chloride

t°	Gms. (NH <sub>4</sub> ) <sub>2</sub> SnCl <sub>4</sub> per 100 gms. sat. sol.	Solid Phase
1.6	28.7	(NH <sub>4</sub> ) <sub>2</sub> SnCl <sub>4</sub> ·H <sub>2</sub> O
14.5	35.4	"
36.6	48.5	"
57.0	61.8	"
79.0	73.0	"

### Tetrammonium Stannous Chloride

t°	Gms. per 100 gms. sol. sat.			Solid Phase
	Cl	Sn	NH <sub>4</sub>	
0.8*	16.31	1.16	7.95	(NH <sub>4</sub> ) <sub>4</sub> SnCl <sub>6</sub> ·H <sub>2</sub> O+SnCl <sub>2</sub>
19.1*	19.23	2.06	9.16	" "
41.7*	21.95	6.62	9.16	" "
58.1*	26.73	11.33	10.17	" "
70.1*	30.05	15.15	10.70	" "
81.3	31.98 +	19.60 +	10.30 = 61.9 gms.	(NH <sub>4</sub> ) <sub>4</sub> SnCl <sub>6</sub>

\*At these temperatures the atomic ratios of Cl:Sn:NH<sub>4</sub> in solution do not correspond to the double salt, hence in these cases the solid phase is a mixture of the double salt and stannous chloride.

## Cl AMMONIUM STANNIC CHLORIDE (NH<sub>4</sub>)<sub>2</sub>SnCl<sub>6</sub>

### SOLUBILITY IN HCl + NH<sub>4</sub>Cl SOLUTIONS (Seidel and Fischer, 1941)

Each solution was saturated with HCl.

Gms. NH <sub>4</sub> Cl per 100 cc at Start	Gms. per 100 cc Sat. Sol.		Gms. NH <sub>4</sub> Cl per 100 cc at Start	Gms. per 100 cc Sat. Sol.	
	NH <sub>4</sub> Cl	Sn		NH <sub>4</sub> Cl	Sn
4.0	4.0	0.0004	1.0	1.0	0.0013
3.0	3.0	.0004	0.5	0.50	.005
2.0	2.0	.0006	0.0	0.11	.088

Additional data for the above system, and also for solutions containing HCl + NaCl are given by Smith, 1928.

## Cl AMMONIUM TITANIUM CHLORIDE (NH<sub>4</sub>)<sub>2</sub>TiCl<sub>6</sub>

### SOLUBILITY IN HCl + NH<sub>4</sub>Cl SOLUTIONS (Seidel and Fischer, 1941)

Gms. NH <sub>4</sub> Cl per 100 cc at Start	Gms. per 100 cc Sat. Sol.		Gms. NH <sub>4</sub> Cl per 100 cc at Start	Gms. per 100 cc Sat. Sol.	
	NH <sub>4</sub> Cl	Ti		NH <sub>4</sub> Cl	Ti
4.0	4.0	0.0005	1.0	1.0	0.0029
3.0	3.0	.0008	0.5	0.52	.0082
2.0	2.0	.0014	0.0	0.15	.065

THE SYSTEM AMMONIUM CHLORIDE - ZINC CHLORIDE - WATER  
(Meerburg, 1903)

Isotherm at 0°			Isotherm at 20°			Isotherm at 30°		
Gms. per 100 Gms. Solution		Solid Phase	Gms. per 100 Gms. Solution		Solid Phase	Gms. per 100 Gms. Solution		Solid Phase
ZnCl <sub>2</sub>	NH <sub>4</sub> Cl		ZnCl <sub>2</sub>	NH <sub>4</sub> Cl		ZnCl <sub>2</sub>	NH <sub>4</sub> Cl	
0	22.8	NH <sub>4</sub> Cl	0.0	26.9	NH <sub>4</sub> Cl	0.0	29.5	NH <sub>4</sub> Cl
3.5	23.0	"	5.1	27.1	"	9.2	29.4	"
7.1	23.5	"	9.5	27.4	"	16.0	29.7	"
10.2	23.9	"	12.7	27.5	"	20.2	30.1	"
15.1	24.7	"	15.7	27.7	"	24.7	30.4	"
18.0	25.3	"	18.0	27.9	"	26.3	30.8	NH <sub>4</sub> Cl+a Cl
22.4	26.0	"	23.5	29.0	"	27.2	30.2	a
24.2	26.1	"	26.0	29.5	NH <sub>4</sub> Cl+a	30.1	29.6	"
25.7	26.3	NH <sub>4</sub> Cl+a	29.5	28.1	a	36.8	28.2	"
27.5	26.4	a	32.3	27.7	"	42.4	27.3	"
30.7	25.7	"	35.8	27.0	"	43.8	27.3	a+b
33.9	25.3	"	38.7	26.9	"	45.0	24.4	b
38.8	24.4	"	40.2	26.6	"	51.2	17.6	"
42.6	24.6	a+b	41.9	26.3	"	61.9	10.4	"
44.3	21.3	b	43.2	26.0	a+b	66.9	9.2	ZnCl <sub>2</sub> +b
49.2	15.3	"	46.9	21.0	b	75.6	6.1	ZnCl <sub>3</sub>
52.6	11.9	"	53.2	14.5	"	70.3	7.6	"
55.4	10.0	"	58.4	11.1	"	78.5	3.2	"
59.3	7.5	"	62.7	8.7	"	76.9	3.5	"
62.1	6.8	"	66.6	7.9	"	79.8	1.6	"
						81.6	0.0	"

a = ZnCl<sub>2</sub>·3NHCl<sub>3</sub>b = ZnCl<sub>2</sub>·2NH<sub>4</sub>Cl

Some results for the system NH<sub>4</sub>Cl - ZnCl<sub>2</sub> - LiCl - CH<sub>3</sub>NH<sub>2</sub>Cl - H<sub>2</sub>O  
are given by Garrett and Woodruff, 1951.

SOLUBILITY OF AMMONIUM CHLORIDE IN AQUEOUS SOLUTIONS  
OF POTASSIUM DICHROMATE AND OF POTASSIUM PERMANGANATE AT 25°  
(Herz and Hiebenthal, 1929)

Results for Potassium Di Chromate

Results for Potassium Permanganate

Gm. Mols. per liter	
K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> /6	NH <sub>4</sub> Cl
0.0	5.62
0.24	5.55
0.45	5.56
0.59	5.55
0.91	5.32

Gm. Mols. per liter	
KMnO <sub>4</sub> /5	NH <sub>4</sub> Cl
0.0	5.62
0.04	5.62
0.13	5.66
0.34	5.61
0.73	5.55



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## SOLUBILITY OF AMMONIUM CHLORIDE IN AQUEOUS METHANOL SOLUTIONS

At 0° (Armstrong and Eyre, 1907, 1910-11)			At 17° (Mocalov, 1939)	
Sol. wt. % CH <sub>3</sub> OH	Gms. NH <sub>4</sub> Cl per 100 gms. sol.		Sat. Sol. wt. %	
			CH <sub>3</sub> OH	NH <sub>4</sub> Cl
0	29.9		0.0	26.5
0.79	29.5		7.8	27.3
1.58	29.2		21.4	19.0
3.10	28.4		44.1	13.6
8.76	25.4		68.6	7.6
			96.9	3.1
			98	3.52 (19.5°; deBruyn, 1892)

### At 25°

The data of Akerlof and Turck, 1935 and of Armstrong and Eyre 1907, 1910-11 are generally lower than those of Remy-Gennete and Bourhis, 1950.

Solvent wt. % CH <sub>3</sub> OH	Moles NH <sub>4</sub> Cl per 1000 gms. solvent	Gms. NH <sub>4</sub> Cl per 100 gms. solvent	(Remy-Gennete and Bourhis, 1950) (24.8°)		
			Sat. Sol.		
(Armstrong and Eyre, 1907, 1910-11)			Solvent wt. % CH <sub>3</sub> OH	Gms. NH <sub>4</sub> Cl per 100 gms. solvent	Sp. Gr.
0	-	39.5			
0.79	-	39.1			
1.58	-	38.7			
3.10	-	38.1			
8.76	-	35.3			
(Akerlof and Turck, 1935)					
0.0	7.384	39.5	0	39.34	1.078
20.0	5.580	29.9	10	35.49	1.047
40.82	3.893	20.83	30	27.72	1.027
60.21	2.657	14.20	50	20.22	0.984
72.39	1.731	9.26	70	11.33	0.910
80.03	1.357	7.26	80	8.12	0.876
89.79	0.9305	4.98	90	5.48	0.850
94.76	0.7691	4.12	100	3.61	0.805
100.0	0.6612	3.54			

### At 30°

(Remy-Gennete and Bourhis, 1950)

Sat. Sol.			Sat. Sol.		
Solvent wt. % CH <sub>3</sub> OH	Gms. NH <sub>4</sub> Cl per 100 gms. solvent	Sp. Gr.	Solvent wt. % CH <sub>3</sub> OH	Gms. NH <sub>4</sub> Cl per 100 gms. solvent	Sp. Gr.
0	41.41	0.996	70	12.07	0.877
10	37.62	0.981	80	8.26	0.851
30	29.90	0.956	90	5.51	0.819
50	21.39	0.926	100	3.68	0.786

## SOLUBILITY OF AMMONIUM CHLORIDE IN AQUEOUS ETHANOL SOLUTIONS

0°, 25° - Armstrong, Eyre, Hussey and Paddington, 1907; Armstrong and Eyre, 1910-11  
 20° - Dolique and Pauc, 1946-7  
 30° - Bathrick, 1896

[additional data at 0°, 30°, 60° are given by Barkan, 1953]

Figures in parentheses are densities of saturated solutions.

Solvent wt. % C <sub>2</sub> H <sub>5</sub> OH	Gms. NH <sub>4</sub> Cl per 100 gms. solvent	Solvent wt. % C <sub>2</sub> H <sub>5</sub> OH	Gms. NH <sub>4</sub> Cl per 100 gms. solvent	Solvent wt. % C <sub>2</sub> H <sub>5</sub> OH	Gms. NH <sub>4</sub> Cl per 100 gms. solvent
At 0°		At 20°		At 30°	
0.0	29.9	0.0	37.4 (1.0763)	0.0	40.40
1.37	27.2	10.8	33.06 -	10.3	35.40
2.25	28.5	29.2	25.56 -	20.8	31.88
4.40	27.4	57.5	14.96 (0.9357)	31.4	27.5
12.13	23.5	70.3	10.13 (0.8963)	41.4	21.7
		79.6	5.80	52.8	16.96
		80.4	5.54	62.2	14.04
		84.	3.67 (0.8580)	72.4	9.76
0.0	39.1 (1.0805)	88.2	2.98 (0.8456)	81.8	8.46
1.37	38.9 (1.0780)	92.	1.96 (0.8300)	91.8	2.90
2.25	38.1 (1.0753)	96.	1.20 (0.8159)		
4.40	37.0 (1.0704)	99.6	0.74 (0.7892)		
12.13	26.1 (1.0528)				
18.7	29.2 (1.0376)				

## SOLUBILITY OF AMMONIUM CHLORIDE IN AQUEOUS PROPANOL SOLUTIONS

(Armstrong, Eyre, Hussey and Paddington, 1907;  
 Armstrong and Eyre, 1910-11)

Moles C <sub>3</sub> H <sub>7</sub> OH per 1000 gms. H <sub>2</sub> O	Gms. NH <sub>4</sub> Cl per 100 gms. sat. sol.	Moles C <sub>3</sub> H <sub>7</sub> OH per 1000 gms. H <sub>2</sub> O	Gms. NH <sub>4</sub> Cl 100 gms. sat. sol.
0.0	23.0	0.0	28.3
0.25	22.7	0.25	28.1
0.50	22.3	0.50	27.5
1.0	21.1	1.0	26.6

THE SYSTEM AMMONIUM CHLORIDE - TERTIARY BUTYL ALCOHOL - WATER AT 30°  
(Ginnings and Robbins, 1930)

The points on the binodal curve of this system were determined by observing the appearance or disappearance of clouding in mixtures of weighed amounts of NH<sub>4</sub>Cl and one of the liquids, upon addition of a weighed amount of the other. Tie lines, \*, were located by determination of the NH<sub>4</sub>Cl in two liquid layers in contact with each other, and from these the plait point, PP, was found by plotting.

(Cont.)

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## THE SYSTEM AMMONIUM CHLORIDE - TERTIARY BUTYL ALCOHOL - WATER AT 30°--Cont.

In a later paper Ginnings, Herring and Webb, 1933, found the plait point of this system at 25° to be 37.6 gms. ter.  $(\text{CH}_3)_3\text{COH}$  + 6.6 gms  $\text{NH}_4\text{Cl}$  per 100 gms. sat. solution. The original results for the remaining points of the binodal curve are not given, but only values corresponding to derived empirical equations for the curve.

CI	Gms. per 100 gms. sat. sol.		sat.	Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
	ter. (CH <sub>3</sub> ) <sub>3</sub> COH	NH <sub>4</sub> Cl		ter. (CH <sub>3</sub> ) <sub>3</sub> COH	NH <sub>4</sub> Cl	ter. (CH <sub>3</sub> ) <sub>3</sub> COH	NH <sub>4</sub> Cl
	82.0	2.0*		30.2	6.6	12.9	14.3
	80.0	- *		27.5	7.4	11.8	15.6
	70.2	2.4		25.3	8.0	11.0	16.8
	65.0	- *		23.2	8.6	10.2	18.4
	61.2	3.3		22.0	9.0	10.2	18.4
	54.1	3.7		20.7	9.4	9.2	20.3
	47.9	4.2		19.8	10.0	8.7	21.7
	44.0	5.0PP		-	10.1*	-	22.7*
	39.3	5.0		15.7	11.5	8.1	23.2
	33.4	6.4		14.1	12.7	7.6	24.7*

## THE SYSTEM AMMONIUM CHLORIDE - DIOXANE - WATER AT 25° (Herz and Lorentz, 1929)

Vol. Percent $\text{C}_4\text{H}_8\text{O}_2$ in Aq. Solvent	Gm. Mol. $\text{NH}_4\text{Cl}$ per liter sat. sol.	Vol. Percent $\text{C}_4\text{H}_8\text{O}_2$ in Aq. Solvent	Gm. Mol. $\text{NH}_4\text{Cl}$ per liter sat. sol.
10	5.15	34(lower layer)	1.50
20	4.50	97(upper layer)	0.02
33	3.50		

## THE SYSTEM AMMONIUM CHLORIDE - URETHAN - WATER AT 25° (Palitzsch, 1928, 1929)

Gm. Mols. per 1000 gms. $\text{H}_2\text{O}$		Solid Phase
$\text{NH}_4\text{Cl}$	$\text{NH}_2\text{COOC}_2\text{H}_5$	
7.411	0.0	$\text{NH}_4\text{Cl}$
7.254	1.123	"
7.0	3.07	" + $\text{NH}_2\text{COOC}_2\text{H}_5$
6.102	3.678	$\text{NH}_2\text{COOC}_2\text{H}_5$
0.0	53.09	"

SOLUBILITY OF AMMONIUM CHLORIDE IN AQUEOUS GLYCEROL AND IN AQUEOUS  
ACETONE SOLUTIONS AT 25°  
(Herz and Knoch, 1905)

In Aqueous Glycerol  
(Sp. Gr. of Glycerine 1.255,  
Impurity about 1.5%)

In Aqueous Acetone<sup>a</sup>

Wt. % Glyc- erine	NH <sub>4</sub> Cl per 100 cc. Solution		Sp. Gr. at 25° 4°	Vol. % Acetone	NH <sub>4</sub> Cl per 100 cc. Solution		Sp. Gr. at 25° 4°
	Millimols.	Grams			Millimols	Grams	
0.	585.1	31.32	1.0793	0	585.1	31.32	1.0793
13.28	544.6	29.16	1.0947	10	534.1	28.59	1.0618
25.98	502.9	26.93	1.1127	20	464.6	24.87	1.0451
45.36	434.4	23.26	1.1452	30	396.7	21.23	1.0263
54.23	403.5	21.60	1.1606	40	328.5	17.59	0.9998
83.84	291.4	15.60	1.2225	*46.5 L	283.7	15.19	0.9800
100.00	228.4	12.23	1.2617	*85.7 U	18.9	1.01	0.8390
				90	9.4	0.50	0.8274

Cl

\*Between these two concentrations of acetone, the solution separates into two layers. L indicates lower layer, U indicates upper layer.  
<sup>a</sup> Additional data are given by Bogin, 1924.

100 cc. of a mixture of equal volumes of ethyl ether and water, saturated with HCl at 0° contain 0.159 gms. NH<sub>4</sub>Cl upon saturation with the salt. (Fischer and Seidel, 1941)

SOLUBILITY OF AMMONIUM CHLORIDE IN METHANOL

t°	Gms. NH <sub>4</sub> Cl per 100 gms. CH <sub>3</sub> OH	Ref.
19	3.35	de Bryun, 1892
25	3.54	Akerlof and Turck, 1935
24.8	3.61 (d = 0.805)	Remy-Gennete and Bourhis, 1950
30	3.68 (d = 0.803)	"
34.8	3.89	"
44.8	4.15	"
54.8	4.46	"
64 (calc.)	4.73	"

SOLUBILITY OF AMMONIUM CHLORIDE IN MIXTURES OF ALCOHOLS AT 25°  
(Herz and Kunn, 1908)

In Methyl and Ethyl Alcohol		In Methyl and Propyl Alcohol		In Propyl and Ethyl Alcohol	
Gms. CH <sub>3</sub> OH per 100 gms. Solvent	Gms. NH <sub>4</sub> Cl per 100 gms. sat. Solution	Gms. C <sub>3</sub> H <sub>7</sub> OH per 100 gms. Solvent	Gms. NH <sub>4</sub> Cl per 100 gms. sat. Solution	Gms. C <sub>3</sub> H <sub>7</sub> OH per 100 gms. Solvent	Gms. NH <sub>4</sub> Cl per 100 gms. sat. Solution
0	0.53	0	2.76	0	0.53
10	0.67	10	2.33	10	0.50
20	0.80	20	1.90	20	0.47

(Cont.)

# N NITROGEN

## SOLUBILITY OF AMMONIUM CHLORIDE IN MIXTURES OF ALCOHOLS AT 25°--Cont.

In Methyl and Ethyl Alcohol		In Methyl and Propyl Alcohol		In Propyl and Ethyl Alcohol	
Gms. CH <sub>3</sub> OH per 100 gms. Solvent	Gms. NH <sub>4</sub> Cl per 100 gms. sat. Solution	Gms. C <sub>3</sub> H <sub>7</sub> OH per 100 gms. Solvent	Gms. NH <sub>4</sub> Cl per 100 gms. sat. Solution	Gms. C <sub>3</sub> H <sub>7</sub> OH per 100 gms. Solvent	Gms. NH <sub>4</sub> Cl per 100 gms. sat. Solution
30	0.98	30	1.58	30	0.42
40	1.18	40	1.26	40	0.39
50	1.40	50	1.03	50	0.36
60	1.65	60	0.82	60	0.32
70	1.92	70	0.60	70	0.30
80	2.18	80	0.41	80	0.26
90	2.48	90	0.30	90	0.22
100	2.76	100	0.18	100	0.18

100 gms. of glycerol of  $d_{20} = 1.2326$  dissolve 12.56 gms. NH<sub>4</sub>Cl at 20°. (Holm, 1922)

100 gms. of glycerol of  $d_{20} = 1.2645$  dissolve 10.17 gms. NH<sub>4</sub>Cl at 20°. (Holm, 1922)

100 cc. of a sat. sol. of ammonium chloride in pure ethyl urethan contain 0.131 gm. NH<sub>4</sub>Cl at 60°.

## SOLUBILITY OF AMMONIUM CHLORIDE IN ANHYDROUS ACETIC ACID (Davidson and Chappell, 1938)

t°	Mol. Percent NH <sub>4</sub> Cl in sat. sol.	Solid Phase	t°	Mol. Percent NH <sub>4</sub> Cl in sat. sol.	Solid Phase
16.60	0.0	CH <sub>3</sub> COOH	58	0.150	NH <sub>4</sub> Cl
16.53	0.053	"	65	0.178	"
21	0.053	NH <sub>4</sub> Cl	72	0.209	"
25	0.065	"	77	0.224	"
32	0.084	"	84	0.259	"
38	0.095	"	87	0.282	"
43	0.110	"	92	0.312	"
53	0.134	"	98	0.348	"

One liter anhydrous CH<sub>3</sub>COOH dissolve 0.7 gm. NH<sub>4</sub>Cl at 16.56°. (Eichelberger, 1934)

## SOLUBILITY OF AMMONIUM CHLORIDE IN LIQUID AMMONIA

(Results of Sherer, 1931)

t°	Gms. NH <sub>4</sub> Cl per 100 cc. sat. sol.
-49.6	5.2
-46.8	5.9
-44.2	6.5
-42.2	7.0
-40.1	7.6
-37.2	8.6
-34.6	9.6
-33.9	9.63 (d = 0.7492)*

\*Johnson and Krumboltz, 1933

(Cont.)

## SOLUBILITY OF AMMONIUM CHLORIDE IN LIQUID AMMONIA--Cont.

(Results of Patscheke and Tanne, 1935)

t°	Gms. $\text{NH}_4\text{Cl}$ per 100 gms. sat. sol.	Solid Phase
-81	1.6 <sup>d</sup>	$\text{NH}_3 + \text{NH}_4\text{Cl} \cdot 3\text{H}_2\text{O}$
-52.9	5.23	$\text{NH}_4\text{Cl} \cdot 3\text{NH}_3$
-39.3	10.00	"
-20.5	22.60	"
-11.8	29.50	"
0	39.9 <sup>a</sup>	"
+ 0.9	40.65	"
4.2	44.20	"
8.2	49.20	"
9.1	50.50	"
9.8	51.50	"
9.3	52.50	"
8.3	54.00	"
9.8 m. pt.	-	"
(7.6 m. pt.) <sup>b</sup>	-	"
5.9	54.3 <sup>b</sup>	" + $\text{NH}_4\text{Cl}$
8	54.5 <sup>d</sup>	" + $\text{NH}_4\text{Cl}$
25	50.65(?) <sup>c</sup>	$\text{NH}_4\text{Cl}$
36.9	55.40	"

<sup>a</sup>Linhard and Stephan, 1933, 1934<sup>b</sup>Abe, Watanabe, and Hara, 1935<sup>c</sup>Hunt, 1932<sup>d</sup>Hurley and Sisler, 1957THE SYSTEM  $\text{NH}_4\text{Cl} - \text{NH}_4\text{NO}_3 - \text{NH}_3$  (liq.) AT 25°  
(Hunt and Boncyk, 1933)

One-fourth gram of the less soluble salt was mixed with variable amounts of the more soluble salt and ammonia added in excess. Ammonia was then allowed to escape until a single crystal of one salt came out of solution. Identical results were obtained by approaching the saturation point from opposite sides.

Mols. per 10 Mols. $\text{NH}_3$		Mols. per 10 Mols. $\text{NH}_3$	
$\text{NH}_4\text{Cl}$	$\text{NH}_4\text{NO}_3$	$\text{NH}_4\text{Cl}$	$\text{NH}_4\text{NO}_3$
3.257	0.0	0.692	7.4
3.01	0.255	0.576	7.70
2.27	1.52	0.4875	7.82
0.903	4.83	0.0	8.2875
0.734	6.54		

THE SYSTEM  $\text{NH}_4\text{Cl} - \text{NaCl} - \text{NH}_3$  LIQ.  
(Akhoumow and Eserowa, 1936)

For additional results at -10°, 0° and +10° see Patscheke and Tanne, 1935.

(Cont.)

# N NITROGEN

## THE SYSTEM $\text{NH}_4\text{Cl} - \text{NaCl} - \text{NH}_3$ LIQ.

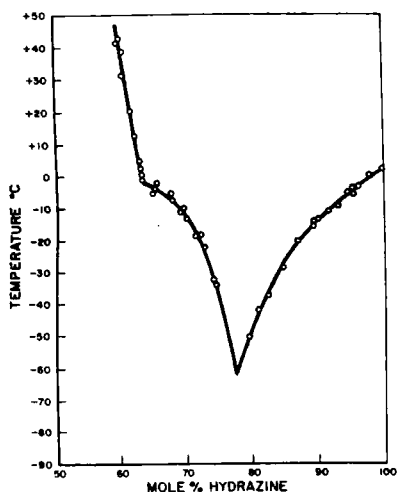
t°	Gms. per 100 gms. sat. sol.			Solid Phase
	NaCl	$\text{NH}_4\text{Cl}$	$\text{NH}_3$	
-76.6	0.28	0.0	99.72	$\text{NH}_3 + \text{Na}_5$
-40	2.0	0.0	98.0	$\text{Na}_5$
"	2.7	1.35	95.95	"
"	3.2	3.2	93.6	"
"	4.0	8.0	88.0	"
"	4.1	11.9	84.0	" + $\text{NH}_3$
"	2.9	11.6	85.5	$\text{NH}_3$
"	0.99	9.9	89.11	"
"	0.0	9.7	90.3	"
-30	3.8	0.0	96.2	$\text{Na}_5$
"	8.5	17.0	74.5	" + $\text{NH}_3$
"	0.0	15.0	85.0	$\text{NH}_3$
-24.3	11.8	23.6	64.6	$\text{Na}_5 + \text{NaCl}$
-20	7.6	0.0	92.4	"
"	14.1	22.9	63.0	" + $\text{NaCl}$
"	10.15	24.85	65.0	$\text{NH}_3 + "$
"	0.0	23.0	77.0	"
-16.3	15.8	15.8	68.4	$\text{Na}_5 + \text{NaCl}$
-15.0	15.52	7.76	76.72	" "
-10.0	14.5	0.0	85.5	"
-10.0	15.1	3.4	81.5	$\text{Na}_5 + \text{NaCl}$
"	8.99	27.92	63.09	$\text{NH}_3 + "$
"	0.0	30.87	69.13	$\text{NH}_3$
-1.8	7.60	30.40	62.0	$\text{NH}_3 + \text{NaCl}$
0	11.3	0.0	88.7	$\text{NaCl}$
"	3.92	39.2	56.88	" + $\text{NH}_3$
"	4.86	37.49	57.65	" "
"	0.0	39.7	60.3	$\text{NH}_3$
+ 8	0.0	54.61	45.39	" + $\text{NH}_4\text{Cl}$
10	7.83	0.0	92.17	$\text{NaCl}$
"	0.85	56.15	43.0	" + $\text{NH}_4\text{Cl}$
"	1.22	50.81	47.97	" + "
"	0.0	55.10	44.90	$\text{NH}_4\text{Cl}$
20	5.2	0.0	94.8	$\text{NaCl}$
"	0.0	54.5	45.5	$\text{NH}_4\text{Cl}$
30	3.3	0.0	96.7	$\text{NaCl}$
"	0.0	55.0	45.0	$\text{NH}_4\text{Cl}$
40	2.0	0.0	98.0	$\text{NaCl}$
"	0.0	55.8	44.2	$\text{NH}_4\text{Cl}$

## THE SYSTEM AMMONIUM CHLORIDE - HYDRAZINE (Hurley and Sisler, 1957)

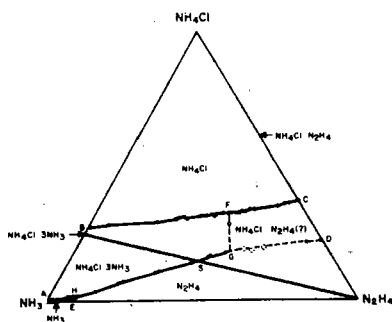
The eutectic D is at about  $-60^\circ$ , 77.5 mole %  $\text{N}_2\text{H}_4$ ; the peritectic C at  $-2.5^\circ$ , 63.0 mole %  $\text{N}_2\text{H}_4$ . The compound is probably  $\text{NH}_4\text{Cl} \cdot \text{N}_2\text{H}_4$ .

(Cont.)

## THE SYSTEM AMMONIUM CHLORIDE - HYDRAZINE--Cont.



Cl

THE SYSTEM AMMONIUM CHLORIDE - AMMONIA - HYDRAZINE  
(Hurley and Sisler, 1957)The system  $\text{NH}_3\text{-N}_2\text{H}_4\text{-NH}_4\text{Cl}$  (mole %)

Point	Solids	Liquid composition, mole%			Temp., °C.
		$\text{NH}_4\text{Cl}$	$\text{NH}_3$	$\text{N}_2\text{H}_4$	
A	$\text{NH}_3 + \text{NH}_4\text{Cl} \cdot 3\text{NH}_3$	0.5	99.5	-	ca. -81
B	$\text{NH}_4\text{Cl} \cdot 3\text{NH}_3 + \text{NH}_4\text{Cl}$	27.5	72.5	-	+ 8
C	$"\text{NH}_4\text{Cl} \cdot \text{N}_2\text{H}_4" + \text{NH}_4\text{Cl}$	37.0	-	63.0	- 2.5
D	$\text{N}_2\text{H}_4 + "\text{NH}_4\text{Cl} \cdot \text{N}_2\text{H}_4"$	22.5	-	77.5	ca. -60
E	$\text{NH}_3 + \text{N}_2\text{H}_4$	-	92.64	7.36	-80
F	$\text{NH}_4\text{Cl} + \text{NH}_4\text{Cl} \cdot 3\text{NH}_3 + "\text{NH}_4\text{Cl} \cdot \text{N}_2\text{H}_4"$	32.3	25.0	42.7	-17
G	$\text{N}_2\text{H}_4 + \text{NH}_4\text{Cl} \cdot 3\text{NH}_3 + "\text{NH}_4\text{Cl} \cdot \text{N}_2\text{H}_4"$	18	32	50	ca. -67
H	$\text{NH}_3 + \text{NH}_4\text{Cl} \cdot 3\text{NH}_3 + \text{N}_2\text{H}_4$	2.0	89.0	9.0	-83
S	$\text{NH}_4\text{Cl} \cdot 3\text{NH}_3 + \text{N}_2\text{H}_4$	15.0	44.9	40.1	-60



## N NITROGEN

### SOLUBILITY OF AMMONIUM CHLORIDE IN LIQUID SULFUR DIOXIDE

0° - 0.009 gms.  $\text{NH}_4\text{Cl}$  per 100 gms.  $\text{SO}_2$  (Jander and Wickert, 1936; Jander and Ruppolt, 1937)

25° - 0.0031 gms.  $\text{NH}_4\text{Cl}$  per 100 gms.  $\text{SO}_2$  (Shatenstein and Viktorov, 1937)

Melting points are given for the following:

$\text{NH}_4\text{Cl} + \text{SbCl}_3$	(Kendall, Crittenden and Miller, 1923)
" $+\text{NH}_4\text{NO}_3$	(Perman, 1922)(Bergman, Radishchev, et al., 1947)
" $+\text{NH}_4\text{NO}_3 + \text{NaNO}_3$	(
" $+\text{NaCl} + \text{NaNO}_3$	"
" $+\text{NH}_4\text{NO}_3$	(Bowen, 1926)
" $+\text{CdCl}_2$	(Hackmeister, 1920)
" $+\text{CuCl}$	"
" $+\text{HgCl}$	(Janecke, 1923)
" $+\text{HgCl}_2$	"
" $+\text{AgCl}$	"
" $+\text{FeCl}_3$	(Hackmeister, 1920)
" $+\text{LiCl}$	"
" $+\text{ZnCl}_2$	"
" $+\text{NH}_4\text{H}_2\text{PO}_4$	(Bergman, Radishchev, et al., 1947)
" $+\text{NH}_4\text{H}_2\text{PO}_4 + \text{NH}_4\text{NO}_3$	"
" $+\text{NH}_4\text{Br}$	(Paris and Cochet-Muchy, 1952)(Mandleberg and Stavely, 1950)

### Cl DI, TETRA METHYL AMMONIUM CHLORIDES $\text{N}(\text{CH}_3)_2\text{H}_2\text{Cl}$ , $\text{N}(\text{CH}_3)_4\text{Cl}$ TETRA ETHYL AMMONIUM CHLORIDE $\text{N}(\text{C}_2\text{H}_5)_4\text{Cl}$

#### DIMETHYL AMMONIUM CHLORIDE (Hantzsch, 1902)

100 gms.  $\text{H}_2\text{O}$  dissolve 208 gms. of the salt.

100 gms.  $\text{CHCl}_3$  dissolve 26.9 gms. of the salt (temp. not stated in abstract).

#### TETRAMETHYL AMMONIUM CHLORIDE (Walden, 1906)

100 cc. sat. solution in  $\text{CH}_3\text{CN}$  contain 0.265 gms.  $\text{N}(\text{CH}_3)_4\text{Cl}$  at 25°.

#### SOLUBILITY OF TETRA METHYL AMMONIUM CHLORIDE IN ETHYLENE DICHLORIDE ( $\text{CH}_2\text{Cl} \cdot \text{CH}_2\text{Cl}$ ) CONTAINING VARIOUS ADDED SALTS AT 25° (Seward, 1934)

It was necessary to remove all traces of moisture from the Ethylene Dichloride since as little as 0.02%  $\text{H}_2\text{O}$  causes the solubility of tetra methyl ammonium chloride to increase two fold. The determinations were made in presence of dry air.

(Cont.)

SOLUBILITY OF TETRA METHYL AMMONIUM CHLORIDE IN ETHYLENE DICHLORIDE  
(CH<sub>2</sub>Cl·CH<sub>2</sub>Cl) CONTAINING VARIOUS ADDED SALTS AT 25°--Cont.

Added Salt	Gm. Mols. per liter solvent	
	Added Salt	N(CH <sub>3</sub> ) <sub>4</sub> Cl
None	0.0	0.0001143
Tetra methyl Ammonium Picrate N(CH <sub>3</sub> ) <sub>4</sub> OC <sub>6</sub> H <sub>2</sub> (NO <sub>2</sub> ) <sub>3</sub>	0.000375	0.0000837
Tetra methyl Ammonium Picrate N(CH <sub>3</sub> ) <sub>4</sub> OC <sub>6</sub> H <sub>2</sub> (NO <sub>2</sub> ) <sub>3</sub>	0.000751	0.0000866
Tetra methyl Ammonium Picrate N(CH <sub>3</sub> ) <sub>4</sub> OC <sub>6</sub> H <sub>2</sub> (NO <sub>2</sub> ) <sub>3</sub>	0.001125	0.0000987
Tetra ethyl Ammonium Nitrate N(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> NO <sub>3</sub>	0.000267	0.000221
Tetra ethyl Ammonium Nitrate N(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> NO <sub>3</sub>	0.000500	0.000311
Tetra ethyl Ammonium Nitrate N(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> NO <sub>3</sub>	0.001000	0.000444
Tetra ethyl Ammonium Picrate N(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> OC <sub>6</sub> H <sub>2</sub> (NO <sub>2</sub> ) <sub>3</sub>	0.0005	0.000172
Tetra ethyl Ammonium Picrate N(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> OC <sub>6</sub> H <sub>2</sub> (NO <sub>2</sub> ) <sub>3</sub>	0.0010	0.000226
Tetra iso amyl Ammonium Picrate N(C <sub>5</sub> H <sub>11</sub> ) <sub>4</sub> OC <sub>6</sub> H <sub>2</sub> (NO <sub>2</sub> ) <sub>3</sub>	0.0005	0.000162
Tetra iso amyl Ammonium Picrate N(C <sub>5</sub> H <sub>11</sub> ) <sub>4</sub> OC <sub>6</sub> H <sub>2</sub> (NO <sub>2</sub> ) <sub>3</sub>	0.0010	0.000185

Cl

TETRA ETHYL AMMONIUM CHLORIDE

SOLUBILITY OF TETRA ETHYL AMMONIUM CHLORIDE IN VARIOUS SOLVENTS  
(Bjerrum and Josefowicz, 1932)

Solvent	Formula	t°	d. of sat. sol.	Gms. N(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> Cl per 100 gms. sat. sol.	Solid Phase
Water	H <sub>2</sub> O	20	1.0295	57.8	N(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> ·Cl·4H <sub>2</sub> O
"	"	25	-	58.5 <sup>a</sup>	N(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> Cl
"	"	35	1.034	75.45	"
Methyl alcohol	CH <sub>3</sub> OH	20	0.9587	69.9	"
"	"	35	0.9543	71.8	"
Ethyl alcohol	C <sub>2</sub> H <sub>5</sub> OH	20	0.9187	57.6	"
"	"	35	0.9163	60.2	"
Acetone	(CH <sub>3</sub> ) <sub>2</sub> CO	20	0.7913	0.337	"
"	"	35	0.7742	0.424	"
Chloroform	CHCl <sub>3</sub>	25	-	7.62 <sup>a</sup>	"
Acetonitrile	CH <sub>3</sub> CN	25	-	29.31 <sup>b</sup>	"

<sup>a</sup>Peddle and Turner, 1913

<sup>b</sup>Walden, 1906

# N NITROGEN

## ClO AMMONIUM PERCHLORATE $\text{NH}_4\text{ClO}_4$

SOLUBILITY IN WATER  
(Carlton, 1910; Mazzucchelli, and Rosa, 1921; Freeth, 1924;  
see also Mathieu, 1949 in the next table.)

t°	Gms. $\text{NH}_4\text{ClO}_4$ per 100 gms. sat. sol.		
	Carlton	M. & R.	Freeth
-2.72 eutec.	9.84	-	9.8
0	10.92 (d. = 1.059)	10.73	10.74
15.2	-	15.95	-
20	19.00 (d. = 1.098)	-	-
25	-	19.89	20.02 (19.95 <sup>a</sup> , d. = 1.098) (19.64 <sup>b</sup> , d. = 1.095) (19.68 <sup>c,d</sup> )
34	-	23.32	-
40	27.1 (d. = 1.128)	-	-
45	-	27.64	28.02
55.2	-	31.55	-
60	33.7 (d. = 1.158)	-	-
65.1	-	35.37	-
75	-	39.05	39.45
80	40.4 (d. = 1.193)	-	-
84.7	-	-	-
100	46.9 (d. = 1.216)	-	-
107 b. pt.	48.4 (d. = 1.221)	-	-

<sup>a</sup>Willard and Smith, 1923

<sup>b</sup>Kolthoff and Stenger, 1934

<sup>c</sup>Karnaikhov, 1954, 1957

<sup>d</sup>Karnaikhov and Druzhinin, 1952

## SOLUBILITY OF AMMONIUM PERCHLORATION WATER AT HIGH PRESSURES (Mathieu, 1949)

The author read the following data from calculated isotherms.  
Values are wt. %  $\text{NH}_4\text{ClO}_4$  in the saturated solution.

t°	1 atm.	250 atm.	500 atm.	750 atm.	1000 atm.
-10	-	-	-	-	9.736
-5	-	-	10.449	10.627	10.543
0	10.696	11.313	11.618	11.650	11.491
5	12.511	12.807	12.909	12.817	12.593
10	14.336	14.388	14.314	14.117	13.836
20	18.031	17.737	17.417	17.060	16.687
30	21.784	21.298	20.827	20.361	19.916
40	25.585	25.004	24.444	23.902	23.398
50	39.438	28.793	28.187	27.565	27.006
60	33.355	32.603	31.904	31.232	30.612

SOLUBILITY OF AMMONIUM PERCHLORATE IN AQUEOUS SOLUTIONS  
OF AMMONIA AT 25°  
(Kolthoff and Stenger, 1934)

Normality of Aq. $\text{NH}_3$ Solvent	d. of sat. sol.	Gms. $\text{NH}_4\text{ClO}_4$ per 100	
		cc. sat. sol.	gms. sat. sol.
0.0	1.095	21.50	19.64
0.443	1.092	21.63	19.61
0.876	1.089	21.98	20.16
1.303	1.088	22.50	20.68
1.731	1.086	22.96	21.14
2.59	1.084	24.08	22.23

ClO

THE SYSTEM AMMONIUM PERCHLORATE - AMMONIUM NITRATE - WATER AT 25°  
(Karnaukhov, 1954)

Continuous anhydrous solid solutions are formed.

Sat. sol. wt. %		wt. % $\text{NH}_4\text{ClO}_4$ in solid by extrapolation	Sat. sol. wt. %		wt. % $\text{NH}_4\text{ClO}_4$ in solid by extrapolation
$\text{NH}_4\text{ClO}_4$	$\text{NH}_4\text{NO}_3$		$\text{NH}_4\text{ClO}_4$	$\text{NH}_4\text{NO}_3$	
0.0	67.58	0.0	10.11	19.90	90.0
1.09	67.52	25.7	9.64	25.77	90.0
4.35	64.71	35.0	11.11	18.89	90.5
4.57	62.95	47.5	11.16	12.00	92.0
6.13	51.87	85.0	12.65	9.32	92.0
7.23	49.84	83.5	15.05	7.14	92.0
7.38	46.30	86.5	15.07	5.67	93.0
7.46	43.37	88.0	16.36	3.41	94.0
8.10	34.00	88.0	19.68	0.0	100.0

THE SYSTEM AMMONIUM PERCHLORATE - SODIUM PERCHLORATE - WATER

Results at 25°

(Karnaukhov and Druzhinin, 1952; Karnaukhov, 1954)

[Freeth, 1924 found similar solubilities, but failed to recognize the complex nature of the solid phases.]

Sat. sol. wt. %		% $\text{NH}_4\text{ClO}_4$ in Anhydrous Solid	Solid Phase
$\text{NH}_4\text{ClO}_4$	$\text{NaClO}_4$		
19.68	0.0	100.0	$\text{NH}_4\text{ClO}_4$
19.07	1.62	100.0	"
18.34	3.00	100.0	"
18.64	4.57	87.50	7:1
16.00	7.57	87.50	"
15.09	8.96	87.50	"
14.45	10.05	87.50	"
13.27	12.73	87.50	"
12.17	14.06	87.50	"
10.31	18.59	87.50	"

7:1 =  $7\text{NH}_4\text{ClO}_4 \cdot \text{NaClO}_4$

(Cont.)

# N NITROGEN

## THE SYSTEM AMMONIUM PERCHLORATE - SODIUM PERCHLORATE - WATER--Cont.

### Results at 25°

C10

$\text{NH}_4\text{ClO}_4$ $\text{NaClO}_4$		% $\text{NH}_4\text{ClO}_4$ in Anhydrous Solid	Solid Phase
7.64	27.20	87.50	7:1
6.28	33.72	87.50	"
5.00	42.00	87.50	"
4.04	44.96	87.50	$\text{NH}_4\text{ClO}_4$
3.68	51.05	87.50	7:1
3.55	56.71	87.50	"
2.66	61.63	79.50	S.S.
2.64	61.49	73.40	"
2.51	61.42	72.00	"
2.01	64.57	49.00	"
1.98	65.85	41.50	S.S. + $\text{NaClO}_4 \cdot \text{H}_2\text{O}$
1.88	66.45	15.50	"
1.88	66.97	7.00	"
1.53	67.21	0.0	$\text{NaClO}_4 \cdot \text{H}_2\text{O}$
1.07	67.49	0.0	"
0.0	67.58	0.0	"

7:1 =  $7\text{NH}_4\text{ClO}_4 \cdot \text{NaClO}_4$

S.S. = Solid Solution

### Results at 60° (Freeth, 1924)

The solid phases are probably incorrect. See note at 25°, above.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{NaClO}_4$	$\text{NH}_4\text{ClO}_4$		$\text{NaClO}_4$	$\text{NH}_4\text{ClO}_4$	
12.35	25.78	$\text{NH}_4\text{ClO}_4$	56.95	6.30	$\text{NH}_4\text{ClO}_4$
25.0	18.00	"	72.86	1.87	" + $\text{NaClO}_4$
37.34	12.54	"	74.30	0.00	$\text{NaClO}_4$

## THE SYSTEM $\text{NH}_4\text{ClO}_4 + \text{NaNO}_3 \rightleftharpoons \text{NH}_4\text{NO}_3 + \text{NaClO}_4 (+\text{H}_2\text{O})$ AT 25° (Karnaukhov, 1954)

Moles per 1000 moles $\text{H}_2\text{O}$				Solid Phase
$\text{NaNO}_3$	$\text{NH}_4\text{NO}_3$	$\text{NH}_4\text{ClO}_4$	$\text{NaClO}_4$	
233.10	392.40	-	-	$\text{NaNO}_3 + 2:1$
150.00	355.00	-	-	$2:1 + \text{NH}_4\text{NO}_3$
52.22	154.00	24.00	-	$\text{SS}_1 + 2:1 + 7:1$
-	-	37.03	7.50	$\text{NH}_4\text{ClO}_4 + 7:1$

2:1 =  $2\text{NaNO}_3 \cdot \text{NH}_4\text{NO}_3$

7:1 =  $7\text{NH}_4\text{ClO}_4 \cdot \text{NaClO}_4$

$\text{SS}_1$  = Solid Solution  $\text{NH}_4\text{NO}_3 + \text{NH}_4\text{ClO}_4$

(Cont.)

THE SYSTEM  $\text{NH}_4\text{ClO}_4 + \text{NaNO}_3 \rightleftharpoons \text{NH}_4\text{NO}_3 + \text{NaClO}_4$  ( $+\text{H}_2\text{O}$ ) AT  $25^\circ$ --Cont.

Moles per 1000 moles $\text{H}_2\text{O}$				Solid Phase
$\text{NaNO}_3$	$\text{NH}_4\text{NO}_3$	$\text{NH}_4\text{ClO}_4$	$\text{NaClO}_4$	
-	-	12.32	140.30	7:1+SS <sub>3</sub>
-	-	11.05	220.00	SS <sub>3</sub>
-	-	9.25	275.00	SS <sub>3</sub> +NaClO <sub>4</sub> ·H <sub>2</sub> O
64.50	-	-	300.00	SS <sub>2</sub> +NaClO <sub>4</sub> ·H <sub>2</sub> O
61.20	-	11.17	234.00	SS <sub>2</sub> +SS <sub>3</sub> +NaClO <sub>4</sub> ·H <sub>2</sub> O
180.00	94.70	28.76	-	2:1+7:1+SS <sub>1</sub>
71.12	194.32	23.28	-	SS <sub>1</sub> +2:1
54.20	160.00	26.00	-	SS <sub>1</sub> +7:1
67.62	112.30	70.00	-	SS <sub>1</sub> +7:1
12.50	33.75	28.75	-	SS <sub>1</sub> +7:1
9.64	24.48	27.61	-	SS <sub>1</sub> +7:1
8.51	17.51	35.77	-	SS <sub>1</sub> +7:1
7.00	11.63	31.63	-	SS <sub>1</sub> +7:1
4.91	12.64	33.73	-	SS <sub>1</sub> +7:1
4.77	-	36.60	-	SS <sub>1</sub> +7:1
33.12	-	7.10	209.50	SS <sub>3</sub> +NaClO <sub>4</sub> ·H <sub>2</sub> O
105.50	-	12.65	112.23	SS <sub>3</sub> +SS <sub>2</sub>
97.70	-	21.15	63.46	SS <sub>3</sub> +SS <sub>2</sub>
157.70	-	38.40	22.70	7:1+SS <sub>2</sub>
204.41	55.11	39.11	-	7:1+SS <sub>2</sub>
189.00	69.00	33.50	-	7:1+SS <sub>2</sub>
124.06	197.64	23.60	-	2:1+7:1
94.35	182.17	24.30	-	2:1+7:1
132.40	200.00	3.31	-	2:1+SS <sub>2</sub>
278.07	121.60	16.60	-	2:1+SS <sub>2</sub>

C10

2:1 =  $2\text{NaNO}_3 \cdot \text{NH}_4\text{NO}_3$

7:1 =  $7\text{NH}_4\text{ClO}_4 \cdot \text{NaClO}_4$

SS<sub>1</sub> = Solid Solution  $\text{NH}_4\text{NO}_3 + \text{NH}_4\text{ClO}_4$

SS<sub>2</sub> = Solid Solution  $\text{NaNO}_3 + \text{NaClO}_4$

SS<sub>3</sub> = Solid Solution  $\text{NH}_4\text{ClO}_4 + \text{NaClO}_3$

THE SYSTEM AMMONIUM PERCHLORATE - AMMONIUM SULFATE - WATER  
(Freeth, 1924)

Results at  $25^\circ$

Results at  $60^\circ$

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$(\text{NH}_4)_2\text{SO}_4$	$\text{NH}_4\text{ClO}_4$	Solid Phase	$(\text{NH}_4)_2\text{SO}_4$	$\text{NH}_4\text{ClO}_4$	Solid Phase
0.0	20.02	$\text{NH}_4\text{ClO}_4$	7.04	28.56	$\text{NH}_4\text{ClO}_4$
11.06	13.11	"	11.89	24.91	"
22.45	8.15	"	16.69	21.66	"
33.75	4.25	"	23.71	17.02	"
41.70	3.00	" + $(\text{NH}_4)_2\text{SO}_4$	30.8	12.6	"
42.83	1.22	$(\text{NH}_4)_2\text{SO}_4$	40.92	8.2	" + $(\text{NH}_4)_2\text{SO}_4$
43.5	0.0	"	(40.81)	(2.06)*	" + "
			41.12	3.48	$(\text{NH}_4)_2\text{SO}_4$

\*Karnaukhov and Karov, 1955

Data for the system  $2\text{NH}_4\text{ClO}_4 + \text{Na}_2\text{SO}_4 \rightleftharpoons (\text{NH}_4)_2\text{SO}_4 + 2\text{NaClO}_4$  ( $+\text{H}_2\text{O}$ ) at  $25^\circ$  and  $60^\circ$  are given by Freeth, 1924.

# N NITROGEN

## SOLUBILITY OF AMMONIUM PERCHLORATE IN WATER AND IN SEVERAL ANHYDROUS SOLVENTS AT 25° (Willard and Smith, 1923)

Solvent	d <sub>25</sub> of 4 solvent	d <sub>25</sub> of 4 sat. sol.	Gms. NH <sub>4</sub> ClO <sub>4</sub> per 100 gms. sat. sol.
Water	-	1.0982	19.95
Methyl alcohol	0.78735	0.8218	6.41
Ethyl alcohol	0.78515	0.79505	1.872
n Propyl alcohol	0.7993	0.8016	0.385
n Butyl alcohol	0.8059	0.8069	0.017
iso Butyl alcohol	0.7981	0.7988	0.127
Acetone	0.7852	0.7997	2.21
Ethyl acetate	0.8945	0.8947	0.032 (0.029) <sup>a</sup>

<sup>a</sup>Smith, 1925

## Results at 25° (Semenchenko and Shakparonov, 1948)

(units not clear)

acetone	0.150	iso C <sub>4</sub> H <sub>9</sub> OH	0.010
n C <sub>3</sub> H <sub>7</sub> OH	0.026	CH <sub>3</sub> OH	0.440
C <sub>2</sub> H <sub>5</sub> OH	0.130	H <sub>2</sub> O	1.870

## SOLUBILITY OF AMMONIUM PERCHLORATE IN MIXTURES OF METHYL ALCOHOL AND ETHYL ACETATE AT 25° (Smith, 1925)

Volume per cent CH <sub>3</sub> OH in Solvent	Gms. NH <sub>4</sub> ClO <sub>4</sub> per 100 gms. sat. sol.	Volume per cent CH <sub>3</sub> OH in Solvent	Gms. NH <sub>4</sub> ClO <sub>4</sub> per 100 gms. sat. sol.
0.0 (= pure CH <sub>3</sub> COO <sub>4</sub> C <sub>2</sub> H <sub>5</sub> )	0.029	60.0	4.35
10.0	0.135	70.0	5.08
20.0	0.550	80.0	5.67
30.0	1.27	90.0	6.12
40.0	2.31	100.0	6.42
50.0	3.47		

100 gms. Liquid Ammonia (NH<sub>3</sub>) dissolve 137.93 gms. NH<sub>4</sub>ClO<sub>4</sub> at 25°.  
(Hunt and Boncyk, 1933)

## QUATERNARY AMMONIUM PERCHLORATES

ClO

## SOLUBILITY OF AMMONIUM PERCHLORATE AND SEVERAL OF ITS DERIVATIVES IN WATER AT 15°

(Hofmann, Hobald and Quoos (1911-12))

	Gms. Salt per 100 Gms. H <sub>2</sub> O		Gms. Salt per 100 Gms. H <sub>2</sub> O
NH <sub>4</sub> ClO <sub>4</sub>	18.5	CH <sub>3</sub> (C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub> NC1O <sub>4</sub>	23.6
CH <sub>3</sub> NH <sub>3</sub> ClO <sub>4</sub>	109.6	C <sub>3</sub> H <sub>7</sub> (C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub> NC1O <sub>4</sub>	7.9
(CH <sub>3</sub> ) <sub>2</sub> NH <sub>2</sub> ClO <sub>4</sub>	208.7	(CH <sub>3</sub> ) <sub>2</sub> (C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> NC1O <sub>4</sub>	134.3
C <sub>2</sub> H <sub>5</sub> NH <sub>3</sub> ClO <sub>4</sub>	208.7	C <sub>2</sub> H <sub>3</sub> (CH <sub>3</sub> ) <sub>3</sub> NC1O <sub>4</sub>	5
(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> NH <sub>2</sub> ClO <sub>4</sub>	150.9	BrC <sub>2</sub> H <sub>4</sub> (CH <sub>3</sub> ) <sub>3</sub> NC1O <sub>4</sub>	3.5
(CH <sub>3</sub> ) <sub>3</sub> NHClO <sub>4</sub>	19.9	BrC <sub>2</sub> H <sub>2</sub> (CH <sub>3</sub> ) <sub>2</sub> NC1O <sub>4</sub>	2.5
(CH <sub>3</sub> ) <sub>4</sub> NC1O <sub>4</sub> *	0.5	(OH)C <sub>2</sub> H <sub>4</sub> (CH <sub>3</sub> ) <sub>3</sub> NC1O <sub>4</sub>	290.7
(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> NC1O <sub>4</sub>	3.7	(OH)CH <sub>2</sub> CH(OH)CH <sub>2</sub> (CH <sub>3</sub> ) <sub>3</sub> NC1O <sub>4</sub>	155.7
C <sub>6</sub> H <sub>5</sub> (CH <sub>3</sub> ) <sub>3</sub> NC1O <sub>4</sub>	17.9	NO <sub>3</sub> C <sub>2</sub> H <sub>4</sub> (CH <sub>3</sub> ) <sub>3</sub> NC1O <sub>4</sub>	0.6
ICH <sub>2</sub> (CH <sub>3</sub> ) <sub>3</sub> NC1O <sub>4</sub>	3.1	C <sub>3</sub> H <sub>5</sub> (CH <sub>3</sub> ) <sub>3</sub> NC1O <sub>4</sub>	199.5
C <sub>2</sub> H <sub>5</sub> (CH <sub>3</sub> ) <sub>3</sub> NC1O <sub>4</sub>	10.9	C <sub>2</sub> H <sub>4</sub> (NH <sub>3</sub> ClO <sub>4</sub> ) <sub>2</sub>	144.5
C <sub>3</sub> H <sub>7</sub> (CH <sub>3</sub> ) <sub>3</sub> NC1O <sub>4</sub>	15.4	C <sub>2</sub> H <sub>4</sub> (CH <sub>3</sub> ) <sub>3</sub> NC1O <sub>4</sub> 2	1.2
C <sub>4</sub> H <sub>9</sub> (CH <sub>3</sub> ) <sub>3</sub> NC1O <sub>4</sub>	3.7	C <sub>3</sub> H <sub>6</sub> (CH <sub>3</sub> ) <sub>3</sub> NC1O <sub>4</sub> 2	1.5
C <sub>5</sub> H <sub>11</sub> (CH <sub>3</sub> ) <sub>3</sub> NC1O <sub>4</sub>	2.2	Br <sub>2</sub> C <sub>2</sub> H <sub>3</sub> (CH <sub>3</sub> ) <sub>3</sub> NC1O <sub>4</sub>	2.2
		BrC <sub>3</sub> H <sub>3</sub> (CH) <sub>3</sub> NC1O <sub>4</sub>	2.6

\*Milbauer (1912-13) found that 100 gms. of cold H<sub>2</sub>O dissolve 1.126 gm. tetramethyl ammonium perchlorate (CH<sub>3</sub>)<sub>4</sub>NC1O<sub>4</sub> and 100 gms. alcohol dissolve 0.04 gm. of the salt.

AMMONIUM CHROMATE (NH<sub>4</sub>)<sub>2</sub>CrO<sub>4</sub>

CrO

## SOLUBILITY OF AMMONIUM CHROMATE IN WATER

(Hill, Soth, and Ricci, 1940<sup>a</sup>)

Solutions of the salt lose ammonia when exposed to the air. At 50° it was found that the % (NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub> in solution, based on a determination of NH<sub>4</sub><sup>+</sup>, was 0.2% low after an hour's exposure of the solution to the open air and about 0.6% low after two hour's exposure. The loss of ammonia from the solid salt was negligible. Each result is the mean of a determination from supersaturation and one from undersaturation.

t°	Gms. (NH <sub>4</sub> ) <sub>2</sub> CrO <sub>4</sub> per 100 gms. Sat. Sol.	t°	Gms. (NH <sub>4</sub> ) <sub>2</sub> CrO <sub>4</sub> per 100 gms. Sat. Sol.
0	19.78 (20.01) <sup>a</sup>	35	30.00 -
15	24.13 -	50	34.40 (34.15) <sup>a</sup>
20	- (25.35) <sup>a</sup>	60	37.21 -
25	27.02 -	75	41.20 (41.80) <sup>a</sup>
30	- (28.80) <sup>b</sup>		

<sup>a</sup>Guerassumow, 1934

<sup>b</sup>Schreinemakers, 1906



# N NITROGEN

## THE SYSTEM AMMONIUM CHROMATE - CHROMIC ACID - WATER AT 30° (Schreinemakers, 1906)

Sat. sol. wt. %		Residue wt. %		Solid Phase
CrO <sub>3</sub>	NH <sub>3</sub>	CrO <sub>3</sub>	NH <sub>3</sub>	
6.933	22.35	-	-	(NH <sub>4</sub> ) <sub>2</sub> CrO <sub>4</sub>
9.966	16.53	47.59	20.44	(NH <sub>4</sub> ) <sub>2</sub> CrO <sub>4</sub>
16.973	8.20	-	-	"
22.53	6.37	38.03	12.15	"
27.09	6.87	48.02	12.01	(NH <sub>4</sub> ) <sub>2</sub> CrO <sub>4</sub> + (NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
26.19	5.70	47.38	8.81	(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
25.99	5.10	41.56	7.58	"
30.16	3.50	-	-	"
CrO 38.89	3.10	61.08	8.80	"
42.44	3.15	59.72	6.75	(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> + (NH <sub>4</sub> ) <sub>2</sub> Cr <sub>3</sub> O <sub>10</sub>
44.08	2.27	54.90	4.14	(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>3</sub> O <sub>10</sub>
52.91	1.11	60.88	3.09	"
54.56	1.03	63.07	3.09	(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>3</sub> O <sub>10</sub> + (NH <sub>4</sub> ) <sub>2</sub> Cr <sub>4</sub> O <sub>13</sub>
56.57	0.97	65.70	2.95	(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>4</sub> O <sub>13</sub>
58.87	0.65	69.74	3.24	"
62.48	0.46	71.93	3.10	"
63.60	0.40	73.68	1.18	(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>4</sub> O <sub>13</sub> + CrO <sub>3</sub>
63.66	0.41	71.47	2.07	"
62.94	0.21	-	-	CrO <sub>3</sub>
62.22	0.0	-	-	CrO <sub>3</sub>

## SOLUBILITY OF AMMONIUM CHROMATE IN AQUEOUS SOLUTIONS OF AMMONIA AT 15° (Weitz and Stamm, 1925)

The authors give several diagrams and a lengthy discussion of the solubility of ammonium chromate and other ammonium salts (bromide, chloride, chlorate, perchlorate, molybdate, nitrate, oxalate, sulfate, sulfite and dithionate) in aqueous solutions of ammonia. Some of the data are evidently taken from the literature and the rest are based on the experiments of Stamm. Numerical results are not given and the diagrams are not large enough to permit quantitative estimations. They show in general that the solubility of ammonium salts of monovalent acids increase and those of divalent acids decrease with increase of the concentration of ammonia.

## THE SYSTEM AMMONIUM CHROMATE + AMMONIUM SULFATE + WATER AT 25° (Araki, 1925)

Gms. per 100 gms. sat. sol.		Solid Phase
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> CrO <sub>4</sub>	
43.41	0.00	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
39.73	3.67	Solid solutions
39.13	4.22	of (NH <sub>4</sub> ) <sub>2</sub> CrO <sub>4</sub> in (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
39.11	4.23	Mixtures
39.96	4.36	of the two series
37.72	4.51	of solid solutions
38.06	4.88	

(Cont.)

## THE SYSTEM AMMONIUM CHROMATE + AMMONIUM SULFATE + WATER AT 25°--Cont.

Gms. per 100 gms. sat. sol.		Solid Phase
$(\text{NH}_4)_2\text{SO}_4$	$(\text{NH}_4)_2\text{CrO}_4$	
34.82	6.98	Solid solutions of $(\text{NH}_4)_2\text{SO}_4$ in $(\text{NH}_4)_2\text{CrO}_4$
30.81	9.04	
26.81	11.73	
17.18	16.76	
14.47	17.76	
2.78	23.22	$(\text{NH}_4)_2\text{CrO}_4$
0.00	25.16	

AMMONIUM LANTHANUM CHROMATE  $3(\text{NH}_4)_2\text{CrO}_4 \cdot \text{La}(\text{CrO}_4)_3 \cdot 5\text{H}_2\text{O}$ 

CrO

Data showing that the range of existence of the double ammonium lanthanum chromate is in the presence of aqueous solutions containing from 5.06 to 23.22 per cent of ammonium chromate, are given by Carobbi, 1926.

AMMONIUM DICHROMATE  $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ 

CrO

SOLUBILITY OF AMMONIUM DICHROMATE IN WATER  
(Gerassimow, 1930)

t°	Gms. $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ per 100 gms.		t°	Gms. $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ per 100 gms.	
	sat. sol.	H <sub>2</sub> O		sat. sol.	H <sub>2</sub> O
-2.51*	13.63 (3)	-	30	32.05 (2)	-
0	15.37	18.26	40	36.91	58.5
5	17.8 (4)	-	50	42.03	71.4
16	23.88 (1)	-		41.7 (4)	-
20	26.23	35.6	60	46.24	86.0
25	28.63 (1)	-	75	52.13	108.6
	28.6 (4)	-	80	53.49	115.0
30	31.74	46.5	100	60.89	155.6

\*Eutectic

(1) = Moles and Gonzalez, 1923

(2) = Schreinemakers, 1905

(3) = Hartford, 1949

(4) = Sheveleva, 1956

# N NITROGEN

## THE SYSTEM AMMONIUM DICHROMATE - AMMONIUM SULFATE - WATER (Sheveleva, 1956)

	At 5°		At 25°		
	Sat. sol. wt. %		Sat. sol. wt. %		
	(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Solid Phase
CrO	-	41.5	-	43.4	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
	0.6	41.7	0.6	43.8	"
	1.2	42.0	1.1	44.0	"
	-	-	2.2	44.0	"
	-	-	-	-	"
	1.8	42.2	3.3	44.2	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + (NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
	2.5	36.5	4.1	41.3	(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
	4.2	28.7	6.7	33.2	"
	5.3	25.0	9.3	27.2	"
	7.3	18.5	14.8	17.0	"
	8.5	15.0	21.7	7.8	"
	11.7	8.8	28.6	-	"
	17.8	-	-	-	"

### At 50°

Sat. sol. wt. %		Solid Phase
(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	
-	45.7	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
0.5	45.8	"
1.1	45.8	"
2.2	45.9	"
3.8	46.0	"
5.0	46.0	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + (NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
5.5	44.8	(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
17.0	24.9	"
26.8	14.6	"
34.8	6.5	"
41.7	-	"

## THE SYSTEM AMMONIUM DICHROMATE SODIUM DICHROMATE - WATER (Gerassimow, 1930)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>		(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	
At 0°			At 20°		
15.37	0.0	(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	26.23	0.0	(NH <sub>4</sub> ) <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
6.79	46.38	"	15.41	25.42	"
5.09	49.30	"	6.269	58.13	"
4.705	61.68	"	6.179	61.38	" + Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
4.248	59.66	" + Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	0.0	65.20	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
0.0	62.0	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>			

(Cont.)

## THE SYSTEM AMMONIUM DICHROMATE SODIUM DICHROMATE - WATER--Cont.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$(\text{NH}_4)_2\text{Cr}_2\text{O}_7$	$\text{Na}_2\text{Cr}_2\text{O}_7$	Solid Phase	$(\text{NH}_4)_2\text{Cr}_2\text{O}_7$	$\text{Na}_2\text{Cr}_2\text{O}_7$	Solid Phase
At 50°			At 75°		
42.03	0.0	$(\text{NH}_4)_2\text{Cr}_2\text{O}_7$	52.13	0.0	$(\text{NH}_4)_2\text{Cr}_2\text{O}_7$
19.55	36.74	"	46.82	6.602	"
12.61	54.41	"	37.79	18.10	"
9.467	64.06	" + $\text{Na}_2\text{Cr}_2\text{O}_7$	31.89	25.44	"
0.0	71.3	$\text{Na}_2\text{Cr}_2\text{O}_7$	28.82	30.36	"
			25.57	35.87	"
			24.92	36.99	"
			20.21	43.03	"
			16.405	57.27	"
			16.02	59.21	"
			16.05	59.28	"
			15.20	60.74	"
			14.94	64.66	" + $\text{Na}_2\text{Cr}_2\text{O}_7$
			1.225	76.43	$\text{Na}_2\text{Cr}_2\text{O}_7$
			0.0	77.7	"

AMMONIUM FLUORIDE  $\text{NH}_4\text{F}$ 

F

SOLUBILITY OF AMMONIUM FLUORIDE IN WATER  
(Yatlov and Polyakova, 1945)

t°	Gms. $\text{NH}_4\text{F}$ per 100 gms. Sat. Sol.	Solid Phase	t°	Gms. $\text{NH}_4\text{F}$ per 100 gms. Sat. Sol.	Solid Phase
-4.1	5.0	Ice	10	42.55	$\text{NH}_4\text{F}$
-8.2	10.0	"	15.3	(45.1) <sup>1</sup>	"
-12.1	15.0	"	20	45.25 <sup>1</sup>	"
-14.7	20.0	"	25	(45.9) <sup>1</sup>	"
-20.7	25.0	"		(45.12) <sup>4</sup>	"
-24.9	30.0	"		(45.50) <sup>2</sup>	"
-26.5	32.3	Ice + $\text{NH}_4\text{F} \cdot \text{H}_2\text{O}$		(45.31) <sup>3</sup>	"
-19.0	39.2	$\text{NH}_4\text{F} \cdot \text{H}_2\text{O}$	30	47.05	"
-16.8	41.0	$\text{NH}_4\text{F} \cdot \text{H}_2\text{O} + \text{NH}_4\text{F}$	40	(52.01) <sup>3</sup>	"
0	41.81	$\text{NH}_4\text{F}$	45	49.81	"
	(41.62) <sup>3</sup>	"	60	52.62	"
+5.6	(43.5) <sup>1</sup>	"	80	54.05	"

<sup>1</sup>Spurgeon, 1941<sup>2</sup>Haendler and Clow, 1952<sup>3</sup>Zhdanov and Sarkozov, 1955<sup>4</sup>Ricci and Skarulis, 1951

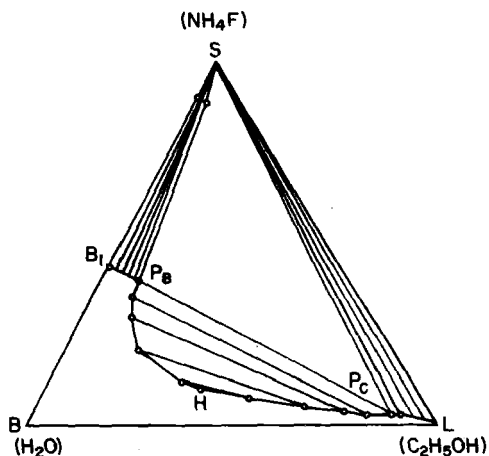
For a study of mixed crystals of  $\text{Ice} + \text{NH}_4\text{F}$  see Brill and Zaromb, 1954; Zaromb and Brill, 1956.

Phase equilibrium in the system  $\text{NH}_4\text{F} - \text{HF}$  at low temperatures were studied by Euler, 1957.

# N NITROGEN

## THE SYSTEM AMMONIUM FLUORIDE - ETHANOL - WATER AT 25° (Zhdanov and Sarkazov, 1955)

The data given in the authors' tables do not agree with their diagram:



The System  $\text{NH}_4\text{F} - \text{C}_2\text{H}_5\text{OH} - \text{H}_2\text{O}$  at 25°

## HF AMMONIUM HYDROGEN FLUORIDE $\text{NH}_4\text{HF}_2$

### SOLUBILITY OF AMMONIUM HYDROGEN FLUORIDE IN WATER (Yatlov and Polyakova, 1945)

t°	Gms. $\text{NH}_4\text{HF}_2$ per 100 gms.		Solid Phase	t°	Gms. $\text{NH}_4\text{HF}_2$ per 100 gms.		Solid Phase
	Sat. Sol.				Sat. Sol.		
-3.4	5.0		Ice	40	50.05		$\text{NH}_4\text{HF}_2$
-6.5	10.0		"	60	61.00		"
-9.4	15.0		"	80	74.53		"
-12.6	20.0		"	100	85.55		"
-14.8	23.6		Ice + $\text{NH}_4\text{HF}_2$	99.5	86.0		"
0	28.45		$\text{NH}_4\text{HF}_2$	104.6	89.0		"
10	31.96		"	110.5	92.0		"
20	37.56		"	114.0	94.0		"
25	43.73 <sup>a</sup>		"	126.1	100.0		"

<sup>a</sup>Zhdanov and Sarazov, 1954; Zhdanov, 1956 (d. = 1.1273)

THE SYSTEM AMMONIUM BIFLUORIDE - ETHANOL - WATER AT 25°  
(Zhdanov and Sarazov, 1954)

[Solid Phase  $\text{NH}_4\text{HF}_2$  throughout]

Sat. sol. wt. %			Sat. sol. wt. %		
$\text{C}_2\text{H}_5\text{OH}$	$\text{NH}_4\text{HF}_2$	Density	$\text{C}_2\text{H}_5\text{OH}$	$\text{NH}_4\text{HF}_2$	Density
0.0	43.73	-	63.97	11.17	0.8979
0.83	38.97	-	73.24	6.53	0.8716
21.47	30.47	-	75.90	5.02	0.8514
27.69	28.45	-	84.80	2.95	0.8302
37.55	22.19	0.9813	88.21	1.73	0.8118
49.69	16.53	0.9395			

AMMONIUM FLUOBORATE  $\text{NH}_4\text{BF}_4$

F

SOLUBILITY OF AMMONIUM FLUOBORATE IN WATER  
(Yatlov and Pinayevskaya, 1945)

Gms. $\text{NH}_4\text{BF}_4$ per 100 gms.			Gms. $\text{NH}_4\text{BF}_4$ per 100 gms.		
t°	Sat. Sol.	Solid Phase	t°	Sat. Sol.	Solid Phase
-1.0	3.00	Ice	50.0	30.60	$\text{NH}_4\text{BF}_4$
-1.5	5.00	"	75.0	40.30	"
-2.7	9.79	Ice+ $\text{NH}_4\text{BF}_4$	100.0	49.73	"
0.0	10.87	$\text{NH}_4\text{BF}_4$	108.5*	53.20	"
25.0	20.53	"			

\*Boiling point at 748 mm.

100 gms. ethanol dissolve 0.7 gms.  $\text{NH}_4\text{BF}_4$  at room temperature.  
Acetone, benzene and chloroform dissolve less than 0.002 gms. (Martin and Riecke, 1951)

AMMONIUM FLUOBERYLLATE  $(\text{NH}_4)_2\text{BeF}_6$

F

THE SYSTEM  $(\text{NH}_4)_2\text{BeF}_6$  -  $\text{NH}_4\text{MnF}_3$  -  $\text{H}_2\text{O}$  AT 25°  
(Batsanova and Novoselova, 1956)

In a later paper (Batsanova, Novoselova and Simanov, 1956) the double salt  $(\text{NH}_4)_2\text{BeF}_6 \cdot \text{NH}_4\text{MnF}_3 \cdot 6\text{H}_2\text{O}$  was found in solutions containing 15.23%  $\text{NH}_4\text{F}$ , 14.92%  $\text{BeF}_2$ , 8.02%  $\text{MnF}_2$ .

Moles per 1000 moles			Moles per 1000 moles		
$\text{H}_2\text{O}$		Solid Phase	$\text{H}_2\text{O}$		Solid Phase
$(\text{NH}_4)_2\text{BeF}_6$	$\text{NH}_4\text{MnF}_3$		$(\text{NH}_4)_2\text{BeF}_6$	$\text{NH}_4\text{MnF}_3$	
70.72 <sup>a</sup>	0.0	$(\text{NH}_4)_2\text{BeF}_6$	26.18	0.93	$\text{NH}_4\text{MnF}_3$
70.45	0.34	"	21.83	1.02	"
70.12	0.53	"	17.03	1.08	"
69.47	0.71	"	13.17	1.12	"
68.71	0.73	" + $\text{NH}_4\text{MnF}_3$	10.59	1.24	"
51.07	0.72	$\text{NH}_4\text{MnF}_3$	5.34	1.31 <sup>b</sup>	"
34.31	0.88	"	0.0	1.95 <sup>b</sup>	"

<sup>a</sup>32.30 wt. %

<sup>b</sup>1.36 wt. %

## N NITROGEN

### F AMMONIUM PLATINUM FLUORIDE $(\text{NH}_4)_2\text{PtF}_6$

At 25°, 7.32 gms.  $(\text{NH}_4)_2\text{PtF}_6$  are dissolved in 100 ml. of saturated solution in water. (Wheeler, Perros and Naeser, 1955)

### AMMONIUM TITANIUM FLUORIDE $(\text{NH}_4)_2\text{TiF}_6$

100 cc.  $\text{H}_2\text{O}$  dissolve 25.0 gms.  $(\text{NH}_4)_2\text{TiF}_6$  at 20-22°.

100 cc. 98%  $\text{C}_2\text{H}_5\text{OH}$  dissolve 0.004 gm.  $(\text{NH}_4)_2\text{TiF}_6$  at 20-22°. (Ginsberg, 1932)

### AMMONIUM HAFNIUM FLUORIDE $(\text{NH}_4)_2\text{HfF}_6$

100 gms. sat. solution of Ammonium Hafnium Fluoride in Water contain 26.0 gms.  $(\text{NH}_4)_2\text{HfF}_6$  at 20°. (V. Hevesy, 1923)

### AMMONIUM MANGANESE FLUORIDE $\text{NH}_4\text{MnF}_3$

At 25° 1000 moles  $\text{H}_2\text{O}$  dissolve 1.95 moles  $\text{NH}_4\text{MnF}_3$  (1.36 wt.2). (Batsanova and Novoselova, 1956)

### F AMMONIUM FLUOSILICATE $(\text{NH}_4)_2\text{SiF}_6$

#### SOLUBILITY IN WATER

(Yatlov and Pinayevskaya, 1945; Simpson and Glocker, 1953)

The results of Simpson and Glocker are also given in gms. per liter of saturated solution (in parentheses).

t°	Gms. $(\text{NH}_4)_2\text{SiF}_6$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $(\text{NH}_4)_2\text{SiF}_6$ per 100 gms. sat. sol.	Solid Phase
-1.3	5.00	Ice	25	18.5	$\alpha(\text{NH}_4)_2\text{SiF}_6$
-1.2	10.23	" + $\beta(\text{NH}_4)_2\text{SiF}_6$		18.75 <sup>b</sup>	"
0	10.94	$\beta(\text{NH}_4)_2\text{SiF}_6$	26.7	19.31 (217.8)	"
1.7	11.58 (126.8)	"	35	21.85 (247.8)	"
10	13.95	"	43.3	24.20 (278.0)	"
	14.10 (157.0)	"	50	26.15	"
12	14.65	"	51.7	26.49 (307.0)	"
13	14.69	"	60	28.75 (337.8)	"
14	15.50	" + $\alpha(\text{NH}_4)_2\text{SiF}_6$	68.3	30.91 (369.8)	"
15	15.61 <sup>a</sup>	$\alpha(\text{NH}_4)_2\text{SiF}_6$	75	32.5	"
17.5	15.62 <sup>a</sup>	"	100	37.90	"
18.3	16.71 (187.2)	"	102.1 <sup>c</sup>	38.18	"

<sup>a</sup>Stolba, 1877

<sup>b</sup>Ricci and Skarulis, 1951

<sup>c</sup>Boiling point, 748 mm.

SOLUBILITY OF AMMONIUM FLUOSILICATE IN FLUOSILICIC ACID SOLUTIONS AT 25°  
(Ricci and Skarulis, 1951)

[Solid phase  $(\text{NH}_4)_2\text{SiF}_6$ ]

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
$(\text{NH}_4)_2\text{SiF}_6$	$\text{H}_2\text{SiF}_6$	$(\text{NH}_4)_2\text{SiF}_6$	$\text{H}_2\text{SiF}_6$
18.75	0.0	12.29	17.65
16.31	6.67	10.16	22.57
13.75	13.09	8.54	27.39

THE SYSTEM AMMONIUM FLUOSILICATE - AMMONIUM FLUORIDE - WATER AT 25° F  
(Ricci and Skarulis, 1951)

Sat. sol. wt. %			Sat. sol. wt. %		
$\text{NH}_4\text{F}$	$(\text{NH}_4)_2\text{SiF}_6$	Solid Phase	$\text{NH}_4\text{F}$	$(\text{NH}_4)_2\text{SiF}_6$	Solid Phase
44.64	1.54	$\text{NH}_4\text{F}:\text{I}:$	20.13	8.18	$1:1+(\text{NH}_4)_2\text{SiF}_6$
41.62	1.71	1:1	19.04	8.31	$(\text{NH}_4)_2\text{SiF}_6$
35.01	2.54	1:1	13.94	9.27	"
27.81	4.14	1:1	7.94	11.54	"
21.42	7.15	1:1			

1:1 =  $\text{NH}_4\text{F} \cdot (\text{NH}_4)_2\text{SiF}_6$

THE SYSTEM AMMONIUM FLUOSILICATE - STRONTIUM FLUOSILICATE - WATER AT 25°  
(Ricci and Skarulis, 1951)

[The solutions contained 0.5%  $\text{H}_2\text{SiF}_6$ ]

Sat. sol. wt. %		Solid Phase	Sat. sol. wt. %		Solid Phase
$(\text{NH}_4)_2\text{SiF}_6$	$\text{SrSiF}_6$		$(\text{NH}_4)_2\text{SiF}_6$	$\text{SrSiF}_6$	
18.60	1.73	$(\text{NH}_4)_2\text{SiF}_6$	12.18	5.02	1:6
18.54	3.25	"	10.86	5.19	"
18.55 <sup>m</sup>	5.70	"	7.45	5.73	"
18.68	4.92	" + 1:6	3.75	7.02	"
18.71	4.87	1:6	1.48	9.44	"
18.55	4.97	"	0.63	11.49	"
17.37	5.02	"	0.20	14.66	$1:6+\text{SrSiF}_6 \cdot 2\text{H}_2\text{O}$

<sup>m</sup> metastable

1:6 =  $(\text{NH}_4)_2\text{SiF}_6 \cdot 6\text{SrSiF}_6$



# N NITROGEN

## I AMMONIUM IODIDE $\text{NH}_4\text{I}$

### SOLUBILITY IN WATER

[Smith and Eastlack, 1916; Francois and Delvaulle, 1936 (FD);  
Briggs, Ballard, Alrich, and Wikswo, 1940 (BBAW)]

I = Ice			N = NH <sub>4</sub> I					
t°	Gms. NH <sub>4</sub> I per 100 gms. sat. sol.		t°	Gms. NH <sub>4</sub> I per 100 gms. sat. sol.		t°	Gms. NH <sub>4</sub> I per 100 gms. sat. sol.	
Solid phase Ice			Solid phase NH <sub>4</sub> I					
- 3	11.8 (BBAW)		-20	57.7		30	64.5	
- 6	20.7 "		-15	58.38 (BBAW)		35	65.1 (FD)	
- 9	28.0 "		-10	59.3		40	65.7	
-13	35.8 "		0	60.7		50	66.6	
-16	40.7 "			60.4 (BBAW)			66.7 (FD)	
-21	47.7 "		10	62.1		60	67.7	
-24	51.5 "		11	62.2 (FD)		70	68.7	
-27.4*	55.5 "		15	62.7		75	69.0 (FD)	
-27.5*	55.8		20	53.3		80	69.6	
				63.3 (FD)		100	71.3	
			25	64.8		120	73.3	
				64.5 <sup>a</sup>		140	74.9	

\*eutectic

<sup>a</sup>Seidell, unpublished work

### THE SYSTEM AMMONIUM IODIDE - IODINE - WATER (Briggs, Ballard, Alrich, and Wikswo, 1940)

Results at 0°				Results at -15°			
Gms. per 100 gms. Sat. Sol.		Solid Phase		Gms. per 100 gms. Sat. Sol.		Solid Phase	
$\text{NH}_4\text{I}$	I			$\text{NH}_4\text{I}$	I		
60.8	0.0	$\text{NH}_4\text{I}$		58.38	0.0	$\text{NH}_4\text{I}$	
57.4	8.4	"		56.91	4.25	"	
54.5	14.4	"		55.14	8.85	"	
51.0	22.4	"		53.96 <sup>m</sup>	11.23	"	
49.2	26.1	"		49.76 <sup>m</sup>	20.95	"	
46.8	31.3	"		54.62	10.00	$\text{NH}_4\text{I} + \text{NH}_4\text{I}_3 \cdot 3\text{H}_2\text{O}$	
46.4	31.5	$\text{NH}_4\text{I} + \text{NH}_4\text{I}_3$		50.55	9.91	$\text{NH}_4\text{I}_3 \cdot 3\text{H}_2\text{O}$	
41.9	37.1	$\text{NH}_4\text{I}_3$		47.83	9.68	"	
39.1	40.9	"		45.81	9.78	"	
34.0	49.1	"		42.03	9.93	"	
33.3	50.3	"		40.47	10.30	"	
28.8	58.0	"		39.12	10.19	"	
25.9	63.8	"		37.08	10.52	"	

<sup>m</sup>metastable

(Cont.)

## THE SYSTEM AMMONIUM IODIDE - IODINE - WATER--Cont.

Results at 0°

Results at -15°

Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
NH <sub>4</sub> I	I		NH <sub>4</sub> I	I	
25.8	64.0	NH <sub>4</sub> I <sub>3</sub> +NH <sub>4</sub> I <sub>5</sub> (?)	36.95	10.64	NH <sub>4</sub> I <sub>3</sub> ·3H <sub>2</sub> O+Ice
25.8	63.9	NH <sub>4</sub> I <sub>5</sub> (?)	31.74 <sup>m</sup>	34.38	Ice
25.0	64.2	"	34.54 <sup>m</sup>	21.10	"
24.1	65.4	NH <sub>4</sub> I <sub>5</sub> (?) + I <sub>2</sub>	36.40 <sup>m</sup>	13.63	"
24.0	64.9	I <sub>2</sub>	37.03	11.06	"
23.8	61.4	"	38.61	4.40	"
23.5	56.4	"	39.54	0.0	"
23.3	52.7	"			
22.2	45.6	"			
17.4	27.6	"			
12.2	15.0	"			
3.5	2.9	"			

<sup>m</sup>metastable

t°	Gms. per 100 gms. Sat. Sol.		Solid Phase
	NH <sub>4</sub> I	I	
-27.4	55.5	0	Ice+NH <sub>4</sub> I
0	0	0.016	Ice+I <sub>2</sub>
175	29.9	70.1	NH <sub>4</sub> I+NH <sub>4</sub> I <sub>3</sub>
88.9	10.5	89.5	NH <sub>4</sub> I <sub>3</sub> +I <sub>2</sub>
114	0	100	I <sub>2</sub>
-27.9	53.5	4.6	Ice+NH <sub>4</sub> I <sub>3</sub> ·3H <sub>2</sub> O+NH <sub>4</sub> I
- 8.3	23.2	52.5	Ice+NH <sub>4</sub> I <sub>3</sub> ·3H <sub>2</sub> O+I <sub>2</sub>
- 0.8	46.7	30.0	NH <sub>4</sub> I+NH <sub>4</sub> I <sub>3</sub> ·3H <sub>2</sub> O+NH <sub>4</sub> I <sub>5</sub>
2.4	25.1	64.6	NH <sub>4</sub> I <sub>3</sub> +NH <sub>4</sub> I <sub>3</sub> ·3H <sub>2</sub> O+NH <sub>4</sub> I <sub>5</sub> (?)
0.2	23.9	65.4	I <sub>2</sub> +NH <sub>4</sub> I <sub>3</sub> ·3H <sub>2</sub> O+NH <sub>4</sub> I <sub>5</sub> (?)
9.8	23.2	68.8	I <sub>2</sub> +NH <sub>4</sub> I <sub>3</sub> +NH <sub>4</sub> I <sub>5</sub> (?)

THE SYSTEM AMMONIUM IODIDE - ANTIMONY IODIDE - WATER  
(Francois and Delwaule, 1936)

The results are given only in the form of a diagram from which the following approximate values have been taken.

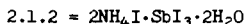
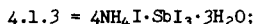
The SbI<sub>3</sub> end of the curves could not be determined on account of hydrolysis.

(Cont.)

# N NITROGEN

## THE SYSTEM AMMONIUM IODIDE - ANTIMONY IODIDE - WATER--Cont.

t°	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	t°	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
	NH <sub>4</sub> I	SbI <sub>3</sub>			NH <sub>4</sub> I	SbI <sub>3</sub>	
11	164	0	NH <sub>4</sub> I	35	225	125	4.1.3
"	180	35	"	"	240	150	" +2.1.2
"	195	62	" +4.1.3	"	190	125	2.1.2
"	190	85	4.1.3	50	200	0	NH <sub>4</sub> I
"	192	110	" + ?	"	215	50	"
"	170	120	2.1.2 + ?	"	245	100	"
"	140	110	2.1.2	"	265	135	" +4.1.3
20	172	0	NH <sub>4</sub> I	"	265	155	2.1.2 + "
"	195	40	"	"	200	130	2.1.2
"	210	70	" +4.1.3	75	223	0	NH <sub>4</sub> I
"	205	100	4.1.3	"	245	50	"
"	215	145	" + ?	"	270	100	"
"	210	150	2.1.2 + ?	"	290	145	" +4.1.3
"	185	130	2.1.2	"	290	155	2.1.2 + "
35	186	0	NH <sub>4</sub> I	"	250	135	2.1.2
"	205	50	"	"	150	110	"
"	235	95	" +4.1.3				



## SOLUBILITY OF AMMONIUM IODIDE IN AQUEOUS ALCOHOL AT 25° (Seidell, unpublished)

Gms. C <sub>2</sub> H <sub>5</sub> OH per 100 gms. Solvent	d <sub>25</sub> of Sat. Sol.	Gms. NH <sub>4</sub> I per 100 gms.		Gms. C <sub>2</sub> H <sub>5</sub> OH per 100 gms. Solvent	d <sub>25</sub> of Sat. Sol.	Gms. NH <sub>4</sub> I per 100 gms.	
		Sat.	Sol. Solvent			Sat.	Sol. Solvent
0	1.646	64.5	181.9	60	1.250	43.8	77.9
10	1.590	61.7	161.1	70	1.168	39.0	64.0
20	1.525	58.7	142.1	80	1.094	33.3	49.9
30	1.462	55.5	124.8	90	1.013	27.5	37.9
40	1.395	52.0	108.3	100	0.929	20.8	26.3
50	1.320	48.0	92.3				

Data for equilibrium in the systems  $\text{NH}_4\text{I} + \text{I} + \text{C}_6\text{H}_6$  and  $\text{NH}_4\text{I} + \text{I} + \text{C}_6\text{H}_5\text{CH}_3$  are given by Foote and Bradley, 1933. The results show that no compound with the solvent occurs but only the binary tri iodide,  $\text{NH}_4\text{I}_3$ , which is stable over a wide range of iodine concentrations. Since  $\text{NH}_4\text{I}$  is practically insoluble in benzene and in toluene the authors analytical values are for the percentages of iodine in solution at each invariant point.

Data for the distribution of  $\text{NH}_4\text{I}$  between ethylene glycol and ethyl acetate at 30° are given by Dawson and Griffiths, 1951. Average K (glycol/ester) = 292 (in moles per liter) when the concentration in the glycol is about 0.1M.

100 cc. of sat. sol. in ethyl urethan at 60° contains 9.00 gms.  $\text{NH}_4\text{I}$ . (Stuckgold, 1917)

## SOLUBILITY OF AMMONIUM IODIDE IN LIQUID AMMONIA

Gms. $\text{NH}_4\text{I}$ per 100			$t^\circ$	Gms. $\text{NH}_4\text{I}$ per 100	
cc. $\text{NH}_3$	gms. $\text{NH}_3$			cc. $\text{NH}_3$	gms. $\text{NH}_3$
-50.0	62.1	- (1)	-38.6	69.2	- (1)
-47.5	63.3	- (1)	-35.3	71.2	- (1)
-45.2	64.6	- (1)	0.0	-	334.6 (2)
-42.0	66.7	- (1)	+25.0	-	368.5 (3)

(1) Scherer, 1931

(2) Linhard and Stephan, 1933, 1934

(3) Hunt and Boncyk, 1933

100 gms. liquid Sulfur Dioxide ( $\text{SO}_2$ ) dissolve 8.4 gms.  $\text{NH}_4\text{I}$  at  $0^\circ$ .  
(Jander and Wickert, 1936; Jander and Ruppert, 1937)

The phase diagram for the system  $\text{NH}_4\text{I} + \text{I}_2$  was determined by Briggs and Ballard, 1940.

Determinations of the vapor pressure - temperature relations in the system  $\text{NH}_4\text{I} + \text{SO}_2$  are given by Foote and Fleischer, 1931.

TETRAMETHYL AMMONIUM IODIDE  $(\text{CN}_3)_4\text{NI}$ SOLUBILITY IN SEVERAL SOLVENTS  
(Walden, 1906)

Solvent	Formula	$t^\circ$	Sp. Gr. of Solution	Gms. $\text{N}(\text{CH}_3)_4\text{I}$ per 100	
				cc. Solution	Gms. Solution
Water	$\text{H}_2\text{O}$	0	1.0188	2.01	1.97
		25	1.0155	5.31 - 5.89	5.22
Methyl Alcohol	$\text{CH}_3\text{OH}$	0	0.8025	0.18 - 0.22	0.22
		25	0.7920	0.38 - 0.42	0.48
Ethyl Alcohol	$\text{C}_2\text{H}_5\text{OH}$	25	0.7894	0.09	-
Glycol	$(\text{CH}_2\text{OH})_2$	0	-	1.014	-
		25	1.0678	0.240	0.224
Acetonitril	$\text{CH}_3\text{CN}$	25	-	0.650	-
Nitro Methane	$\text{CH}_3\text{NO}_2$	0	1.1387	0.25 - 0.32	0.22
		25	1.1285	0.34 - 0.38	0.21
Acetone	$(\text{CH}_3)_2\text{CO}$	0	-	0.118	-
		25	-	0.187	-
Salicyl Aldehyde	$\text{C}_6\text{H}_4\text{OH}.\text{COH}$	0	1.1492	0.302	0.263
		25	1.1379	0.510	0.484
Ethyl Urethan	$\text{C}_2\text{H}_5\text{NHCOOC}_2\text{H}_5$	60	-	0.45 <sup>a</sup>	-

<sup>a</sup>Stuckgold, 1917

Very exact determinations of the solubility of tetra methyl ammonium iodide in aqueous solutions of KOH and of  $\text{NH}_4\text{CN}$  at  $25^\circ$  are given by Hill (1917).

Freezing points for mixtures of tetra methyl ammonium iodide and iodine are given by Olivari, 1908.

# N NITROGEN

## TETRAETHYL AMMONIUM IODIDE $(C_2H_5)_4NI$

### SOLUBILITY IN SEVERAL SOLVENTS (Walden, 1906)

Results in parentheses are by Walden, 1908; those at 20° and 35° are by Bjerrum and Josefowicz, 1932.

Solvent	Formula	t°	Sp. Gr. of Solution	Gms. $N(C_2H_5)_4I$ per 100	
				cc. Solution	Gms. Solution
Water	$H_2O$	0	1.0470	16.31	15.58
		20	1.0846	-	27.50
		25	1.1021	36.33	32.9
				(35.5)	31.1 <sup>a</sup>
		35	1.1227	-	39.55
Methyl Alcohol	$CH_3OH$	0	0.8326	3.7-4.3	4.44
		20	0.8277	-	9.05
		25	0.8463	10.5	12.29
				(10.7)	
Ethyl Alcohol	$C_2H_5OH$	35	0.8430	-	16.14
		0	0.7928	0.348	0.439
		20	0.7937	-	0.914
		25	0.7844	0.98	1.113
Glycol	$(CH_2OH)_2$			(0.88)	
		35	0.7848	-	1.86
		0	1.1039	3.27	2.97
		25	1.0904	7.63	7
Acetonitrile	$CH_3CN$			(7.55)	
		0	0.8163	2.24	2.74
		25	0.7929	2.97	3.74
Propionitrile	$CH_3CH_2CN$			(3.54)	
		0	0.8059	0.618	0.767
		25	0.7830	0.81-	0.99
Benzonitrile	$C_6H_5CN$	25	-	1.01	
Methyl Sulphocyanide	$CH_3SCN$	25	1.0828	0.467	0.451
Ethyl Sulphocyanide	$C_2H_5SCN$	25	1.0012	4.40	4.06
Nitromethane	$CH_3NO_2$	0	1.1658	0.475	0.47
		25	1.1476	3.59	3.004
				5.38-	4.72
				6.27	
Nitroso Dimethylamine	$(CH_3)_2N.NO$	25	1.0059	2.67	2.66
Acetyl Acetone	$CH_3COCH_2COCH_3$	25	-	0.268	-
Furfural	$C_4H_3O.CO$	0	1.1738	3.91	3.33
		25	1.1692	5.33	4.55
Benzaldehyde	$C_6H_5COH$	25	-	0.43	-
Salicylaldehyde	$C_6H_4OH.CO$	25	-	change-	-
				able -	
				17.7	
Anisaldehyde	$C_6H_4.OCH_3.CO$	25	-	0.59	-
Acetone	$(CH_3)_2CO$	0	0.7991	0.174	0.218
		20	0.7903	-	0.198
		25	-	0.249	0.316
		35	0.7738	-	0.250
Ethyl Acetate	$CH_3COOCH_2CH_3$	25	-	0.00039	-

<sup>a</sup>Peddle and Turner, 1913

(Cont.)

## SOLUBILITY IN SEVERAL SOLVENTS--Cont.

Solvent	Formula	t°	Sp. Gr. of Solution	Gms. N(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> I per 100	
				cc. Solution	Gms. Solution
Ethyl Nitrate	C <sub>2</sub> H <sub>5</sub> ONO <sub>2</sub>	25	1.0984	0.062	0.056
Benzoyl Ethyl Acetate	C <sub>6</sub> H <sub>5</sub> COCH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>	25	1.1303	0.321	0.284
Dimethyl Malonate	CH <sub>2</sub> (COOCH <sub>3</sub> ) <sub>2</sub>	25	1.1335	0.040	0.035
Methyl Cyano Acetate	CH <sub>2</sub> CNCOOCH <sub>3</sub>	0	1.1341	1.82	1.605
		25	-	2.83	-
Ethyl Cyano Acetate	CH <sub>2</sub> CNCOOCH <sub>2</sub> H <sub>5</sub>	0	1.0760	1.057	0.981
		25	1.0607	1.71	1.41
Nitrobenzene	C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>	25	-	0.504	0.422
Acetophenone	C <sub>6</sub> H <sub>5</sub> COCH <sub>3</sub>	-	-	0.13	0.127
Amyl Alcohol	C <sub>5</sub> H <sub>11</sub> OH	-	-	0.071	0.089
Paraldehyde	(C <sub>2</sub> H <sub>4</sub> O) <sub>3</sub>	-	-	0.036	0.037
Methyl Formate	HCOOCH <sub>3</sub>	-	-	0.031	0.032
Bromobenzene	C <sub>6</sub> H <sub>5</sub> Br	-	-	0.009	0.006
Ethyl Urethan	C <sub>2</sub> H <sub>5</sub> NHCO <sub>2</sub> C <sub>2</sub> H <sub>5</sub>	60	-	1.63 <sup>b</sup>	-
Chloroform	CHCl <sub>3</sub>	25	-	-	1.53 <sup>a</sup>

<sup>a</sup>Peddle and Turner, 1913<sup>b</sup>Stuckgold, 1914TETRAPROPYL AMMONIUM IODIDE N(C<sub>3</sub>H<sub>7</sub>)<sub>4</sub>ISOLUBILITY IN SEVERAL SOLVENTS  
(Walden, 1906)

Solvent	Formula	t°	Sp. Gr. of Solution	Gms. N(C <sub>3</sub> H <sub>7</sub> ) <sub>4</sub> I per 100	
				cc. Solution	Gms. Solution
Water	H <sub>2</sub> O	25	-	-	15.74 <sup>a</sup>
Methyl Alcohol	CH <sub>3</sub> OH	0	0.9756	40.92	41.94
		25	1.0187	56.42	55.37
Ethyl Alcohol	C <sub>2</sub> H <sub>5</sub> OH	0	0.8349	6.5-6.8	8.14
		25	0.8716	19.88-20.29	23.28
Acetonitrile	CH <sub>3</sub> CN	0	0.8553	13.03	15.24
		25	0.8584	18.69	21.77
Propionitrile	C <sub>2</sub> H <sub>5</sub> CN	0	0.8280	6.37	7.66
		25	0.8191	9.65	10.29
Benzonitrile	C <sub>6</sub> H <sub>5</sub> CN	25	1.0199	8.44	8.35
Nitro Methane	CH <sub>3</sub> NO <sub>2</sub>	0	1.181	14.79	12.52
		25	1.158	22.24	19.21
		25	1.193	5.71	4.79
Benzaldehyde	C <sub>6</sub> H <sub>5</sub> COH	0	1.0581	7.06	6.67
		25	1.0549	9.87	9.35

<sup>a</sup>Peddle and Turner, 1913

(Cont.)

# N NITROGEN

## SOLUBILITY IN SEVERAL SOLVENTS--Cont.

Solvent	Formula	5°	Sp. Gr. of Solution	Gms. $N(C_2H_7)_4I$ per 100	
				cc. Solution	Gms Solution
Anisaldehyde	$C_6H_5 \cdot OCH_3 \cdot COH$	0	1.1114	5.60	5.04
		25	1.004	6.75	6.14
Salicylaldehyde	$C_6H_5 \cdot OH \cdot COH$	25	-	39.28	-
Ethyl nitrite	$C_2H_5NO_2$	0	1.1207	0.522	0.466
		25	1.1025	0.653	0.592
Dimethyl Malonate	$CH_2(COOCH_3)_2$	0	1.1532	0.298	0.259
		25	1.1345	0.320	0.282
Acetone	$(CH_3)_2CO$	0	0.8259	2.692	4.65
		25	0.8049	3.944	4.90
Ethyl Acetate	$CH_3COOC_2H_5$	25	0.8975	0.0063	0.007
Ethyl Bromide	$C_2H_5Br$	25	-	-	0.187
Chloroform	$CHCl_3$	25	-	-	35.3 <sup>a</sup>

<sup>a</sup>Peddle and Turner, 1913

## I TETRABUTYL AMMONIUM IODIDE $N(C_4H_9)_4I$

### SOLUBILITY IN MIXTURES OF BENZENE AT 25° (Vernon, Luder, and Giella, 1941)

Tetrabutyl Ammonium Picrate Added Moles per liter $\times 10^4$	Moles $N(C_4H_9)_4I$ per liter $\times 10^4$ ,	Tetrabutyl Ammonium Picrate Added Moles per liter $\times 10^4$	Moles $N(C_4H_9)_4I$ per liter $\times 10^4$
0.0	3.36	0.0	3.36
1.42	3.88	4.36	6.78
2.84	5.39	8.73	9.3
11.33	8.28	21.82	14.8
28.40	16.5	43.64	20.0
56.80	30.5		

## I TETRA AMYL AMMONIUM IODIDE $N(C_5H_{11})_4I$

100 gms.  $H_2O$  dissolve 0.74 gms.  $N(C_5H_{11})_4I$  at 25°.

100 gms.  $CHCl_3$  dissolve 210.8 gms.  $N(C_5H_{11})_4I$  at 25°.

(Peddle and Turner, 1913)

Freezing points for mixtures of phenyltrimethyl ammonium iodide and iodine are given by Olivari (1908).

AMMONIUM IODATE  $\text{NH}_4\text{IO}_3$ 

10

THE SYSTEM AMMONIUM IODATE - IODIC ACID - WATER AT  $30^\circ$   
(Meerburg, 1905)

Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
$\text{HIO}_3$	$\text{NH}_4\text{IO}_3$		$\text{HIO}_3$	$\text{NH}_4\text{IO}_3$	
0	4.20	$\text{NH}_4\text{IO}_3$	24	0.62	$\text{NH}_4\text{IO}_3 \cdot 2\text{HIO}_3$
2.54	3.89	"	44.43	0.39	"
4.52	3.83	" $+\text{NH}_4\text{IO}_3 \cdot 2\text{HIO}_3$	76.35	0.31	" $+\text{HIO}_3$
6.57	1.94	$\text{NH}_4\text{IO}_3 \cdot 2\text{HIO}_3$	76.70	0	$\text{HIO}_3$

AMMONIUM PERIODATE  $\text{NH}_4\text{IO}_4$ 

100 gms.  $\text{H}_2\text{O}$  dissolve 2.7 gms. salt at  $16^\circ$ ,  $d_{16} = 1.078$ . (Barker, 1908)

AMMONIUM PERMANGANATE  $\text{NH}_4\text{MnO}_4$ 

MnO

100 parts water dissolve approximately 8 parts of  $\text{NH}_4\text{MnO}_4$  at  $15^\circ$ . (Aschoff)

AMMONIUM MOLYBDATES  $x(\text{NH}_4)_2\text{O} \cdot y\text{MoO}_3 \cdot z\text{H}_2\text{O}$ 

MoO

THE SYSTEM AMMONIA - MOLYBDIC ACID - WATER  
(Results of Funaki and Segawa, 1950)

At 25°		At 40°		Solid Phase at each temp.
Sat. Sol. wt. %		Sat. Sol. wt. %		
NH <sub>3</sub>	MoO <sub>3</sub>	NH <sub>3</sub>	MoO <sub>3</sub>	
0.172	4.3	0.261	5.12	(NH <sub>4</sub> ) <sub>2</sub> O·3MoO <sub>3</sub> ·2H <sub>2</sub> O
0.73	6.1	0.706	7.03	"
0.88	8.3	1.06	8.29	"
1.18	10.0	1.36	10.1	"
1.74	18.0	2.02	16.9	3(NH <sub>4</sub> ) <sub>2</sub> O·7MoO <sub>3</sub> ·4H <sub>2</sub> O
3.16	18.5	3.04	18.7	"
3.56	19.1	3.74	20.2	"
4.69	22.1	-	-	"
5.15	25.9	4.75	23.2	(NH <sub>4</sub> ) <sub>2</sub> O·2MoO <sub>3</sub> ·H <sub>2</sub> O
6.15	28.0	5.55	25.6	"
6.28	28.5	6.25	28.8	"
6.74	31.1	6.54	29.3	"
-	-	7.48	31.9	"
6.83	31.2	7.63	32.7	(NH <sub>4</sub> ) <sub>2</sub> O·MoO <sub>3</sub>
8.12	30.4	7.85	32.4	"
11.48	27.1	8.73	31.4	"
-	-	9.30	30.4	"
		10.70	29.8	"

(Cont.)



# N NITROGEN

## THE SYSTEM AMMONIA - MOLYBDIC OXIDE - WATER--Cont.

(Earlier results of Foote and Bradley, 1936, at 25°, differing from those above)

The study of this system is rendered difficult by the slowness with which equilibrium is reached at the molybdenum end of the diagram and the colloidal character and high concentration of the solutions at the other end. The mixtures were prepared from the well crystalline ammonium paramolybdate,  $3(\text{NH}_4)_2\text{MoO}_4 \cdot 4\text{MoO}_3 \cdot 4\text{H}_2\text{O}$ , and either ammonia or  $\text{MoO}_3$ , and rotated for periods of several weeks to several months. Both the saturated solutions and solid phases were analyzed.

The authors call attention to the improbability of the existence at 25° of all of the five ammonium molybdates, mentioned in the literature, which contain a larger proportion of  $\text{MoO}_3$  than present in the above two compounds.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{NH}_3$	$\text{MoO}_3$		$\text{NH}_3$	$\text{MoO}_3$	
5.72	26.94	3.4.4	3.39	17.54	3.5.4
4.40	21.97	"	3.02	14.75	"
4.09	20.86	"	2.56	12.71	"
3.60	19.45	"	2.27	11.25	"
3.44	19.03	"	1.86	9.54	"
3.56	18.87	" + 3.5.4	1.35	7.00	"

3.4.4 =  $3(\text{NH}_4)_2\text{MoO}_4 \cdot 4\text{MoO}_3 \cdot 4\text{H}_2\text{O}$

3.5.4 =  $3(\text{NH}_4)_2\text{MoO}_4 \cdot 5\text{MoO}_3 \cdot 4\text{H}_2\text{O}$

100 gms. of a saturated solution of ammonium molybdate in furfural contain 0.4 gms.  $(\text{NH}_4)_2\text{MoO}_4$  at 25°. (Trimble, 1941)

## MoO AMMONIUM DIMOLYBDATE $(\text{NH}_4)_2\text{Mo}_2\text{O}_7$

### THE SYSTEM $(\text{NH}_4)_2\text{Mo}_2\text{O}_7$ - $(\text{NH}_4)_2\text{SO}_4$ - $\text{H}_2\text{O}$ AT 25° (Zvorykin and Perel'man, 1954)

Sat. Sol. wt. %			Solid Phase	Sat. Sol. wt. %			Solid Phase
$\text{NH}_4^+$	$\text{MoO}_4^-$	$\text{SO}_4^{2-}$		$\text{NH}_4^+$	$\text{MoO}_4^-$	$\text{SO}_4^{2-}$	
11.74	-	33.5	$(\text{NH}_4)_2\text{SO}_4$	9.09	10.9	16.4	$(\text{NH}_4)_2\text{Mo}_2\text{O}_7$
12.27	4.29	30.5	"	8.47	14.02	13.2	"
11.72	6.4	28.03	"	7.08	21.5	6.1	"
11.8	7.5	27.0	" + $(\text{NH}_4)_2\text{Mo}_2\text{O}_7$	6.3	26.57	-	"
11.9	9.1	26.2	$(\text{NH}_4)_2\text{Mo}_2\text{O}_7$				

AMMONIUM TRIMOLYBDATE  $(\text{NH}_4)_2\text{Mo}_3\text{O}_{10}$ 

MoO

At 15°, 1 liter sat. sol. contains 14.0 gms.  $(\text{NH}_4)_2\text{Mo}_3\text{O}_{10}$ ; the solid phase is the monohydrate. (Travers and Malaprade, 1926).

AMMONIUM TETRAMOLYBDATE  $(\text{NH}_4)_2\text{Mo}_4\text{O}_{13}$ [Solid phase  $(\text{NH}_4)_2\text{Mo}_4\text{O}_{13} \cdot 2\text{H}_2\text{O}$ ]

t°

Solubility in Water

15	9.5 gms. $(\text{NH}_4)_2\text{Mo}_4\text{O}_{13}$ per liter sat. sol.	(Travers and
	3.52 gms. $(\text{NH}_4)_2\text{Mo}_4\text{O}_{13} \cdot 2\text{H}_2\text{O}$ per 100 gms. $\text{H}_2\text{O}$	Malaprade, 1926)
	(d. = 1.03)	
18	3.67 gms. $(\text{NH}_4)_2\text{Mo}_4\text{O}_{13} \cdot 2\text{H}_2\text{O}$ per 100 gms. $\text{H}_2\text{O}$	(Wempe, 1912)
	(d. = 1.04)	
32	4.60 gms. $(\text{NH}_4)_2\text{Mo}_4\text{O}_{13} \cdot 2\text{H}_2\text{O}$ per 100 gms. $\text{H}_2\text{O}$	(Wempe, 1912)
	(d. = 1.05)	

AMMONIUM PHOSPHO MOLYBDATE  $(\text{NH}_4)_3\text{PO}_4 \cdot 14\text{MoO}_3 \cdot 4\text{H}_2\text{O}$ 

SOLUBILITY IN WATER AND AQUEOUS SOLUTIONS AT 15°  
(de Lucchi, 1910)

Solvent	Gms. Salt per 1000 Gms. Solvent
Water	0.238
5 per cent aqueous $\text{NH}_4\text{NO}_3$ solution	0.137
1 per cent aqueous $\text{HNO}_3$ solution	0.203

AMMONIUM TRI NITRIDE  $\text{NH}_4\text{N}_3$ 

N

SOLUBILITY OF AMMONIUM TRINITRIDE IN WATER  
(Frost, Cothran and Browne, 1933)

t°	Gms. $\text{NH}_4\text{N}_3$ per 100 gms. sat. sol.	Solid Phase
0	13.8	$\text{NH}_4\text{N}_3$
20	20.16	"
40	27.07	"

Pressure-temperature-concentration relations in the binary system ammonium tri nitride-ammonia are given by Howard, Jr., Friederichs and Browne, 1934. The solvates, ammonium trinitride diammonate,  $\text{NH}_4\text{N}_3 \cdot 2\text{NH}_3$ , and ammonium trinitride penta ammonate,  $\text{NH}_4\text{N}_3 \cdot 5\text{NH}_3$ , were obtained as white crystalline solids. The diammonate undergoes inversion into ammonous salt at -9° and the pentaammonate undergoes inversion into the diammonate at -71°. The eutectic is located at -87° and 76% ammonia.

## N NITROGEN

### N TRIMETHYL AMMONIUM TRINITRIOE $N(CH_3)_3N_3$

APPROXIMATE SOLUBILITY IN SEVERAL SOLVENTS AT 20°  
(Friedlander, 1918)

	Gms. $N(CH_3)_4N_3$ per 100 gms. sat. sol.		Gms. $N(CH_3)_4N_3$ per 100 gms. sat. sol.
Water	50.0	Benzene	0.4
Ethyl alcohol	5.0	Chloroform	0.1
Methyl alcohol	2.0	Ethyl ether	0.05

Excess of the salt in contact with carbon tetrachloride forms two layers, the lower of which contains 0.5 gm.  $N(CH_3)_4N_3$  per 100 cc.

### NO AMMONIUM NITRITE $NH_4NO_2$

SOLUBILITY OF AMMONIUM NITRITE IN WATER\_  
DETERMINED BY THE FREEZING-POINT METHOD  
(Bureau, 1937)

t°	Gms. $NH_4NO_2$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $NH_4NO_2$ per 100 gms. sat. sol.	Solid Phase
- 5.2	20.2	Ice	-11.15	50.05	$NH_4NO_2$
-10.5	17.95	"	+ 1.4	56.0	"
-12.4	21.3	"	19.15	64.3	"
-21.75	35.0	"	33.45	75.0	"
-27.9 (Eutec.)	42.5	" + $NH_4NO_2$			

Above 33° the saturated solutions decompose rapidly.

### AMMONIUM SODIUM RHODIUM NITRITE $(NH_4)_2Na[Rh(NO_2)_6]$

SOLUBILITY IN WATER  
(Petkov, 1949)

t°	Gms. $(NH_4)_2Na[Rh(NO_2)_6]$ per liter Sat. Sol.
10	0.94
20	1.47
25	2.09

### NO AMMONIUM NITRATE $NH_4NO_3$

THE SYSTEM AMMONIUM NITRATE - WATER

Although a large number of determinations have been made on this common system, the agreement between authors is only within 1% of the average curve. This is probably caused both by the high solubility and by the existence of several polymorphic forms. The transition between two forms at 32.3° can be observed as a break in the solubility curve, but the other transitions (at -16°, 84°, 125°) cannot.

(Cont.)

## THE SYSTEM AMMONIUM NITRATE - WATER--Cont.

The following results were read from the average curve through the data of Rodenbush, 1918; Early and Lowry, 1919; Millican, Joseph and Lowry, 1922; Kazantzev, 1923, 1925; Mondain Monval, 1923, 1925; Cohen and Bredee, 1925; Schwarz; Muller and Kaufman, 1901-02; de Waal, 1910; Schreinemakers and Haenen, 1910; Hunt, 1932; Kurnakow and Rawitsch, 1933; Nikitina, 1933; Sokolov, 1938; Bergman and Botchkareff, 1937; Bahl and Singh, 1941; Shpunt, 1946; Alexandrov, 1941; Thompson and Vener, 1948; Karnaukhov, 1954; Urazov and Shevtsova, 1957.

t°	Gms. NH <sub>4</sub> NO <sub>3</sub> per 100 gms. sat. sol.	Solid Phase	t°	Gms. NH <sub>4</sub> NO <sub>3</sub> per 100 gms. sat. sol.	Solid Phase	NO
- 5	12.5	Ice	50	77.8	NH <sub>4</sub> NO <sub>3</sub> III	
-10	25.1	"	55	79.3	"	
-15	37.8	"	60	80.7	"	
-16.8	42.4	" + NH <sub>4</sub> NO <sub>3</sub>	65	82.0	"	
-16	-	NH <sub>4</sub> NO <sub>3</sub> V + NH <sub>4</sub> NO <sub>3</sub> IV	70	83.3	"	
-15	43.8	NH <sub>4</sub> NO <sub>3</sub> IV	75	84.6	"	
-10	47.3	"	80	85.7	"	
- 5	50.7	"	84-85	86.9	" + NH <sub>4</sub> NO <sub>3</sub> II	
0	54.2	"	90	88.2	NH <sub>4</sub> NO <sub>3</sub> II	
+ 5	57.0	"	95	89.3	"	
10	60.0	"	100	90.3	"	
15	62.8	"	110	92.3	"	
20	65.5	"	120	94.1	"	
25	68.2	"	125	94.8	" + NH <sub>4</sub> NO <sub>3</sub> I	
30	70.4	"	130	95.7	NH <sub>4</sub> NO <sub>3</sub> I	
32.3	71.0	" + NH <sub>4</sub> NO <sub>3</sub> III	140	96.9	"	
35	72.3	NH <sub>4</sub> NO <sub>3</sub> III	150	98.2	"	
40	74.6	"	160	99.2	"	
45	76.3	"	170	100.0	"	

NH<sub>4</sub>NO<sub>3</sub> I = cubic

II = tetragonal

III = rhombohedral

IV = rhombic

V = orthorhombic

Data for the Solubility of Ammonium Nitrate in Water at 25° and under pressures up to 12 kilobars are given by Adams and Gibson, 1932. The Solubility decreases continually from 67.6 percent at atmospheric pressure to 43.6% at 5 kilobars pressure, 29.7% at 10 kilobars and 25.3% at 12 kilobars, the eutectic pressure.

SOLUBILITY OF AMMONIUM NITRATE IN AQUEOUS SOLUTIONS OF NITRIC ACID (Kazantzev, 1923, 1925 at 0°, 15°, 30°, 75°; Nichols, Howes et al., 1919 at 20°; Flatt and Fritz, 1950 at 25°; Flatt, Brunisholz and Denereaz, 1956 at 50°)

The results of Kurnakow and Rawitsch, 1933 are in agreement with these. Additional data are given by Perov and Kharitonov, 1955 between 0 - 70°, 10 - 50% HNO<sub>3</sub>.

(Cont.)

# N NITROGEN

## SOLUBILITY OF AMMONIUM NITRATE IN AQUEOUS SOLUTIONS OF NITRIC ACID--Cont.

[Solid Phase  $\text{NH}_4\text{NO}_3$ , except as noted]

Results at 0°		Results at 15°		Results at 20°	
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
HNO <sub>3</sub>	NH <sub>4</sub> NO <sub>3</sub>	HNO <sub>3</sub>	NH <sub>4</sub> NO <sub>3</sub>	HNO <sub>3</sub>	NH <sub>4</sub> NO <sub>3</sub>
0.0	54.3	0.0	62.4	0.0	65.63
9.2	43.5	0.7	61.1		
15.5	38.4	2.8	59.1	3.98	60.16
21.0	34.5	7.7	53.3	8.81	55.95
24.0	32.8	9.0	52.0		
27.0	31.9	16.4	45.7	14.65	51.17
30.0	31.1	21.7	42.2	21.46	46.35
33.2	31.0	27.1	40.9		
36.2	32.1	31.5	39.2	28.33	43.35
39.1	33.2	36.7	39.9		
41.4	34.0	39.0	40.8		
45.8	39.5	44.0	46.8		
47.4	48.2	45.0	52.5		

NO

Results at 25°		Results at 30°		Results at 50°			Results at 75°	
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Moles per 100 moles dissolved electrolyte			Gms. per 100 gms. sat. sol.	
HNO <sub>3</sub>	NH <sub>4</sub> NO <sub>3</sub>	HNO <sub>3</sub>	NH <sub>4</sub> NO <sub>3</sub>	HNO <sub>3</sub>	NH <sub>4</sub> NO <sub>3</sub>	H <sub>2</sub> O	HNO <sub>3</sub>	NH <sub>4</sub> NO <sub>3</sub>
0.0	67.51	0.0	70.2	0	100.0	130.7	0.0	84.1
14.19	53.28	3.5	65.5	30.6	69.4	95.4	12.8	73.7
25.06	46.69	8.6	60.9	34.0	66.0	83.8	16.0	71.8
38.94	46.93	10.6	58.8	41.1	58.9	59.9	26.3	67.5
42.13	49.88	14.4	55.6	55.2	44.8	5.0	31.6	66.8
43.50	56.31	16.7	53.1	55.3	44.7	4.2		
51.94	48.10*	20.8	51.5					
60.05	38.13*	22.1	50.0					
69.65	30.28*	26.4	48.5					
		30.0	47.5					
		37.5	48.6					
		40.1	51.0					
		42.2	55.6					

\*Solid phase  $\text{NH}_4\text{NO}_3 \cdot 2\text{HNO}_3$

## SOLUBILITY OF AMMONIUM "TRI-NITRATE" IN WATER (Groschuff, 1904)

t°	Gms. $\text{HNO}_3$ per 100 gms. Solution	Gms. $\text{NH}_4\text{NO}_3$ per 100 gms. Solution	Mols. $\text{NH}_4\text{NO}_3$ * per 100 mols. $\text{H}_2\text{O}$	Mols. $\text{NH}_4\text{NO}_3$ per 100 total mols. Solution	Solid Phase
- 8	34.2	53.9	64.3	22	$\text{NH}_4\text{NO}_3 \cdot 2\text{HNO}_3$
- 2.5	34.8	54.8	75.1	23.1	"

\*or  $\text{NH}_4\text{NO}_3 \cdot 2\text{HNO}_3$

(Cont.)

## SOLUBILITY OF AMMONIUM "TRI-NITRATE" IN WATER--Cont.

t°	Gms. $\text{NH}_4\text{NO}_3$ per 100 gms. Solution	Gms. $\text{HNO}_3$ per 100 gms. Solution	$\text{NH}_4\text{NO}_3^*$ per 100 mols. $\text{H}_2\text{O}$	Mols. $\text{NH}_4\text{NO}_3$ per 100 total mols. Solution	Solid Phase
+ 3	35.4	55.8	90	24.3	$\text{NH}_4\text{NO}_3 \cdot 2\text{HNO}_3$
8.5	36.6	56.9	113	25.7	"
19.5	37.4	58.9	225	29	"
25	38.1	60.0	450	31	"
29.5	38.8	61.2	$\infty$	33	"

m. pt.

\*or  $\text{NH}_4\text{NO}_3 \cdot 2\text{HNO}_3$ 

## SOLUBILITY OF AMMONIUM NITRATE IN AQUEOUS AMMONIA SOLUTIONS

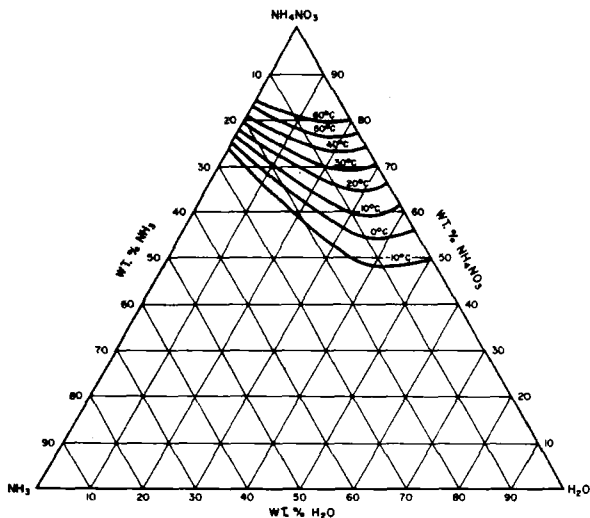
The various data are in good agreement. Worthington, Datin and Schutz also give density and vapor pressure values. The densities and partial pressures of solutions of ammonium nitrate in aqueous ammonia were determined at 10° and 35° by Schultz and Elmore, 1946.

NO

## Results of Alexandrov, 1941

Gms. $\text{NH}_3$ per 100 gms. $\text{H}_2\text{O}$	-20°	-10°	0°	10°	20°	30°	40°	50°
0	-	89.5	118	150	186	235	296	355
10	69	96	128	161	201	253	315	373
20	80	106	138	174	218	273	337	405
25	88	114.5	149.5	185	230	287	353	420
30	96	123.5	158.5	198	242	303	370	438
40	110	141	180	221	268	333	405	477

## Results of Worthington, Datin and Schutz, 1952



(Cont.)

## N NITROGEN

### SOLUBILITY OF AMMONIUM NITRATE IN AQUEOUS AMMONIA SOLUTIONS--Cont.

#### Results of Hunt, 1932 at 25°

Gms. H <sub>2</sub> O per 100 gms. NH <sub>3</sub> +H <sub>2</sub> O	Gms. NH <sub>4</sub> NO <sub>3</sub> per 100 gms. solvent	Gms. H <sub>2</sub> O per 100 gms. NH <sub>3</sub> +H <sub>2</sub> O	Gms. NH <sub>4</sub> NO <sub>3</sub> per 100 gms. solvent
0	390.0	13.2	351.9
1.78	383.7	15.9	337.4
2.80	381.0	18.6	331.8
3.40	378.6	21.8	316.8
4.82	372.8	47.5	247.0
6.86	368.6	68.0	220.0
10.1	354.7	100.	214.2
12.1	352.1		

NO

### THE SYSTEM AMMONIUM NITRATE - AMMONIUM THIOCYANATE - AMMONIA - WATER (Foote and Brinkley, 1921)

The mixtures were shaken at constant temperatures and the saturated solutions analyzed by titrating the ammonia, using Congo Red as indicator, and the thiocyanate by the Volhard method. The NH<sub>4</sub>NO<sub>3</sub> was estimated by difference.

Results at 0°		Results at 10°		Results at 20°		Solid Phase at each temperature
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
NH <sub>3</sub>	NH <sub>4</sub> CNS	NH <sub>3</sub>	NH <sub>4</sub> CNS	NH <sub>3</sub>	NH <sub>4</sub> CNS	
22.88	77.12	22.70	77.30	21.35	78.65	NH <sub>4</sub> CNS
20.96	69.88	20.11	71.49	19.59	75.72	"
19.60	64.95	17.85	64.66	18.12	70.24	"
19.05	61.72	17.28	61.64	15.20	60.00	" +NH <sub>4</sub> NO <sub>3</sub>
19.97	59.97	18.52	56.37	17.73	54.37	NH <sub>4</sub> NO <sub>3</sub>
23.70	44.58	21.87	44.53	20.37	42.38	"
24.70	37.15	23.06	34.53	21.20	29.64	"
24.75	24.55	23.32	21.70	21.15	19.47	"
24.22	9.64	22.55	8.80	21.13	14.20	"
23.13	0.0	21.91	0.0	20.55	0.00	"

### THE SYSTEM AMMONIUM NITRATE - AMMONIUM SULFATE - WATER

Most authors report two double salts: 3NH<sub>4</sub>NO<sub>3</sub>·(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> and 2NH<sub>4</sub>NO<sub>3</sub>·(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>, but Jänecke, Eissner, and Brill (1927) found only the 2:1 salt between 0 and 100°.

(Cont.)

## THE SYSTEM AMMONIUM NITRATE - AMMONIUM SULFATE - WATER--Cont.

Sat. sol. wt. %			Sat. sol. wt. %			Sat. sol. wt. %		
$\text{NH}_4\text{NO}_3$ $(\text{NH}_4)_2\text{SO}_4$		Sol- id	$\text{NH}_4\text{NO}_3$ $(\text{NH}_4)_2\text{SO}_4$		Sol- id	$\text{NH}_4\text{NO}_3$ $(\text{NH}_4)_2\text{SO}_4$		Sol- id
At 0°								
(de Waal, 1910)			(Sokolov, 1938)					
54.19	0.	A	54.2	0.0	A	29.3	21.95	D+B
49.12	6.0	A	51.3	3.26	A	24.0	26.65	B
45.99	9.53	A+C	47.5	8.34	A	18.9	29.75	B
31.61	19.5	C	6.1	10.12	A+C	13.2	32.6	B
30.87	20.43	C+D	37.6	15.2	C	7.9	35.5	B
31.04	20.4	D	34.6	17.8	C	4.74	37.9	B
29.81	21.33	D	31.8	20.5	C	2.30	39.6	B
29.58	41.64	D+B	35.1	17.4	C+D	0.0	45.5	B
5.61	37.89	B	31.6	20.4	D			
0.	41.4	B						
At 25°								
(Bahl and Singh, 1941)			(Sokolov, 1938)					
68.17	0.0	A	67.8	0.0	A	55.0	9.6	D*
65.43	2.25	A	66.1	2.2	A	50.0	12.5	D
64.10	3.95	A+C	64.1	4.1	A	45.8	15.1	D
61.50	4.56	C	63.6	4.7	A+C	44.6	15.7	D+B
59.54	6.24	C	61.4	5.3	C	34.7	21.2	B
57.62	7.51	C+D	58.2	7.4	C	27.7	25.1	B
55.78	8.46	D	56.2	8.5	C	20.1	29.9	B
51.41	10.83	D	53.0	10.5	C+D	14.6	33.3	B
47.95	13.58	D+B	59.3	7.2	D*	0.0	43.5	B
45.47	14.92	B						
32.14	22.21	B						
15.21	32.97	B						
0.0	43.43	B						
At 30°			At 40°			At 70°		
(Schreinemakers and Haenen, 1910)			(Sokolov, 1938)			(de Waal, 1910)		
70.1	0	A	73.5	0.0	A	84.03	0	A
67.63	2.38	A	72.0	1.8	A	81.38	2.41	A
66.93	3.46	A+C	70.8	3.2	A+C	81.01	2.45	A+C
63.84	4.96	C	67.8	4.2	C	80.25	2.68	C
58.06	8.22	C+D	62.4	7.3	C+D	76.01	3.96	C
52.75	11.42	D	58.2	9.9	D	73.48	5.14	C+D
49.80	13.27	D+B	54.7	11.6	B+D	71.58	5.82	D
37.20	19.48	B	46.8	15.8	B	70.15	6.71	D+B
19.91	28.83	B	35.9	21.2	B	11.10	40.81	B
12.05	34.7	B	28.5	25.8	B	0	47.81	B
0	44.1	B	20.7	30.7	B			
			14.4	34.1	B			
			0.0	44.8	B			
*Metastable			B = $(\text{NH}_4)_2\text{SO}_4$			D = $2\text{NH}_4\text{NO}_3 \cdot (\text{NH}_4)_2\text{SO}_4$		
A = $\text{NH}_4\text{NO}_3$			C = $3\text{NH}_4\text{NO}_3 \cdot (\text{NH}_4)_2\text{SO}_4$					



## N NITROGEN

### THE SYSTEM AMMONIUM NITRATE - AMMONIUM ACID SULFATE - WATER AT 25° (Wohler and Schäffer, 1925)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{NH}_4\text{NO}_3$	$\text{NH}_4\text{HSO}_4$		$\text{NH}_4\text{NO}_3$	$\text{NH}_4\text{HSO}_4$	
59.0	13.9	$\text{NH}_4\text{NO}_3$	30.1	51.1	$\text{NH}_4\text{NO}_3 \cdot \text{NH}_4\text{HSO}_4$
52.5	25.5	"	27.3	58.8	"
45.5	36.6	"	23.3	62.5	$\text{NH}_4\text{HSO}_4$
35.8	47.9	$\text{NH}_4\text{NO}_3 \cdot \text{NH}_4\text{HSO}_4$	16.9	66.1	"
32.3	49.1	"	8.2	69.5	"

Solubility of the double salt at various temperatures:

NO

	t°	20	30	40	50	60
Gms. $\text{NH}_4\text{NO}_3 \cdot \text{NH}_4\text{HSO}_4$ per 100 gms. sat. sol.		82.9	84.6	86.9	89.3	92.6

### THE SYSTEM AMMONIUM NITRATE - LANTHANUM NITRATE - WATER AT 25° (Urazov and Shevtsova, 1957)

Sat. Sol. wt. %		Residue wt. %		Solid Phase
$\text{La}(\text{NO}_3)_3$	$\text{NH}_4\text{NO}_3$	$\text{La}(\text{NO}_3)_3$	$\text{NH}_4\text{NO}_3$	
60.28	-	-	-	$\text{La}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$
59.75	1.46	71.55	3.00	Solid Solution
59.00	2.95	69.72	4.70	"
58.08	5.56	68.67	8.91	"
57.55	8.00	66.00	15.52	"
54.20	14.20	56.40	21.32	$\text{La}(\text{NO}_3)_3 \cdot 2\text{NH}_4\text{NO}_3 \cdot 4\text{H}_2\text{O}$
50.00	15.25	55.32	25.93	"
47.12	17.00	51.22	21.57	"
46.00	18.02	50.00	22.00	"
42.71	19.37	46.24	21.49	"
40.02	22.21	38.12	40.04	" + $\text{NH}_4\text{NO}_3$
33.63	24.31	21.62	51.33	$\text{NH}_4\text{NO}_3$
31.70	25.75	19.20	54.00	"
22.36	30.83	12.73	62.25	"
14.00	38.47	5.38	78.40	"
6.35	48.90	1.12	88.15	"
4.72	54.05	-	-	"
4.0	55.00	1.00	90.00	"
2.56	60.85	0.42	97.30	"
1.35	65.05	0.14	97.61	"
0.50	67.14	0.03	98.59	"
0.00	68.00	0.03	98.59	"

### THE SYSTEM AMMONIUM NITRATE - SODIUM NITRATE - WATER (Nikitina, 1933; Shpunt, 1946; Karnaukhov, 1951, 1954, 1956, Schloesing, 1920; also Mondain Monval, 1925, Fedotieff and Koltunoff, 1914, Rudolf)

Although many authors studied this system, the double salt  $2\text{NaNO}_3 \cdot \text{NH}_4\text{NO}_3$  was first found by Karnaukhov at 25°.

(Cont.)

## THE SYSTEM AMMONIUM NITRATE - SODIUM NITRATE - WATER--Cont.

 $N\beta = \text{NH}_4\text{NO}_3$  $\text{Na} = \text{NaNO}_3$ 

I = ice

 $\alpha\beta\gamma$  are  $\text{NH}_4\text{NO}_3$  phases

Sat. Sol. wt. %

Sat. Sol. wt. %

Sat. Sol. wt. %

$\text{NaNO}_3$	$\text{NH}_4\text{NO}_3$	Solid	$\text{NaNO}_3$	$\text{NH}_4\text{NO}_3$	Solid	$\text{NaNO}_3$	$\text{NH}_4\text{NO}_3$	Solid
-----------------	--------------------------	-------	-----------------	--------------------------	-------	-----------------	--------------------------	-------

At  $-20^\circ$  (Sh.)At  $-17^\circ$  (Sh.)At  $-10^\circ$  (Sh.)

11.1	34.6	N+I	38.4	0.0	Na+I	39.8	0.0	Na
15.1	29.8	I	33.9	10.0	Na	35.5	9.8	Na
18.3	26.6	I	29.2	21.4	Na	30.8	20.8	Na
20.2	24.0	I	25.6	29.6	Na+N	25.2	33.4	Na+N
24.4	18.6	I	20.4	32.0	N	23.6	34.0	N
31.1	10.4	I	17.0	33.8	N	19.0	36.6	N
35.6	5.4	Na+I	9.4	37.2	N	18.5	36.8	N
33.4	10.2	Na	0.0	42.3	Na+I	8.5	48.1	N
28.6	21.6	Na	10.3	30.6	I	0.0	47.2	N
25.8	28.4	Na+N	14.4	25.8	I	23.1	0.0	I
20.9	30.4	N	26.4	12.0	I	10.7	13.4	I
16.6	32.8	N	27.2	11.0	I	9.8	14.4	I
						8.2	16.4	I
						0.0	24.6	I

NO

At  $0^\circ$  (N.)At  $16^\circ$  (Sch.)At  $20^\circ$  (N.)

42.34	0.0	Na	22.6	47.4	Na+N	46.80	0.0	Na
24.63	38.71	Na+N $\beta$	(22.7)	(47.8)	Na+N	41.34	10.95	Na
(24.1)	(39.1)	Na+N			(R.)	35.25	22.85	Na
		(Sch.)				30.27	33.48	Na
(24.5)	(38.7)	Na+N				22.40	49.60	Na+N $\beta$
		(Sh.)				(22.8)	(49.0)	Na+N $\beta$
20.02	41.37	N $\beta$						(Sh.)
7.18	49.05	N $\beta$				16.47	52.24	N $\beta$
4.25	50.42	N $\beta$				12.64	55.01	N $\beta$
2.08	52.46	N $\beta$				5.30	61.51	N $\beta$
0.0	54.20	N $\beta$				2.72	62.54	N $\beta$
						0.0	64.0	N $\beta$

At  $25^\circ$  (K.)At  $30^\circ$  (Sh.)At  $40^\circ$  (N.)

(See separate table,			48.0	0.0	Na	51.30	0.0	Na
below)			44.6	8.4	Na	44.98	13.01	Na
			42.2	14.89	Na	31.02	41.47	Na
			39.6	18.3	Na	21.68	60.07	Na+N $\alpha$
			34.4	29.68	Na	(21.0)	(57.5)	Na+N
			28.2	40.8	Na			(Sch.)
			26.98	43.78	Na	2.70	72.98	Na
			24.5	48.2	Na	0.0	74.64	Na
			21.5	54.3	Na+N			
			16.81	57.68	N			
			11.59	61.10	N			
			11.2	62.2	N			
			7.28	64.86	N			
			4.7	67.4	N			
			0.0	70.5	N			

(Cont.)

# N NITROGEN

## THE SYSTEM AMMONIUM NITRATE - SODIUM NITRATE - WATER--Cont.

Na = $\text{NH}_4\text{NO}_3$			Na = $\text{NaNO}_3$			I = ice			$\alpha\beta\gamma$ are $\text{NH}_4\text{NO}_3$ phases		
Sat. Sol. Wt. %			Sat. Sol. Wt. %			Sat. Sol. Wt. %			Sat. Sol. Wt. %		
$\text{NaNO}_3$	$\text{NH}_4\text{NO}_3$	Solid	$\text{NaNO}_3$	$\text{NH}_4\text{NO}_3$	Solid	$\text{NaNO}_3$	$\text{NH}_4\text{NO}_3$	Solid	$\text{NaNO}_3$	$\text{NH}_4\text{NO}_3$	Solid
At 60° (N.)			At 80° (N.)			At 95° (Sch.)					
55.58	0.0	Na	59.9	0.0	Na	20.0	74.0	Na+N			
40.34	64.59	Na+Na	51.6	10.83	Na						
(20.2)	(64.4)	Na+N	42.03	31.89	Na						
		(Sch.)	25.37	61.48	Na						
9.02	73.82	Na	19.25	72.06	Na+Na						
6.87	75.30	Na	15.09	75.58	Na						
2.24	78.60	Na	8.73	80.13	Na						
0.0	80.41	Na	0.0	86.44	Na						
At 98° (N.)			At 117° (Sch.)			At 140° (Sch.)					
63.04	0.0	Na	21.1	78.0	Na+N	26.4	73.1	Na+N			
18.45	78.26	Na+Na									
8.79	85.51	Na									
7.23	85.97	Na									
5.38	86.89	Na									
2.78	88.89	Na									
0.0	91.15	Na									

### Results at 25° (K.)

Sat. Sol. Wt. %		Wet Residue Wt. %		Solid Phase
$\text{NaNO}_3$	$\text{NH}_4\text{NO}_3$	$\text{NaNO}_3$	$\text{NH}_4\text{NO}_3$	
47.29	0.0	87.91	0.0	$\text{NaNO}_3$
42.49	11.47	85.58	2.87	"
35.77	22.83	73.95	9.20	"
32.87	30.13	76.06	9.04	"
29.65	36.45	69.40	14.40	"
25.72	42.98	72.83	16.60	"
28.41	45.52	40.34	40.73	$2\text{NaNO}_3 \cdot \text{NH}_4\text{NO}_3$
25.14	47.05	50.93	37.56	"
23.76	46.98	51.50	37.92	"
22.05	47.39	44.02	42.59	"
21.02	48.23	44.23	40.16	"
21.31	51.20	7.02	83.70	$\text{NH}_4\text{NO}_3$
11.29	60.07	3.40	88.00	"
13.00	56.00	4.51	87.37	"
0.0	67.08	0.0	86.72	"

## THE SYSTEM AMMONIUM NITRATE - LEAD NITRATE - WATER

Malquori's results were plotted, and the results taken from the average curves.

Results at 10°			Results at 20°		
(Malquori, 1926)			(Malquori, 1926)		
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{NH}_4\text{NO}_3$	$\text{Pb}(\text{NO}_3)_2$		$\text{NH}_4\text{NO}_3$	$\text{Pb}(\text{NO}_3)_2$	
60.5	0.0	$\text{NH}_4\text{NO}_3$	65.8	0.0	$\text{NH}_4\text{NO}_3$
51.0	10.0	"	58.5	10.0	"
45.5	20.0	"	53.0	20.0	"
41.5	30.0	"	48.5	29.0	" + $\text{Pb}(\text{NO}_3)_2$
40.5	36.0	" + $\text{Pb}(\text{NO}_3)_2$	40.0	31.0	$\text{Pb}(\text{NO}_3)_2$
30.0	32.0	$\text{Pb}(\text{NO}_3)_2$	30	31.7	"
20.0	29.5	"	20	32.5	"
10.0	27.5	"	10	33.2	"
0.0	27.4	"	0	36.0	"

## Results at 25°

(Hill and Kaplen, 1936)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{NH}_4\text{NO}_3$	$\text{Pb}(\text{NO}_3)_2$		$\text{NH}_4\text{NO}_3$	$\text{Pb}(\text{NO}_3)_2$	
68.17	0.0	$\text{NH}_4\text{NO}_3$	36.92	32.61	$\text{Pb}(\text{NO}_3)_2$
56.15	18.04	"	28.75	33.65	"
49.00	29.44	" + $\text{Pb}(\text{NO}_3)_2$	16.28	34.02	"
48.47	29.63	$\text{Pb}(\text{NO}_3)_2$	12.35	33.99	"
44.58	30.79	"	0.0	37.17	"

The vapor pressures of saturated solutions in the system  $\text{NH}_4\text{NO}_3$  -  $\text{Pb}(\text{NO}_3)_2$  -  $\text{H}_2\text{O}$  have been measured by Dingemans, 1945.

## THE SYSTEM AMMONIUM NITRATE - RUBIDIUM NITRATE - WATER AT 25°

(Karnaukov, 1956)

Anhydrous solid solutions are formed.

Sat. Sol. Wt. %		Wet Residue Wt. %		Calc'd Solid Phase Wt. %	
$\text{RbNO}_3$	$\text{NH}_4\text{NO}_3$	$\text{RbNO}_3$	$\text{NH}_4\text{NO}_3$	$\text{RbNO}_3$	$\text{NH}_4\text{NO}_3$
40.00	-	-	-	100.00	-
38.36	3.00	94.2	1.80	98.50	1.50
36.55	5.82	93.20	2.41	98.00	2.00
34.42	12.59	92.74	2.80	97.50	2.50
29.82	21.06	91.74	5.0	95.50	4.50
28.46	26.66	89.86	6.84	94.50	5.50

(Cont.)

# N NITROGEN

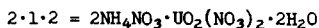
## THE SYSTEM AMMONIUM NITRATE - RUBIDIUM NITRATE - WATER AT 25°--Cont.

Sat. Sol. Wt. %		Wet Residue Wt. %		Calc'd Solid Phase Wt. %	
RbNO <sub>3</sub>	NH <sub>4</sub> NO <sub>3</sub>	RbNO <sub>3</sub>	NH <sub>4</sub> NO <sub>3</sub>	RbNO <sub>3</sub>	NH <sub>4</sub> NO <sub>3</sub>
24.97	34.93	88.56	8.38	92.50	7.50
22.81	41.56	82.60	14.00	89.00	11.00
21.44	43.51	64.20	30.00	73.50	26.50
19.48	47.31	42.77	51.23	49.0	51.0
17.65	50.62	35.07	56.90	41.00	59.00
15.23	52.70	34.20	60.47	38.50	61.50
13.39	55.70	28.56	62.61	35.00	65.00
10.03	58.42	23.15	73.34	24.50	75.50
6.97	61.55	7.81	77.12	8.50	91.50
NO	3.51	2.55	87.93	2.00	98.00
-	67.08	-	-	-	-

## THE SYSTEM AMMONIUM NITRATE - URANYL NITRATE - WATER AT 25° (Colani, 1927, 1928)

For other data see under uranyl nitrate.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
NH <sub>4</sub> NO <sub>3</sub>	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>		NH <sub>4</sub> NO <sub>3</sub>	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>	
65.72	0.0	NH <sub>4</sub> NO <sub>3</sub>	24.92	49.33	2·1·2
60.84	6.9	"	22.13	52.00	"
51.84	18.10	"	20.99	54.35	" + UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O
48.21	23.12	"	17.24	53.06	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O
43.26	30.54	"	10.38	51.79	"
35.19	40.23	" + 2·1·2	6.36	53.23	"
34.69	40.81	2·1·2	2.50	54.53	"
28.64	46.31	"	0.0	56.08	"



## AMMONIUM URANYL NITRATES NH<sub>4</sub>NO<sub>3</sub>·UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub> and 2NH<sub>4</sub>NO<sub>3</sub>·UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub>

### SOLUBILITY OF AMMONIUM URANYL NITRATES IN AQUEOUS NITRIC ACID AT 20° (Nichols, Hawes, et al., 1919)

Results for NH <sub>4</sub> NO <sub>3</sub> ·UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>					
Percent HNO <sub>3</sub> in Solvent	Gms. NH <sub>4</sub> NO <sub>3</sub> ·UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> per 100 gms. solvent	Solid Phase	Percent HNO <sub>3</sub> in Solvent	Gms. NH <sub>4</sub> NO <sub>3</sub> ·UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> per 100 gms. solvent	Solid Phase
0	165.0	A	20	144.5	B
10	128.5	A	30	144.0	B
20	80.3	A	40	95.6	B
30	68.2	A	50	61.4	B
40	60.5	A	60	38.6	B



(Cont.)

SOLUBILITY OF AMMONIUM URANYL NITRATES IN AQUEOUS  
NITRIC ACID AT 20°--Cont.

Results for  $2\text{NH}_4\text{NO}_3 \cdot \text{UO}_2(\text{NO}_3)_2$

Percent $\text{HNO}_3$ in Solvent	Gms. $\text{NH}_4\text{NO}_3 \cdot \text{UO}_2(\text{NO}_3)_2$ per 100 gms. solvent	Solid Phase	Percent $\text{HNO}_3$ in Solvent	Gms. $\text{NH}_4\text{NO}_3 \cdot \text{UO}_2(\text{NO}_3)_2$ per 100 gms. solvent	Solid Phase
0	251.0	A	20	215.0	B
10	201.0	A	30	150.0	B
20	150.0	A	40	98.2	B
30	144.0	A	50	58.0	B
0	380.0	B	60	35.6	B
10	380.0	B			

NO

A =  $\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$       B =  $\text{NH}_4\text{NO}_3 \cdot \text{UO}_2(\text{NO}_3)_2$

THE SYSTEM AMMONIUM NITRATE - UREA - WATER  
(Sokolov, 1939)

The system was studied from the eutectic to 25° and a diagram is drawn which shows the equilibrium phases at 5° intervals. The compositions of solutions in equilibrium with more than one solid phase are given below:

t°	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{CO}(\text{NH}_2)_2$	$\text{NH}_4\text{NO}_3$	
-20.6	30.0	21.0	Ice
-18.1	25.0	22.5	"
-16.8	20.0	24.0	"
-14.9	15.0	25.5	"
-13.6	10.0	27.0	"
-11.0	0.0	30.0	"
-12.8	30.0	7.0	"
- 9.5	20.0	8.0	"
- 6.2	10.0	9.0	"
- 3.7	0.0	10.0	"
-16.65	0.0	43.1	" + $\text{NH}_4\text{NO}_3$
-11.1	32.9	0.0	" + $\alpha\text{CO}(\text{NH}_2)_2$
-14.0	37.7	6.8	" "
-20.7	30.1	20.9	" "
-23.5	29.2	26.8	Ice + $\alpha + \beta \text{CO}(\text{NH}_2)_2$
-25.5	28.4	31.7	Ice + $\beta + \gamma$ "
-26.5	29.8	35.1	" + $\gamma\text{CO}(\text{NH}_2)_2 + \alpha\text{NH}_4\text{NO}_3$
-18.5	7.7	41.0	" + $\alpha + \beta\text{NH}_4\text{NO}_3$
-13.2	33.0	6.7	$\alpha\text{CO}(\text{NH}_2)_2$
-11.2	34.0	6.6	"
- 9.3	35.0	6.5	"
-19.8	31.0	7.44	"
- 7.4	36.4	2.07	$\alpha + \beta\text{CO}(\text{NH}_2)_2$
-19.6	31.3	20.6	" "
-17.6	32.0	20.4	$\beta\text{CO}(\text{NH}_2)_2$
-15.2	33.0	20.1	"
-12.8	34.0	19.8	"

(Cont.)

# N NITROGEN

## THE SYSTEM AMMONIUM NITRATE - UREA - WATER--Cont.

	t°	Gms. per 100 gms. sat. sol.		Solid Phase
		CO(NH <sub>2</sub> ) <sub>2</sub>	NH <sub>4</sub> NO <sub>3</sub>	
	- 8.6	36.0	18.2	β CO(NH <sub>2</sub> ) <sub>2</sub>
	- 4.2	38.0	7.06	"
	- 0.1	40.0	6.95	"
	- 6.2	37.0	6.3	"
	- 0.2	40.0	6.0	"
	+ 3.5	42.0	5.8	"
	8.7	45.0	5.5	"
	12.2	47.0	5.3	"
	15.7	49.0	5.4	"
	16.2	49.2	5.0	β + γ CO(NH <sub>2</sub> ) <sub>2</sub>
	0.5	40.5	17.9	" "
	-21.2	30.0	35.0	γ CO(NH <sub>2</sub> ) <sub>2</sub>
	- 7.6	35.0	32.5	"
	+ 4.0	40.0	30.0	"
	15.5	45.0	27.7	"
	26.6	50.0	25.0	"
	- 9.8	33.6	39.0	"
	- 6.0	35.2	36.0	"
	- 2.6	36.9	33.0	"
	+ 0.5	38.5	30.0	"
	2.6	40.0	27.3	"
	4.0	42.0	17.4	"
	8.3	44.0	16.8	"
	12.4	46.0	16.2	"
	16.8	48.0	15.6	"
	28.0	51.0	14.7	"
	30.8	55.0	13.5	"
	21.7	52.0	4.8	"
	27.6	55.0	4.5	"
	7.2	37.2	47.0	"
	8.9	37.8	46.0	"
	12.8	39.9	43.0	"
	16.6	42.0	40.0	"
	20.0	44.2	37.0	"
	24.4	47.0	33.8	"
	27.6	49.0	30.0	"
	-25.9	28.4	35.9	" + α NH <sub>4</sub> NO <sub>3</sub>
	-13.4	32.2	41.5	" + β NH <sub>4</sub> NO <sub>3</sub>
	+ 6.6	36.8	47.4	" "
	-18.5	30.5	39.5	γ CO(NH <sub>2</sub> ) <sub>2</sub> + α + β NH <sub>4</sub> NO <sub>3</sub>
	+ 9.5	37.6	48.3	" + β + γ NH <sub>4</sub> NO <sub>3</sub>
	-23.3	25.0	37.5	α NH <sub>4</sub> NO <sub>3</sub>
	-19.2	20.0	40.0	"
	-15.3	15.0	42.5	"
	-11.8	10.0	40.0	"
	- 8.7	5.0	47.5	"
	- 5.8	0.0	50.0	"
	-12.2	31.9	42.0	β NH <sub>4</sub> NO <sub>3</sub>
	- 5.0	30.2	45.3	"
	+ 0.7	28.7	48.0	"
	7.0	27.0	51.0	"
	7.9	36.5	48.0	"

(Cont.)

## THE SYSTEM AMMONIUM NITRATE - UREA - WATER--Cont.

t°	Gms. per 100 gms. sat. sol.		Solid Phase
	CO(NH <sub>2</sub> ) <sub>2</sub>	NH <sub>4</sub> NO <sub>3</sub>	
12.0	25.7	53.5	α + γNH <sub>4</sub> NO <sub>3</sub>
10.0	35.6	49.2	" "
13.1	25.3	54.0	γNH <sub>4</sub> NO <sub>3</sub>
20.6	23.5	57.3	"
12.5	35.0	50.0	"
14.9	34.3	51.0	"
22.0	32.3	54.0	"
28.5	30.1	57.0	"

NO

SOLUBILITY OF AMMONIUM NITRATE IN AQUEOUS METHANOL SOLUTIONS AT 30°  
(Aravamudan, 1956)

Solvent Wt. %	Sat. Sol. Wt. %		Solvent Wt. %	Sat. Sol. Wt. %	
	CH <sub>3</sub> OH	NH <sub>4</sub> NO <sub>3</sub>		CH <sub>3</sub> OH	NH <sub>4</sub> NO <sub>3</sub>
0.0	0.0	69.86	64.21	35.24	45.13
7.22	2.29	68.29	73.77	46.20	37.37
14.28	4.75	66.73	76.80	49.99	34.91
25.70	9.32	66.74	83.79	59.40	29.10
39.60	16.21	59.06	85.37	62.05	27.31
44.87	19.55	56.43	93.89	74.49	20.66
53.73	25.65	52.24	100.0	83.20	16.80
59.89	31.01	48.19			

SOLUBILITY OF AMMONIUM NITRATE IN AQUEOUS ETHANOL SOLUTIONS  
(Thompson and Vener, 1948)

Older, similar data were reported by Fleckenstein, 1905.

Composition of solvents:

Number	Density at 35°	Wt. % C <sub>2</sub> H <sub>5</sub> OH	Mole % C <sub>2</sub> H <sub>5</sub> OH
10	0.99714	9.82	4.09
20	.96150	19.90	8.86
30	.94424	29.89	14.29
50	.90191	49.90	28.03
70	.85510	69.83	47.51
82	.82511	82.08	64.17
88	.80995	88.03	74.20
92	.79769	92.63	83.09



# N NITROGEN

## SOLUBILITY OF AMMONIUM NITRATE IN AQUEOUS ETHANOL SOLUTIONS--Cont.

Solubilities in gms.  $\text{NH}_4\text{NO}_3$  per 100 gms. Saturated Solution

Densities are in gms. per ml. in Vacuum

Solvent Number						
H <sub>2</sub> O	10	20	30	50	70	92
25°						
	65.45	60.90	56.38	43.50	26.05	7.29
	1.2859	1.2532	1.2110	1.1052	0.9758	0.8382
30°						
NO	69.86	67.46	63.73	59.37	46.90	29.16
	1.3295	1.2968	1.2669	1.2265	1.1222	0.9882
35°						
	71.84	69.40	66.22	62.25	50.26	32.27
	1.3376	1.3063	1.2790	1.2413	1.1380	1.0007
40°						
	73.58	71.34	68.59	64.89	53.51	35.36
	1.3449	1.3160	1.2904	1.2546	1.1535	1.0134
45°						
	75.35	73.24	70.89	67.27	56.55	38.48
	1.3520	1.3428	1.3014	1.2667	1.1688	1.0267
50°						
	76.99	75.10	73.11	69.57	59.49	41.63
	1.3586	1.3331	1.3121	1.2784	1.1842	1.0406

Solvent Number						
H <sub>2</sub> O	10	20	30	50	70	92
55°						
	78.61	76.90	75.27	71.79	62.39	44.92
	1.3653	1.3410	1.3222	1.2908	1.1996	1.0561
60°						
	80.14	78.68	77.34	73.97	65.20	48.39
	1.3713	1.3489	1.3322	1.3032	1.2143	1.0724
65°						
	81.72	80.41	79.18	76.11	67.94	51.93
	1.3768	1.3565	1.3418	1.3159	1.2276	1.0888
70°						
	83.20	82.12	80.71	78.22	70.65	51.93
	1.3818	1.3641	1.3513	1.3286	1.2402	1.0888
75°						
	84.56	83.81	81.75	80.30	73.33	51.93
	1.3872	1.3716	1.3608	1.3413	1.2524	1.0888

## SOLUBILITY OF AMMONIUM NITRATE IN AQUEOUS ETHANOL SOLUTIONS--Cont.

## Additional Data

Solvent Number	Temperature			
	60°	65°	70°	75°
82	29.73	32.98	36.24	-
	0.9434	0.9576	0.9718	-
88	19.98	22.36	24.74	27.12
	0.8795	0.8848	0.8902	0.8954

## Data for the Two Phase Region

NO

t°	Upper Phase			Lower Phase		
	Wt. % NH <sub>4</sub> NO <sub>3</sub> in Sat. Sol.	Density of Sat. Sol.	Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	Wt. % NH <sub>4</sub> NO <sub>3</sub> in Sat. Sol.	Density of Sat. Sol.	Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent
66.91	46.60	1.0479	76.3	60.75	1.1594	65.9
69.01	42.89	1.0180	78.9	64.95	1.1972	60.3
70.41	40.53	0.9995	80.4	67.29	1.2129	56.8
71.84	39.21	.9875	81.4	69.39	1.2229	54.7
73.98	37.67	.9700	82.7	72.41	1.2341	51.9

SOLUBILITY OF AMMONIUM NITRATE IN AQUEOUS ETHYL AND METHYL  
ALCOHOLS AND IN A MIXTURE OF THE TWO AT 30°  
(Schreinemakers, 1908-09)

Gms. per 100 Gms. Sat. Sol.			Gms. per 100 Gms. Sat. Sol.			Gms. per 100 Gms. Sat. Sol.		
H <sub>2</sub> O	C <sub>2</sub> H <sub>5</sub> OH	NH <sub>4</sub> NO <sub>3</sub>	H <sub>2</sub> O	CH <sub>3</sub> OH	NH <sub>4</sub> NO <sub>3</sub>	H <sub>2</sub> O	*CH <sub>3</sub> OH +C <sub>2</sub> H <sub>5</sub> OH	NH <sub>4</sub> NO
0	96.4	3.6	0	83.3	16.7	3.4	84.9	11.7
5	99.6	6.5	5	74.8	21.3	5	82.9	12.3
10	80.4	10.7	10	63.8	27.1	10	74.6	16.4
15	68.6	17	15	50.7	35	15	63.5	24
20	53.5	26.8	20	35.2	46.3	20	48.2	35.1
25	32.5	44.8	25	19.8	59	25	22.4	54
29.9	0	70.1	29.9	0	70.1	29.9	0	70.1

\*Weight per cent CH<sub>3</sub>OH = 51.7, C<sub>2</sub>H<sub>5</sub>OH = 48.3

Additional determinations of the solubility of ammonium nitrate in aqueous ethyl alcohol solutions at 0°, 30° and 70° are given by deWaal (1910). At certain concentrations at 67.5° the solutions separate into two layers.

# N NITROGEN

## SOLUBILITY OF AMMONIUM NITRATE IN AQUEOUS ISOPROPANOL SOLUTIONS (Thompson and Molstad, 1945)

Number	7	10	87	93	95
Density at 35°	0.98186	0.97726	0.80358	0.78924	0.78382
Wt. % i-C <sub>3</sub> H <sub>7</sub> OH	7.01	9.96	87.60	93.43	95.58
Mole % i-C <sub>2</sub> H <sub>7</sub> OH	2.21	3.21	67.94	81.01	86.63

Solubilities in gms. NH<sub>4</sub>NO<sub>3</sub> per 100 gms. Saturated Solution

Densities in gms. per ml. in Vacuo

NO	t°	Solvent				
		H <sub>2</sub> O	7	10	87	93
30	69.86	67.65	66.69	8.70	4.57	3.23
	1.3295	1.3079	1.2996	0.8461	0.8162	0.8025
35	71.84	69.74	68.99	9.52	5.01	3.47
	1.3376	1.3173	1.3097	0.8453	0.8130	0.7993
40	73.58	71.76	71.10	10.37	5.50	3.81
	1.3449	1.3255	1.3187	0.8444	0.8099	0.7962
45	75.35	73.71	73.10		6.01	4.19
	1.3520	1.3332	1.3272		0.8070	0.7930
50	76.99	75.55	75.60		6.53	4.59
	1.3586	1.3406	1.3354		0.8044	0.7902
55	78.61	77.29	76.81		7.07	5.00
	1.3653	1.3478	1.3434		0.8021	0.7872
60	80.14	79.01	78.50		7.66	5.45
	1.3713	1.3548	1.3509		0.8005	0.7848
65	81.72	80.65	80.26		8.29	5.90
	1.3768	1.3619	1.3581		0.7999	0.7830
70	83.20	82.26	81.97		8.97	6.37
	1.3818	1.3690	1.3650		0.7995	0.7817
75	84.56	83.79	83.51			6.89
	1.3872	1.3754	1.3717			0.7806

### Two-Phase Data

t°	Upper Layer			Lower Layer		
	Wt. %	Density	Wt. %	Wt. %	Density	Wt. %
	NH <sub>4</sub> NO <sub>3</sub> in Sat. Sol.	Saturated Solution	Alcohol in Solvent	NH <sub>4</sub> NO <sub>3</sub> in Sat. Sol.	Saturated Solution	Alcohol in Solvent
30	11.32	0.8638	84.5	66.44	1.2840	14.5
35	10.89	.8542		67.90	1.2964	
40	10.56	.8456	87.4	70.12	1.3072	14.7
45	10.31	.8380		72.25	1.3171	
50	10.11	.8305	89.5	74.20	1.3269	15.3
55	9.96	.9234		75.99	1.3360	
60	9.83	.8177	91.3	77.70	1.3442	16.6
65	9.72	.8102		79.39	1.3504	
70	9.62	.8038	92.8	81.09	1.3552	18.3
75	9.52	.7990		82.81	1.3604	

Results for the system ammonium nitrate - tertiary butyl alcohol - water at 25° are given by Ginnings, Herring and Webb, 1933.

The composition of the homogeneous mixture, plait point, of the three components, as determined by the synthetic method, is 21.6 gms.  $\text{NH}_4\text{NO}_3$  + 33.1 gms. tertiary butyl alcohol  $(\text{CH}_3)_3\text{COH}$ , per 100 gms. sat. solution. The original results for the remaining points on the binodal curve are not given, but only the values corresponding to derived empirical equations for the curve.

The binodal curve for the system ammonium nitrate - allyl alcohol - water at 25° has been determined by Ginnings and Dees, 1935, but the authors do not give their experimental results but only the values of a series of constants calculated from them by means of an empirical equation. From these the conclusion is drawn that allyl alcohol seems to be more difficult to salt out than either iso propyl or normal propyl alcohol. NO

#### SOLUBILITY OF AMMONIUM NITRATE IN ANHYDROUS ORGANIC SOLVENTS

Solvent	t°	Solubility	Reference
Methanol	14	14.6 gms. $\text{NH}_4\text{NO}_3$ /100 gms. alcohol	(Schiff and Monsacchi, 1896)
	18.5	16.3	"
	17.1	20.5	(de Bruyn, 1892)
Ethanol	14	4.6 gms. $\text{NH}_4\text{NO}_3$ /100 gms. alcohol	(Schiff and Monsacchi, 1896)
	20	2.5	(Fleckenstein, 1905)
	20.5	3.8	(de Bruyn, 1892)
	30	4	(Fleckenstein, 1905)
	40	5	"
	50	6	"
	60	7.5	"
	70	9	"
	80	10.5	"
Pyridine	25	22.88 gms. $\text{NH}_4\text{NO}_3$ /100 cc. pyridine	(R. Muller, 1924)
Furfural	25	0.4 gms. $\text{NH}_4\text{NO}_3$ /100 gms. sat. sol.	(Trimble, 1941)

#### SOLUBILITY OF AMMONIUM NITRATE IN ANHYDROUS NITRIC ACID (Groschuff, 1904)

Determinations by the "Synthetic Method," a = solution in  $\text{HNO}_3$ ,  
b = solution in  $\text{NH}_4\text{NO}_3$ .

t°	Gms. $\text{NH}_4\text{NO}_3$ per 100 Gms. Sol.	Mols. $\text{NH}_4\text{NO}_3$ per 100 Mols. $\text{HNO}_3$	Solid Phase
8	21.1	21.1	$\text{NH}_4\text{NO}_3 \cdot 2\text{HNO}_3$
23	28.7	31.6	" a
29.5 m.pt.	38.8	50.0	"
27.5	44.6	63.4	" b
23.5	49.4	76.8	"
17.5	54.0	92.4	"
16.5	54.3	93.5	"
4.0	45.8	66.7	$\text{NH}_4\text{NO}_3 \cdot \text{HNO}_3$
	(Cont.)		labil

## N NITROGEN

### SOLUBILITY OF AMMONIUM NITRATE IN ANHYDROUS NITRIC ACID--Cont.

Determinations by the "Synthetic Method," a = solution in  $\text{HNO}_3$ ,  
b = solution in  $\text{NH}_4\text{NO}_3$ .

t°	Gms. $\text{NH}_4\text{NO}_3$ per 100 Gms. Sol.	Mols. $\text{NH}_4\text{NO}_3$ per 100 Mols. $\text{HNO}_3$	Solid Phase
11.0	51.7	84.3	$\text{NH}_4\text{NO}_3 \cdot \text{HNO}_3$
12.0	54.7	95.1	" labil
11.5	57.6	108.0	" b
11.5	54.0	92.4	$\text{NH}_4\text{NO}_3$ labil
17.0	54.7	95.1	" stabil
27.0	56.2	101.0	"
49.0	60.4	120.0	"
NO 50	(61.2)	-	" (1)
79.0	68.1	168.0	"

(1) Flatt, Brunisholz and Denereaz, 1956

### SOLUBILITY OF AMMONIUM NITRATE IN ANHYDROUS ACETIC ACID, DETERMINED BY THE FREEZING-POINT METHOD: (Davidson and Greer, 1933)

t°	Gm. Mols. $\text{NH}_4\text{NO}_3$ per 100 gm. mols. sat. sol.	t°	Gm. Mols. $\text{NH}_4\text{NO}_3$ per 100 gm. mols. sat. sol.	t°	Gm. Mols. $\text{NH}_4\text{NO}_3$ per 100 gm. mols. sat. sol.
16.60	0.0 (1)	72.8	3.447	117.0	47.56
16.57	0.0741 (1)	78.3	4.710	118.3	51.67
16.47	0.1287 (1)	80.9	5.508	120.0	55.5
17.7	0.2832	85.7	7.255	121.4	60.1
21.4	0.3249	89.0	8.620	122.9	63.1
27.0	0.3916	97.1	13.68	224.8	66.8
33.6	0.5143	101.0	17.15	128.9	71.6
45.8	0.8745	102.6	19.36	131.4	75.0
61.2	1.634	106.3	23.3	136.9	78.6
63.5	1.887	108.9	27.64	143.1	82.3
67.6	2.468	110.6	31.25	149.7	86.3
69.0	2.636	113.1	37.98	157.8	89.6
71.4	3.239	115.8	43.31	167.5	100.0

(1) The solid phase in these cases is  $\text{CH}_3\text{COOH}$  and  $\text{NH}_4\text{NO}_3$  in all others. One liter sat. solution of ammonium nitrate in pure acetic acid contains 3.5 gms.  $\text{NH}_4\text{NO}_3$  at 16.46°. (Eichelberger, 1934.)

### SOLUBILITY OF AMMONIUM NITRATE IN ANHYDROUS AMMONIA

Results of Kuriloff, 1898

t°	Gms. $\text{NH}_4\text{NO}_3$	Gms. $\text{NH}_3$	Mols. $\text{NH}_4\text{NO}_3$ per 100 Mols. $\text{NH}_4\text{NO}_3 + \text{NH}_3$	t°	Gms. $\text{NH}_4\text{NO}_3$	Gms. $\text{NH}_3$	Mols. $\text{NH}_4\text{NO}_3$ per 100 Mols. $\text{NH}_4\text{NO}_3 + \text{NH}_3$
-80	0	100	0.0	33.3	0.9358	0.2352	45.9
-60	1.3918	4.4327	6.25	35.9	0.7746	0.1857	47.0
-44.5	0.9526	1.2457	13.9	68.8	4.2615	0.7747	53.8
-30	0.8308	0.3700	32.3	94.0	0.6439	0.0665	67.3
-10.5	0.9675	0.3515	36.9	190.8	0.7578	0.0588	74.2
0	0.7600	0.2607	38.3	168.0	-	-	100.0

## SOLUBILITY OF AMMONIUM NITRATE IN ANHYDROUS AMMONIA--Cont.

Results of Scherer, 1931

t°	Gms. $\text{NH}_4\text{NO}_3$ per 100	
	cc. $\text{NH}_3$	gms. $\text{NH}_3$
-50.6	70.1	-
-46.5	72.6	-
-45.0	73.4	-
-44.0	73.5	-
-40.8	75.1	-
-36.6	77.0	-
-34.0	77.9	-
+25	235.56	390.0* ( $d_{25} = 1.212$ )

NO

\*Hunt, 1932

THE SYSTEM  $\text{NH}_4\text{NO}_3$  -  $\text{NaNO}_3$  -  $\text{NH}_3$ (liq.) AT 25°  
(Hunt and Boncyk, 1933)

One-fourth gram of the less soluble salt was mixed with variable amounts of the more soluble salt and ammonia added in excess. Ammonia was then allowed to escape until a single crystal of one salt separated from solution.

Gm. Moles. per 10 gm. Moles. $\text{NH}_3$		Gm. Moles. per 10 gm. Moles. $\text{NH}_3$	
$\text{NaCl}$	$\text{NH}_4\text{NO}_3$	$\text{NaCl}$	$\text{NH}_4\text{NO}_3$
0.0	8.2875	0.667	5.85
0.484	8.50	0.534	1.562
0.655	8.60	0.088	0.0
0.632	7.39		

## Solubility in Hydrazine

100 cc. anhydrous hydrazine dissolve 78 gms.  $\text{NH}_4\text{NO}_3$  with decomposition at about 18°. (Welsh and Brodersen, 1915.)

Melting point data are given for the following systems:

$\text{NH}_4\text{NO}_3$ + $\text{AgNO}_3$	(Flavitzkii, 1909; Zawidzki, 1904)
$\text{NH}_4\text{NO}_3$ + $(\text{NH}_4)_2\text{SO}_4$	(Bowen, 1926; Janecke, Eissner and Brill, 1927; Nikonova and Bergman, 1942)
$\text{NH}_4\text{NO}_3$ + $\text{NaCl}$	(Perman, 1922)
$\text{NH}_4\text{NO}_3$ + $\text{NaCl}$ + $\text{NaNO}_3$	(Perman, 1922)
$\text{NH}_4\text{NO}_3$ + $\text{NaNO}_3$	(Perman, 1922; Earley and Lowry, 1922; Campbell and Campbell, 1947; Holmes and Revinson, 1944; Janecke 1949)
$\text{NH}_4\text{NO}_3$ + $\text{Na}_2\text{SO}_4$	(Perman and Harrison, 1924)
$\text{NH}_4\text{NO}_3$ + $\text{Pb}(\text{NO}_3)_2$	(Bogitch, 1915; Campbell and Campbell, 1947)
$\text{NH}_4\text{NO}_3$ + $\text{LiNO}_3$	(Campbell and Campbell, 1947)
$\text{NH}_4\text{NO}_3$ + $\text{LiNO}_3$ + $\text{NaNO}_3$	(Campbell and Campbell, 1947)

(Cont.)

## NITROGEN

### Melting point data, contd.

$\text{NH}_4\text{NO}_3 + \text{KNO}_3 + \text{NaNO}_3$	(Campbell and Campbell, 1947)
$\text{NH}_4\text{NO}_3 + \text{Cd}(\text{NO}_3)_2$	(Campbell and Campbell, 1947)
$\text{NH}_4\text{NO}_3 + \text{Ba}(\text{NO}_3)_2$	(Campbell and Campbell, 1947)
$\text{NH}_4\text{NO}_3 + \text{Ba}(\text{NO}_3)_2 + \text{NaNO}_3$	(Campbell and Campbell, 1947)
$\text{NH}_4\text{NO}_3 + \text{NaNO}_3 + \text{urea}$	(Campbell and Campbell, 1947; Howells, 1929, 1930)
$\text{NH}_4\text{NO}_3 + \text{NaNO}_3 + \text{urea nitrate}$	(Campbell and Campbell, 1947)
$\text{NH}_4\text{NO}_3 + \text{ethylenediamine dinitrate}$	(Campbell and Campbell, 1947)
$\text{NH}_4\text{NO}_3 + \text{NH}_4\text{SO}_3\text{NH}_2$	(Thelin and van der Meulen, 1948)
$\text{NH}_4\text{NO}_3 + \text{Ca}(\text{NO}_3)_2$	(Clark and Esterbrook, 1949)
$\text{NH}_4\text{NO}_3 + \text{Ca}(\text{NO}_3)_2 + \text{guanidine nitrate}$	(Clark and Esterbrook, 1948)
$\text{NH}_4\text{NO}_3 + \text{LiNO}_3 + \text{guanidine nitrate}$	(Clark and Esterbrook, 1948)
$\text{NH}_4\text{NO}_3 + \text{NaNO}_3 + \text{guanidine nitrate}$	(Clark and Esterbrook, 1948)
$\text{NH}_4\text{NO}_3 + \text{guanidine nitrate}$	(Urbanski and Skrzynecki, 1936; Clark, Clow and Easterbrook, 1949)
$\text{NH}_4\text{NO}_3 + \text{nitro guanidine}$	(Urbanski and Skrzynecki, 1936)
$\text{NH}_4\text{NO}_3 + \text{aniline hydrochloride}$	(Klug and Pardee, 1945)
$\text{NH}_4\text{NO}_3 + \text{aniline nitrate}$	(Klug and Pardee, 1945)
$\text{NH}_4\text{NO}_3 + \text{methylamine hydrochloride}$	(Klug and Pardee, 1945)
$\text{NH}_4\text{NO}_3 + \text{mannitol}$	(Khayshbashev, 1945)
$\text{NH}_4\text{NO}_3 + \text{resorcinol}$	(Khayshbashev, 1945)
$\text{NH}_4\text{NO}_3 + \text{urea}$	(Khayshbashev, 1945; Campbell and Campbell, 1947; Howells, 1929, 1930)
$\text{NH}_4\text{NO}_3 + \text{acetamide}$	(Khayshbashev, 1945)
$\text{NH}_4\text{NO}_3 + \text{p-phenylenediamine}$	(Khayshbashev, 1945)
$\text{NH}_4\text{NO}_3 + \text{o-phenylenediamine}$	(Khayshbashev, 1945)
$\text{NH}_4\text{NO}_3 + \text{picric acid}$	(Khayshbashev, 1945)
$\text{NH}_4\text{NO}_3 + \text{cholesterol}$	(Khayshbashev, 1945)
$\text{NH}_4\text{NO}_3 + \text{trinitrotoluene}$	(Khayshbashev, 1945; Campbell and Campbell, 1947)
$\text{NH}_4\text{NO}_3 + 22 \text{ simple salts}$	(Shirai and Ishibashi, 1955)

### AMMONIUM HYDROGEN PHOSPHITE $(\text{NH}_4\text{H})\text{HPO}_3$

100 grams water dissolve 171 grams  $(\text{NH}_4\text{H})\text{HPO}_3$  at  $0^\circ$ , 190 grams at  $14.5^\circ$  and 260 grams at  $31^\circ$ . (Amat., 1887.)

AMMONIUM HYPOPHOSPHITE  $\text{NH}_4\text{H}_2\text{PO}_2$ 

PO

100 cc.  $\text{H}_2\text{O}$  dissolve 83 gms.  $\text{NH}_4\text{H}_2\text{PO}_2$  at room temperature. (Squire and Caines, 1905.)

MONO AMMONIUM HYDROGEN PHOSPHATE  $\text{NH}_4\text{H}_2\text{PO}_4$ 

PO

## SOLUBILITY IN WATER

The solubility between  $0^\circ$  and  $110^\circ$  was determined by Buchanan and Winner (1920) and by Jänecke (1927) with identical results. The data of Ross, Merz, and Jacob (1929) are considerably higher than these above  $70^\circ$ , and are about 1-2% (absolute) lower below  $40^\circ$ . Between  $0^\circ$  and  $40^\circ$  the solubility has been determined by Bergman and Botchkareff (1938), Shpunt (1941), Belchew and Bergman (1944), Polosin (1946), and Polosin and Shakhparonov, 1947, with fairly good agreement among the various data. The results were plotted, and the average curve drawn through the points was about 1% lower than that of Buchanan and Winner over the same temperature interval. The solubilities of Bergman and Botchkareff are the lowest of all. All investigators except Ross, Merz, and Jacob agree on the solubility at  $0^\circ$ .

Data for the ice curve are included by Bergman and Botchkareff, Belchew and Bergman, Shpunt, Polosin, and Polosin and Ozolin (1940). Those of Shpunt are about  $0.4^\circ$  lower than the others at the same concentrations. These results were also plotted and the eutectic was determined graphically.

- (1) average of Bergman et al., Polosin et al., and Shpunt
- (2) average of Buchanan and Winner, and Jänecke
- (3) average of Ross, Merz, and Jacob

Results for the ice curve:

		Gms. $\text{NH}_4\text{H}_2\text{PO}_4$ per 100 gms. - Sat. Sol.			
$t^\circ$	Gms. $\text{NH}_4\text{H}_2\text{PO}_4$ per 100 gms. Sat. Sol.	$t^\circ$	(1)	(2)	(3)
		0	18.4	18.5	16.6
		5	20.1	20.6	19.1
		10	21.9	22.8	21.7
		15	24.0	25.0	24.0
	Average of Bergman, Polosin, et al.	20	26.1	27.2	26.35
		25	28.3	29.4(29.1) <sup>b</sup>	28.57
		30	30.5	31.7	31.2
-1.0	4.0	35	32.8	33.8	33.5
-2.0	8.1	40		36.3	36.0
-3.0	12.3	50		40.9(40.6) <sup>b</sup>	--
-4.0	16.6	60		45.2	45.5
*-4.2	17.4	70		50.0	--
		75		(52.13) <sup>a</sup>	--
*Eutectic		80		54.2	57.1
		90		58.9	--
		100		63.4	81.4
		110.5		68.3	--

<sup>a</sup>Brosheer and Anderson, 1946

<sup>b</sup>Flatt, Brunisholz and Denereaz, 1956



# H NITROGEN

## PO DI AMMONIUM HYDROGEN PHOSPHATE $(\text{NH}_4)_2\text{HPO}_4$

### THE SYSTEM $(\text{NH}_4)_2\text{HPO}_4 - \text{H}_2\text{O}$

Janecke, 1927; Buchanan and Winner, 1920. Below 20°, Chernova, 1947; above 100°, Janecke, 1936.

Solid Phase Ice		Solid Phase $(\text{NH}_4)_2\text{HPO}_4 \cdot 2\text{H}_2\text{O}$		Solid Phase $(\text{NH}_4)_2\text{HPO}_4$	
t°	Wt. % $(\text{NH}_4)_2\text{HPO}_4$	t°	Wt. % $(\text{NH}_4)_2\text{HPO}_4$	t°	Wt. % $(\text{NH}_4)_2\text{HPO}_4$
-0.6	3	-6.5	29.6 <sup>a</sup>	- 9.5	35.0 <sup>*b</sup>
-1.2	6	0.0	30.4 (30.0)	0.0	36.4 <sup>*</sup>
-1.6	9	4.0	32.0	10	38.6 <sup>*</sup>
-2.2	12	8.4	34.0	20	40.8
-2.8	15	10.6	35.2	25	41.0 <sup>d</sup> (42.3) <sup>e</sup>
-3.6	19	12.2	36.0	30	42.9
-4.2	21.6	15.8	38.4	40	45.0
-4.8	24	16.5	39.0 <sup>c</sup>	50	47.2 (46.8) <sup>e</sup>
-6.1	28			60	49.3
-7.0	30.4 <sup>*</sup>			70	51.5
-7.8	32.0 <sup>*</sup>			75	52.0 <sup>f</sup>
-8.2	33.0 <sup>*</sup>			117	63.0
-9.0	34.4 <sup>*</sup>			122	65.9
				160	74.8
				180	80.6
				191	83.1
				250	100.0

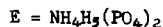
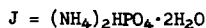
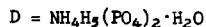
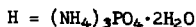
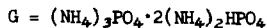
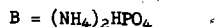
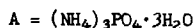
<sup>\*</sup>metastable  
<sup>a</sup>m. pt.  
<sup>a</sup>solid phases ice +  $(\text{NH}_4)_2\text{HPO}_4 \cdot 2\text{H}_2\text{O}$   
<sup>b</sup>solid phases ice +  $(\text{NH}_4)_2\text{HPO}_4$   
<sup>c</sup>solid phases  $(\text{NH}_4)_2\text{HPO}_4$  +  $(\text{NH}_4)_2\text{HPO}_4 \cdot 2\text{H}_2\text{O}$   
<sup>d</sup>Ross, Merz, and Jacob, 1929  
<sup>e</sup>Flatt, Brunisholz and Denereaz, 1956  
<sup>f</sup>Brosheer and Anderson, 1946

## PO TRI AMMONIUM PHOSPHATE $(\text{NH}_4)_3\text{PO}_4$

### SOLUBILITY IN WATER

t°	Gms. $(\text{NH}_4)_3\text{PO}_4$ per 100 gms. H <sub>2</sub> O	Reference
25	17.7	Ross, Merz and Jacobs, 1929
25	19.0	Wolkowitsch, Berlin and Manzew, 1932

## THE SYSTEM AMMONIA - PHOSPHORIC ACID - WATER



## Results at 0°

Data of  
Mourontzev and Nazarova, 1938

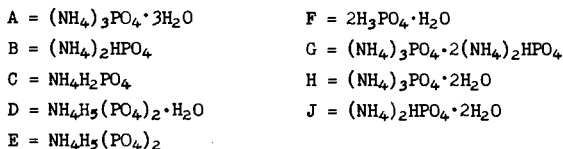
Data of Chernova, 1947

Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.		
NH <sub>3</sub>	H <sub>3</sub> PO <sub>4</sub>	Solid Phase	NH <sub>3</sub>	H <sub>3</sub> PO <sub>4</sub>	Solid Phase
23.71	0.07	A	9.35	26.95	B
16.48	0.15	A	7.80	22.60	J
13.88	0.23	A	7.38	20.79	J
7.85	0.62	A	8.38	26.31	J
3.22	1.88	A	8.31	26.52	J
2.26	3.10	A	9.25	30.40	J
2.41	5.24	A	9.50	31.93	J
3.65	9.65	A	9.85	33.30	J
7.14	19.92	A	10.04	34.24	J
7.78	21.81	A	10.12	35.26	J
8.18	22.92	A	10.71	37.84	B
8.35	23.50	A	11.14	41.06	B + C
9.34	26.56	A + B	Data of Jänecke, 1927		
9.97	32.35	B			
10.12	33.26	B	Percent NH <sub>3</sub> in dissolved NH <sub>3</sub> +P <sub>2</sub> O <sub>5</sub>	Gms. H <sub>2</sub> O to dissolve 1 gms. NH <sub>3</sub> +P	
10.71	37.84	B			
11.14	41.06	B + C			
8.60	33.76	C			
6.32	27.02	C			
3.89	19.37	C	92.2	1090	
3.52	17.98	C	86.1	1480	
3.07	16.61	C	75.0	1870	
2.85	18.69	C	68.0	2075	
2.90	21.19	C	65.0	2110	
3.00	23.25	C	55.7	1990	
3.52	61.96	C	42.0	1440	
3.50	69.46	C + D	34.0	659	
3.54	71.09	D	31.0	257	
3.25	71.80	D	26.0	210	
2.70	74.54	D	24.5	315	
2.96	77.00	D	24.0	326	
2.82	79.22	D	19.2	486	
3.40	83.93	D	6.0	65.8	
3.52	84.55	E			
2.92	86.36	F			
1.71	82.93	F			

PO

# N NITROGEN

## THE SYSTEM AMMONIA - PHOSPHORIC ACID - WATER--Cont.



### Results at 25°

Considerable additional data at 25° are given by Flatt, Brunisholz and Chapuis-Gottreux, 1951.

PO

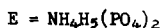
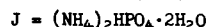
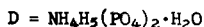
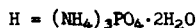
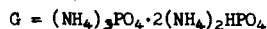
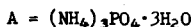
Data of Parker, 1914*			Data of Jänecke, 1927 (See also D'Ans and Schreiner, 1910)		
Sat. Sol. Wt. %		Solid Phase	Percent NH <sub>3</sub> in dissolved NH <sub>3</sub> + P <sub>2</sub> O <sub>5</sub>	Gms. H <sub>2</sub> O to dissolve 100 gms. NH <sub>3</sub> + P <sub>2</sub> O <sub>5</sub>	Solid Phase
NH <sub>3</sub>	H <sub>3</sub> PO <sub>4</sub>				
22.6	4.1	A	95.3	563	-
18.4	4.4	A	85.8	881	-
13.1	10.0	A	60.7	1090	-
7.0	20.0	A	41.5	705	-
7.7	30.0	A	32.5	222	-
10.0	34.4	A + B	27.2	127	-
10.2	40.0	B	22.5	92.2	-
11.6	48.2	B + C	20.1	333	-
9.0	40.0	C	12.62	232	-
5.4	30.0	C	8.60	63.7	-
4.0	20.6	C	4.2	32.7	E + F
3.8	30.0	C	4.9	58.1	E + F
4.0	40.0	C	7.1	97.5	E + F
4.2	50.0	C	10.8	140.0	E + F
4.4	60.6	C			

\*Recalculated and interpolated from the author's results

### Data of Mouromtzev and Nazarova, 1938

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
NH <sub>3</sub>	H <sub>3</sub> PO <sub>4</sub>	Solid Phase	NH <sub>3</sub>	H <sub>3</sub> PO <sub>4</sub>	Solid Phase
4.31	34.09	C	4.93	25.94	C
4.25	27.20	C	8.55	36.50	C
4.18	25.09	C	5.22	81.40	C + E
4.34	24.46	C	3.27	87.44	E
4.48	24.92	C	2.90	88.93	E

## THE SYSTEM AMMONIA - PHOSPHORIC ACID - WATER--Cont.



## Results at 50°

Data of  
Mouromtzev and Nazarova, 1938Data  
Flatt, Brunisholz and Denereaz, 1956

Sat. Sol. Wt. %			Saturated Solution				Solid Phase	PO
NH <sub>3</sub>	H <sub>3</sub> PO <sub>4</sub>		eq.-% NH <sub>4</sub>	eq.-% H	eq.-% PO <sub>4</sub>	g.mol. H <sub>2</sub> O		
12.26	3.01	A	22.7	77.3	100.0	171.8	C	
9.35	8.80	A	33.4	66.6	100.0	309.6	C	
8.97	14.10	A	33.4	66.6	100.0	312.6	C	
9.33	18.05	A	39.4	60.6	100.0	233.2	C	
11.18	29.02	A	43.3	56.7	100.0	187.2	C	
11.49	30.96	A	46.0	54.0	100.0	150.5	C	
12.20	34.10	A + B	49.5	50.5	100.0	111.0	C + B	
12.03	34.71	B	49.7	50.3	100.0	111.3	C + B	
12.00	34.81	B	53.3	46.7	100.0	154.5	B	
12.03	35.52	B	55.5	44.5	100.0	176.6	B	
12.07	36.07	B	59.0	41.0	100.0	217.6	B	
12.28	38.67	B	62.8	37.2	100.0	250.0	B	
12.64	42.35	B + C	65.5	34.5	100.0	274.7	B	
13.88	53.20	C	66.2	33.8	100.0	278.3	B	
8.50	40.42	C	66.3	33.7	100.0	274.2	B	
6.68	35.63	C	68.1	31.9	100.0	281.7	B + G	
6.10	34.58	C						
5.84	35.51	C						
5.77	41.88	C						
5.68	54.77	C						
5.97	71.92	C						
6.48	83.03	C						
6.44	85.33	C + E						
5.88	88.06	E						

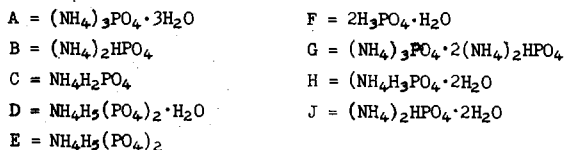
## Results at 60°

(Brosheer and Anderson, 1946)

Sat. Sol. Wt. %		Solid Phase
NH <sub>3</sub>	H <sub>3</sub> PO <sub>4</sub>	
12.74	41.24	B
12.36	37.96	B
12.45	36.76	B
12.54	35.90	B
12.62	35.69	B + G
12.64	35.61	B + G
11.72	31.13	G
11.04	25.98	G

# N NITROGEN

## THE SYSTEM AMMONIA - PHOSPHORIC ACID - WATER--Cont.



### Results at 75°

(Brosheer and Anderson, 1946)

PO	Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
	NH <sub>3</sub>	H <sub>3</sub> PO <sub>4</sub>		NH <sub>3</sub>	H <sub>3</sub> PO <sub>4</sub>	
	6.70	73.56	C	14.34	58.19	C
	6.67	72.85	C	14.39	58.41	C
	6.75	63.86	C	14.61	58.55	C
	6.87	58.11	C	14.89	59.23	C + B
	6.98	54.81	C	14.70	56.85	B
	7.02	54.67	C	14.47	53.04	B
	7.25	43.79	C	14.24	49.93	B
	7.23	47.96	C	13.82	46.48	B
	7.48	45.25	C	13.58	43.66	B
	7.71	44.42a	C	13.38	41.53	B
	7.81	44.54	C	13.42	39.13	B
	7.80	44.68	C	13.38	38.69b	B
	8.11	44.91	C	7.08	85.49	C
	8.20	45.11	C	6.85	80.35	C
	8.53	45.31	C	6.72	75.24	C
	9.22	47.02	C	13.55	38.46	B + G
	9.27	47.17	C	12.88	35.61	G
	9.60	47.93	C	12.47	33.02	G
	9.72	48.05	C	12.08	29.57	G
	9.90	48.13	C	11.91	27.16	G
	10.54	49.73	C	11.98	25.74	G
	11.09	51.06	C	11.83	22.60	G
	11.34	51.61	C	11.94	20.86	G
	11.52	52.00	C	12.15	14.96	G
	12.07	53.25	C	13.47	8.86	G
	12.50	54.07	C	15.40	5.36	G
	13.04	55.05	C	20.47	1.92	G
	13.14	55.79	C	23.73	1.09	G
	14.10	57.68	C			

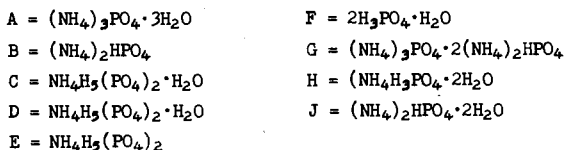
### Results at higher temperatures

(Jänecke, 1936)

The temperatures are those at which the last trace of solid phase disappeared when heating synthetic mixtures.

The author also gives similar determinations for the region of the system in which two liquid layers are formed.

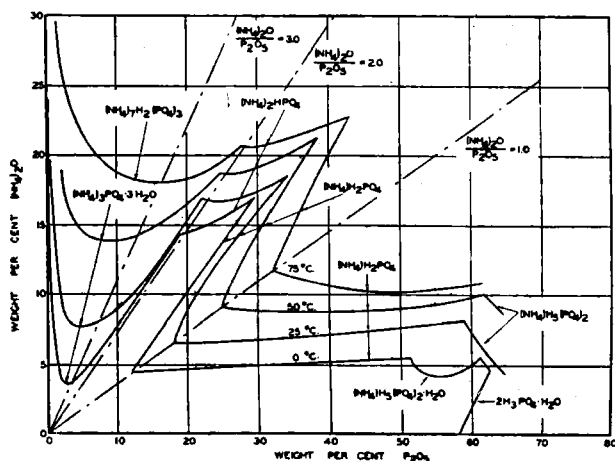
## THE SYSTEM AMMONIA - PHOSPHORIC ACID - WATER--Cont.



## Results at higher temperatures

t°	Wt. Percent		Solid Phase	t°	Wt. Percent		Solid Phase	PQ
	NH <sub>3</sub>	H <sub>2</sub> O			NH <sub>3</sub>	H <sub>2</sub> O		
90(?)	6.5	35.0	E	185(?)	22.6	19.2	H	
49	5.9	3.0	E	187	21.5	22.3	H	
--	11.3	2.2	C	146	18.5	32.6	H	
126	8.5	30.0	C	148	18.7	36.3	H	
88	6.5	30.0	C	149	19.1	41.1	H	
93	11.0	35.0	C	124	16.7	40.9	H	
85	8.5	35.0	C	115	19.3	58.9	H	
88	10.0	40.0	C	138	18.6	57.0	H	
--	17.0	30.7	B	121	27.0	17.0	H	
164	18.5	22.6	B	117	16.6	57.3	H	
180	16.4	18.4	B	125(?)	16.5	51.4	H	
110	15.0	30.0	B	114	15.3	52.5	H	
100	12.5	30.0	B	95	13.9	53.9	H	
72	13.5	35.0	B	101	17.8	69.6	H	
58	13.2	41.8	B					
53	12.5	40.0	B					

Diagram of the various results as drawn by Wendrow and Kobe, 1954



The system  $(NH_4)_2O - P_2O_5 - H_2O$  from 0°C. to 75°C.

# N NITROGEN

## THE SYSTEM MONO AMMONIUM HYDROGEN PHOSPHATE - AMMONIUM SULFATE - WATER (Belchew and Bergmann, 1944)

	Gms. per 100 gms.			Gms. per 100 gms.				
	Sat. Sol.		Solid Phase	Sat. Sol.		Solid Phase		
	$(\text{NH}_4)_2\text{SO}_4$	$\text{NH}_4\text{H}_2\text{PO}_4$		$(\text{NH}_4)_2\text{SO}_4$	$\text{NH}_4\text{H}_2\text{PO}_4$			
<b>Results at -10°</b>								
PO	29.4	0.0	Ice	16.7	0.0	Ice		
	27.2	2.8	"	14.4	3.4	"		
	24.0	6.0	"	11.6	7.0	"		
	22.2	7.6	$\text{NH}_4\text{H}_2\text{PO}_4$	9.0	10.0	"		
	28.1	6.3	"	6.0	13.7	Ice + $\text{NH}_4\text{H}_2\text{PO}_4$		
	26.1	4.8	"	8.7	12.7	$\text{NH}_4\text{H}_2\text{PO}_4$		
	37.8	4.6	$\text{NH}_4\text{H}_2\text{PO}_4 + (\text{NH}_4)_2\text{SO}_4$	18.0	9.6	"		
	39.1	2.4	$(\text{NH}_4)_2\text{SO}_4$	28.1	7.2	"		
	40.4	0.0	"	36.1	5.4	"		
			38.0	5.2	$\text{NH}_4\text{H}_2\text{PO}_4 + (\text{NH}_4)_2\text{SO}_4$			
			39.6	2.4	$(\text{NH}_4)_2\text{SO}_4$			
			40.8	0.0	"			
<b>Results at 0°</b>								
	0.0	18.8	$\text{NH}_4\text{H}_2\text{PO}_4$	0.0	22.2	$\text{NH}_4\text{H}_2\text{PO}_4$		
	8.6	14.7	"	8.2	17.4	"		
	17.8	10.7	"	17.3	13.4	"		
	27.6	8.0	"	27.0	10	"		
	35.7	5.9	"	35.0	7.6	"		
	38.0	5.4	$\text{NH}_4\text{H}_2\text{PO}_4 + (\text{NH}_4)_2\text{SO}_4$	38.2	6.9	$\text{NH}_4\text{H}_2\text{PO}_4 + (\text{NH}_4)_2\text{SO}_4$		
	38.5	5.0	$(\text{NH}_4)_2\text{SO}_4$	39.6	4.9	$(\text{NH}_4)_2\text{SO}_4$		
	40.0	2.4	"	41.0	2.4	"		
	41.2	0.0	"	42.0	0.0	"		
<b>Results at 20°</b>								
	0.0	26.0	$\text{NH}_4\text{H}_2\text{PO}_4$	0.0	30.6	$\text{NH}_4\text{H}_2\text{PO}_4$		
	7.8	21.3	"	7.4	25.2	"		
	16.6	16.6	"	16.1	20.1	"		
	26.3	12.1	"	25.4	15.4	"		
	34.3	9.5	"	33.2	12.0	"		
	38.5	8.3	$\text{NH}_4\text{H}_2\text{PO}_4 + (\text{NH}_4)_2\text{SO}_4$	38.4	10.2	$\text{NH}_4\text{H}_2\text{PO}_4 + (\text{NH}_4)_2\text{SO}_4$		
	40.5	4.8	$(\text{NH}_4)_2\text{SO}_4$	40.2	7.2	$(\text{NH}_4)_2\text{SO}_4$		
	41.9	2.3	"	41.8	4.7	"		
	42.9	0.0	"	43.1	2.3	"		
				43.7	0.0	"		
<b>Results at 30°</b>								
<b>Results of Apfel, 1911</b>								
	Mols. per 1000		Gms. per 100 gms.		Mols. per 1000		Gms. per 100 gms.	
	gms. sat.	sol.	sat.	sol.	gms. sat.	sol.	sat.	sol.
	$\text{PO}_4$	$\text{SO}_4$	$\text{NH}_4\text{H}_2\text{PO}_4$	$(\text{NH}_4)_2\text{SO}_4$	$\text{PO}_4$	$\text{SO}_4$	$\text{NH}_4\text{H}_2\text{PO}_4$	$(\text{NH}_4)_2\text{SO}_4$
	2.58	0.0	29.7	0.0	1.53	1.43	17.6	18.90
	2.40	0.17	27.6	2.25	1.31	1.84	15.1	24.31
	2.34	0.27	26.9	3.57	0.99	2.55	11.4	33.68
	2.26	0.35	26.0	4.62	0.82	2.92	9.44	38.58
	1.78	1.05	20.5	13.87	0.814	2.89	9.37	38.18

Data for the ternary systems  $\text{NH}_4\text{H}_2\text{PO}_4 - (\text{NH}_4)_2\text{SO}_4 - \text{H}_2\text{O}$  from  $0^\circ$  to  $100^\circ$  and  $\text{NH}_4\text{H}_2\text{PO}_4 - \text{H}_3\text{PO}_4 - \text{H}_2\text{O}$  at  $25^\circ$  and  $75^\circ$  and for part of the quaternary system  $\text{NH}_4\text{H}_2\text{PO}_4 - (\text{NH}_4)_2\text{SO}_4 - \text{H}_3\text{PO}_4 - \text{H}_2\text{O}$  at  $25^\circ$  and  $70^\circ$  are given by Uno, 1940a.

THE SYSTEM AMMONIUM NITRATE - MONO AMMONIUM HYDROGEN PHOSPHATE - WATER  
(Bergman and Botchkareff, 1937)

For additional data at  $20^\circ$  and  $70^\circ$  see Loginova, 1938.

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
$\text{NH}_4\text{NO}_3$	$\text{NH}_4\text{H}_2\text{PO}_4$	Solid Phase	$\text{NH}_4\text{NO}_3$	$\text{NH}_4\text{H}_2\text{PO}_4$	Solid Phase
Results at $-10^\circ$			Results at $20^\circ$ —Cont.		
27.2	0	Ice	17.5	12.2	$\text{NH}_4\text{H}_2\text{PO}_4$
22	5.5	Ice + $\text{NH}_4\text{H}_2\text{PO}_4$	27.6	8.1	"
28.8	3.8	$\text{NH}_4\text{H}_2\text{PO}_4$	30.5	7	"
38.9	2.4	"	37.9	5.1	"
45	2	"	44.3	3.7	"
45.6	1.8	$\text{NH}_4\text{NO}_3 + \text{NH}_4\text{H}_2\text{PO}_4$	48.6	9.8	"
47	0.0	$\text{NH}_4\text{NO}_3$	53.8	2.2	"
			59	1.6	$\text{NH}_4\text{NO}_3 + \text{NH}_4\text{H}_2\text{PO}_4$
			65.1	0.0	$\text{NH}_4\text{NO}_3$
Results at $0^\circ$			Results at $30^\circ$		
0	18.4	$\text{NH}_4\text{H}_2\text{PO}_4$			
8.8	12.4	"			
18.3	8.2	"	0.0	30.2	$\text{NH}_4\text{H}_2\text{PO}_4$
28.6	4.8	"	7.8	22.7	"
38.7	3.1	"	16.9	15.1	"
44.9	2.4	"	26.9	10.3	"
49	1.9	"	37.5	6.2	"
51.2	1.5	$\text{NH}_4\text{NO}_3 + \text{NH}_4\text{H}_2\text{PO}_4$	43.9	4.5	"
53.6	0.0		48.2	8.5	"
			53.5	2.7	"
			58.8	2	"
			68.7	1.2	$\text{NH}_4\text{NO}_3 + \text{NH}_4\text{H}_2\text{PO}_4$
			69.7	0.0	$\text{NH}_4\text{NO}_3$
Results at $10^\circ$			Results at $50^\circ$		
0.0	21.4	$\text{NH}_4\text{H}_2\text{PO}_4$			
8.4	15.5	"			
18	10	"			
23.5	7.7	"			
28.1	6.2	"	(Kuznetsov, Kozhukhovskii, and Borovaya, 1948)		
38.2	4.1	"			
44.6	3	"			
48.8	2.2	"	77.0	0.0	$\text{NH}_4\text{NO}_3$
54.1	1.6	"	75.6	1.4	"
58	1.2	$\text{NH}_4\text{NO}_3 + \text{NH}_4\text{H}_2\text{PO}_4$	74.4	2.5	$\text{NH}_4\text{H}_2\text{PO}_4$
59.6	0.0	$\text{NH}_4\text{NO}_3$	68.9	3.3	"
			55.6	7.6	"
			45.6	10.7	"
			42.3	11.8	"
			27.9	20.3	"
			21.8	25.3	"
			13.3	32.2	"
			0.0	47.05	"
Results at $20^\circ$					
0.0	25.5	$\text{NH}_4\text{H}_2\text{PO}_4$			
8.1	18.8	"			
(Cont.)					



# N NITROGEN

## THE SYSTEM AMMONIUM NITRATE - MONO AMMONIUM HYDROGEN PHOSPHATE - WATER--Cont.

Additional Data of B. + B. :

t°	Sat. Sol. Wt. %		Solid Phase
	NH <sub>4</sub> NO <sub>3</sub>	NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>	
- 4.4	0.0	17.4	Ice + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>
- 4.6	2.7	14.1	"
- 6.3	9	10.4	"
- 6.9	12	8.8	"
- 9.0	18.6	6.6	"
-12.9	29.0	3.6	"
-15.9	39.1	2.2	"
-11.0	45.2	1.8	NH <sub>4</sub> NO <sub>3</sub> + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>
- 3.2	49.2	1.6	"
+ 5.2	54.2	1.3	"
+11.4	59.3	1.3	"
-16.4	42.7	0.0	Ice + NH <sub>4</sub> NO <sub>3</sub>
-16.3	41.1	1.0	"
-16.8	40.3	2.1	Ice + NH <sub>4</sub> NO <sub>3</sub> + NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>

The system  $\text{NH}_4^+, \text{H}^+ || \text{PO}_4^{3-}, \text{NO}_3^- + \text{H}_2\text{O}$  has been extensively studied by Flatt, Brunisholz and Blumer, 1955; Flatt, Brunisholz and Rod, 1955 (both at 25°) and by Flatt, Brunisholz and Denereaz, 1955, at 50°. The results are given on an equivalent % basis and diagrams are drawn for each temperature.

Results for the quinary system  $\text{NH}_4^+, \text{H}^+, \text{Ca}^{++} || \text{PO}_4^{3-}, \text{NO}_3^- + \text{H}_2\text{O}$  at 25° in the region saturated with the double salt  $(\text{NH}_4)_4\text{Ca}_9\text{H}_{32}(\text{PO}_4)_{18} \cdot 10\text{H}_2\text{O}$  are given by Flatt, Brunisholz and Hotz, 1950.

## THE SYSTEM DI AMMONIUM HYDROGEN PHOSPHATE - AMMONIUM SULFATE - WATER (Chernova and Korzh, 1946)

t°	Gms. per 100 gms. Sat. Sol.		Solid Phase	t°	Gms. per 100 gms. Sat. Sol.		Solid Phase
	(NH <sub>4</sub> ) <sub>2</sub> HPO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>			(NH <sub>4</sub> ) <sub>2</sub> HPO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	
0	27.80	7.80	(NH <sub>4</sub> ) <sub>2</sub> HPO <sub>4</sub> ·2H <sub>2</sub> O	10	16.40	28.90	(NH <sub>4</sub> ) <sub>2</sub> HPO <sub>4</sub>
	22.20	15.80	"		16.00	31.60	"
	17.50	25.00	"		0.0	42.40	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
	14.00	30.00	"	20	34.20	6.90	(NH <sub>4</sub> ) <sub>2</sub> HPO <sub>4</sub>
	13.20	32.10	"		27.40	14.70	"
	0.0	41.60	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>		21.20	23.80	"
10	30.40	7.90	(NH <sub>4</sub> ) <sub>2</sub> HPO <sub>4</sub> ·2H <sub>2</sub> O		18.60	28.20	"
	24.20	15.50	"		17.80	30.80	"
	19.80	24.10	(NH <sub>4</sub> ) <sub>2</sub> HPO <sub>4</sub>		0.0	43.60	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>

Data for the system  $\text{NH}_4 + \text{P}_2\text{O}_5 + \text{SO}_3 + \text{H}_2\text{O}$  at 25° are given by Berlin and Mautsev, 1933.

Data for the system  $\text{KH}_2\text{PO}_4 - \text{NH}_4\text{H}_2\text{PO}_4 - \text{H}_2\text{O}$  at many temperatures are given by Polosin and Ozolin, 1940.

The author also gives data for the quarternary system  $\text{NH}_3 + \text{K}_2\text{O} + \text{P}_2\text{O}_5 + \text{H}_2\text{O}$  at  $0^\circ$  and at  $25^\circ$ . (Jänecke, 1927.)

Data for the quaternary system  $\text{KCl} + \text{NH}_4\text{H}_2\text{PO}_4 - \text{H}_2\text{O}$  from the eutectic to  $35^\circ$  are reported by Polosin and Shakhparonov, 1940.

THE SYSTEM MONO AMMONIUM HYDROGEN PHOSPHATE - MONOSODIUM HYDROGEN  
PHOSPHATE - WATER  
(Shpunt, 1941)

The eutectic temperature is  $-12.1^\circ$  with the solution containing 8.0%  $\text{NH}_4\text{H}_2\text{PO}_4$  and 26.6%  $\text{NaH}_2\text{PO}_4$ .

PO

Gms. per 100 gms. Sat. Sol.		Solid Phase
$\text{NH}_4\text{H}_2\text{PO}_4$	$\text{NaH}_2\text{PO}_4$	
<u>Results at <math>-9.9^\circ</math></u>		
0.0	42.4	Ice + $\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
3.6	28.6	
7.5	24.6	"
9.2	22.8	Ice + $\text{NH}_4\text{H}_2\text{PO}_4$
8.5	28.4	
3.4	30.4	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$ $\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
<u>Results at <math>-7^\circ</math></u>		
0.0	24.2	Ice
4.0	21.0	
8.4	17.4	"
12.3	13.8	Ice + $\text{NH}_4\text{H}_2\text{PO}_4$
10.6	20.8	
8.8	29.4	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
7.0	29.7	
3.4	31.5	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
0.0	33.6	"
<u>Results at <math>-4.3^\circ</math></u>		
0.0	15.1	Ice
8.8	7.0	
16.8	0.0	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{Ice}$
15.3	6.6	
13.3	13.5	$\text{NH}_4\text{H}_2\text{PO}_4$
11.4	20.6	"
9.1	30.3	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
6.9	31.0	
3.3	32.8	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
0.0	34.6	"

(Cont.)

# N NITROGEN

## THE SYSTEM MONO AMMONIUM HYDROGEN PHOSPHATE - MONOSODIUM HYDROGEN PHOSPHATE - WATER--Cont.

Gms. per 100 gms. Sat. Sol.		Solid Phase
$\text{NH}_4\text{H}_2\text{PO}_4$	$\text{NaH}_2\text{PO}_4$	
<u>Results at 0°</u>		
18.4	0.0	$\text{NH}_4\text{H}_2\text{PO}_4$
16.9	6.4	"
16.06	9.02	"
14.7	13.1	"
13.11	18.46	"
12.9	20.0	"
10.53	27.47	"
10.0	31.1	"
9.64	31.69	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
9.8	31.7	"
6.7	33.2	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
5.8	33.5	"
3.2	34.8	"
2.62	34.84	"
0.0	36.4	"
<u>Results at 10°</u>		
21.8	0.0	$\text{NH}_4\text{H}_2\text{PO}_4$
20.5	6.2	"
18.0	12.7	"
16.1	19.4	"
12.7	30.2	"
11.5	34.1	"
11.1	35.5	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
6.2	38.0	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
3.0	39.5	"
0.0	40.5	"
<u>Results at 20°</u>		
25.9	0.0	$\text{NH}_4\text{H}_2\text{PO}_4$
24.2	5.7	"
21.4	12.1	"
19.5	18.9	"
15.8	29.2	"
14.5	32.9	"
13.4	36.7	"
12.4	39.1	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
5.7	42.9	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
2.8	44.2	"
0.0	45.3	"
<u>Results at 30°</u>		
30.2	0.0	$\text{NH}_4\text{H}_2\text{PO}_4$
28.0	5.5	"
26.10	9.77	"

(Cont.)

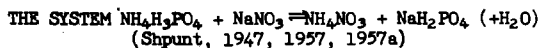
THE SYSTEM MONO AMMONIUM HYDROGEN PHOSPHATE - MONOSODIUM HYDROGEN  
PHOSPHATE - WATER—Cont.

Gms. per 100 gms. Sat. Sol.		Solid Phase
$\text{NH}_4\text{H}_2\text{PO}_4$	$\text{NaH}_2\text{PO}_4$	
<u>Results at 30°—Cont.</u>		
25.2	11.5	$\text{NH}_4\text{H}_2\text{PO}_4$
23.0	18.2	"
20.0	24.97	"
18.6	28.2	"
17.3	31.9	"
16.2	35.4	"
15.78	35.62	"
13.30	41.89	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
13.20	41.60	"
9.55	43.75	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
6.26	46.50	"
5.2	47.8	"
3.42	58.55	"
2.5	49.0	"
0.0	51.2	"

## AMMONIUM SODIUM PHOSPHATES

PO

Data for the distribution of each of 5 ammonium sodium ortho- and pyro-phosphates between water and chloroform at 18° are given by Abbott and Bray (1909).



Extensive tables and diagrams are given.

Moles per 100 moles dissolved salts					Solid Phase
$\text{NaNO}_3$	$\text{NH}_4\text{NO}_3$	$\text{NH}_4\text{H}_2\text{PO}_4$	$\text{NaH}_2\text{PO}_4$	$\text{H}_2\text{O}$	
<u>Results at + 30°</u>					
100.0	-	-	-	490	$\text{NaNO}_3$
27.1	72.9	-	-	147	$\text{NaNO}_3 + \text{NH}_4\text{NO}_3$
-	100.0	-	-	186	$\text{NH}_4\text{NO}_3$
-	98.8	1.2	-	192	$\text{NH}_4\text{NO}_3 + \text{NH}_4\text{H}_2\text{PO}_4$
-	-	100.0	-	1477	$\text{NH}_4\text{H}_2\text{PO}_4$
-	-	24.9	75.1	536	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
-	-	24.9	75.1	536	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
-	-	-	100.0	628	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
58.8	-	-	41.2	479	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O} + \text{NaNO}_3$
59.4	-	-	40.6	485	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O} + \text{NaNO}_3$
43.3	-	17.8	38.9	378	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NaNO}_3 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
27.5	71.7	0.8	-	147	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NaNO}_3 + \text{NH}_4\text{NO}_3$

(Cont.)

# N NITROGEN

THE SYSTEM  $\text{NH}_4\text{H}_2\text{PO}_4 + \text{NaNO}_3 \rightleftharpoons \text{NH}_4\text{NO}_3 + \text{NaH}_2\text{PO}_4 (+\text{H}_2\text{O})$ ---Cont.

Moles per 100 moles dissolved salts

$\text{NaNO}_3$   $\text{NH}_4\text{NO}_3$   $\text{NH}_4\text{H}_2\text{PO}_4$   $\text{NaH}_2\text{PO}_4$   $\text{H}_2\text{O}$

Solid Phase

Results at + 20°

100.0	-	-	-	555	$\text{NaNO}_3$
30.4	69.6	-	-	178	$\text{NaNO}_3 + \text{NH}_4\text{NO}_3$
-	100.0	-	-	277	$\text{NH}_4\text{NO}_3$
-	98.7	1.3	-	236	$\text{NH}_4\text{NO}_3 + \text{NH}_4\text{H}_2\text{PO}_4$
-	98.8	1.2	-	239	$\text{NH}_4\text{NO}_3 + \text{NH}_4\text{H}_2\text{PO}_4$
-	-	100.0	-	1824	$\text{NH}_4\text{H}_2\text{PO}_4$
P0	-	24.9	75.1	621	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O} + \text{NH}_4\text{H}_2\text{PO}_4$
-	-	-	100.0	789	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
71.7	-	-	28.3	540	$\text{NaNO}_3 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
71.0	-	-	29.0	542	$\text{NaNO}_3 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
63.4	-	18.5	18.1	446	$\text{NaNO}_3 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O} + \text{NH}_4\text{H}_2\text{PO}_4$
30.3	68.9	0.8	-	171	$\text{NaNO}_3 + \text{NH}_4\text{H}_2\text{PO}_4 + \text{NH}_4\text{NO}_3$

Results at 0°

100.0	-	-	-	654	$\text{NaNO}_3$
37.4	62.6	-	-	265	$\text{NaNO}_3 + \text{NH}_4\text{NO}_3$
-	100.0	-	-	385	$\text{NH}_4\text{NO}_3$
-	98.1	1.9	-	395	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NH}_4\text{NO}_3$
-	98.0	2.0	-	402	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NH}_4\text{NO}_3$
-	-	100.0	-	2833	$\text{NH}_4\text{H}_2\text{PO}_4$
-	-	24.1	75.9	937	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O} + \text{NH}_4\text{H}_2\text{PO}_4$
-	-	24.3	75.7	931	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O} + \text{NH}_4\text{H}_2\text{PO}_4$
-	-	-	100.0	1150	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
81.3	-	-	18.7	657	$\text{NaNO}_3 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
81.4	-	-	18.6	667	$\text{NaNO}_3 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
79.5	-	20.1	0.4	558	$\text{NaNO}_3 + \text{NH}_4\text{H}_2\text{PO}_4 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
37.9	61.2	0.9	-	255	$\text{NaNO}_3 + \text{NH}_4\text{H}_2\text{PO}_4 + \text{NH}_4\text{NO}_3$

Results at -10°

100.0	-	-	-	714	$\text{NaNO}_3$
41.5	58.5	-	-	322	$\text{NaNO}_3 + \text{NH}_4\text{NO}_3$
-	100.0	-	-	497	$\text{NH}_4\text{NO}_3$
-	97.4	2.6	-	497	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NH}_4\text{NO}_3$
-	(97.3)	(2.7)	-	(498)	"
-	84.8	15.2	-	1243	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{Ice}$
-	(85.1)	(14.9)	-	(1246)	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{Ice}$
-	-	30.8	69.2	1325	"
-	-	(30.4)	(69.9)	(1364)	"
-	-	23.7	76.8	1141	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
-	-	-	100.0	1391	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
83.5	-	-	16.5	744	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O} + \text{NaNO}_3$
83.7	-	-	16.3	721	"
80.3	2.3	17.1	-	579	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O} + \text{NaNO}_3 + \text{NH}_4\text{H}_2\text{PO}_4$
43.0	55.8	1.2	-	325	$\text{NaNO}_3 + \text{NH}_4\text{H}_2\text{PO}_4 + \text{NH}_4\text{NO}_3$

(Cont.)

THE SYSTEM  $\text{NH}_4\text{H}_2\text{PO}_4 + \text{NaNO}_3$   $\text{NH}_4\text{NO}_3 + \text{NaH}_2\text{PO}_4$  (+ $\text{H}_2\text{O}$ )--Cont.

Moles per 100 moles dissolved salts

$\text{NaNO}_3$	$\text{NH}_4\text{NO}_3$	$\text{NH}_4\text{H}_2\text{PO}_4$	$\text{NaH}_2\text{PO}_4$	$\text{H}_2\text{O}$
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Solid Phase

Results at  $-15^\circ$ 

100.0	-	-	-	742	$\text{NaNO}_3$
43.7	56.3	-	-	353	$\text{NaNO}_3 + \text{NH}_4\text{NO}_3$
-	-	-	-	570	$\text{NH}_4\text{NO}_3$
-	(97.3)	(2.7)	-	524	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NH}_4\text{NO}_3$
-	(95.1)	(4.9)	-	738	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{Ice}$
58.6	-	-	41.4	1073	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O} + \text{Ice}$
84.4	-	-	15.6	767	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O} + \text{NaNO}_3$
29.0	22.4	-	48.6	935	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O} + \text{NH}_4\text{H}_2\text{PO}_4 + \text{Ice}$
80.5	2.5	17.0	-	588	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O} + \text{NH}_4\text{H}_2\text{PO}_4 + \text{NaNO}_3$
45.3	53.4	1.3	-	337	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NaNO}_3 + \text{NH}_4\text{NO}_3$

PO

Results at  $-20^\circ$ 

86.3	13.8	-	-	675	$\text{NaNO}_3 + \text{Ice}$
46.0	54.0	-	-	386	$\text{NaNO}_3 + \text{NH}_4\text{NO}_3$
23.2	76.8	-	-	536	$\text{NH}_4\text{NO}_3 + \text{Ice}$
70.8	10.7	-	18.5	749	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O} + \text{NaNO}_3 + \text{Ice}$
63.3	17.7	-	19.0	633	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O} + \text{NH}_4\text{H}_2\text{PO}_4 + \text{Ice}$
79.3	3.0	17.7	-	650	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O} + \text{NH}_4\text{H}_2\text{PO}_4 + \text{NaNO}_3$
47.4	51.5	1.1	-	373	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NaNO}_3 + \text{NH}_3\text{NO}_3$
21.4	77.1	1.5	-	488	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{NH}_4\text{NO}_3 + \text{Ice}$

( ) Results in parentheses are from Bergman and Bochkarev, 1938.

SOLID SOLUTIONS IN THE SYSTEM AMMONIUM DIHYDROGEN PHOSPHATE - THALLIUM DIHYDROGEN PHOSPHATE - WATER AT  $29.5^\circ$   
(Bruzau, 1948)

Gms. per 100 gms. Sat. Sol.

$\text{TlH}_2\text{PO}_4$	$\text{NH}_4\text{H}_2\text{PO}_4$
---------------------------	------------------------------------

Density

Gms.  $\text{TlH}_2\text{PO}_4$   
in solid phase

0.0	30.87	1.174	0.0
2.52	29.86	1.197	7.49
4.90	29.03	1.217	14.81
9.02	27.10	1.257	25.41
15.35 <sup>a</sup>	25.10	1.321	41.52
21.00	22.10	1.381	49.08
23.85	21.66	1.416	56.94
26.79	20.04	1.453	59.16
28.25	19.63	1.472	60.18
30.45	16.13	1.479	96.66
30.97	11.92	1.448	98.22
33.56	5.16	1.425	98.72
33.94	0.0	1.394	100

<sup>a</sup> at  $30^\circ$

## N NITROGEN

### PO AMMONIUM ZINC PHOSPHATE $\text{NH}_4\text{ZnPO}_4$

100 cc. sat. solution of ammonium zinc phosphate in water contain 0.0136 gm.  $\text{NH}_4\text{ZnPO}_4$  at 10.5° and 0.0145 gm. at 17.5°. (Artmann, 1915.)

### EQUILIBRIUM IN THE SYSTEM DIAMMONIUM PHOSPHATE, ISO PROPYL ALCOHOL AND WATER AT 25° (Ginnings and Chen, 1931)

The points on the binodal curve of this system were determined by observing the appearance or disappearance of clouding in a mixture of weighed amounts of the salt and one of the liquids upon addition of weighed amounts of the other. Tie lines, \*, were located by means of determinations of the salt in pairs of liquid layers in contact with each other, and the plait point, PP, was found by plotting.

Gms. per 100 gms. homogeneous mixture		Gms. per 100 gms. homogeneous mixture	
$(\text{NH}_4)_2\text{HPO}_4$	iso $\text{C}_3\text{H}_7\text{OH}$	$(\text{NH}_4)_2\text{HPO}_4$	iso $\text{C}_3\text{H}_7\text{OH}$
3.48	39.20*	17.19	14.11
5.55	32.84	18.10	13.19
9.53	24.80	23.20	8.79
11.8	21.6 PP	27.14	6.18
12.74	20.10	32.84	3.62*
16.48	14.90		

The composition of the homogeneous mixture (plait point) of the system composed of di ammonium phosphate, tertiary butyl alcohol and water at 25° was found by Ginnings, Herring and Webb, 1933, to be 3.8 percent  $(\text{NH}_4)_2\text{HPO}_4$  + 33.8 percent tertiary  $(\text{CH}_3)_3\text{COH}$  + 62.4 percent  $\text{H}_2\text{O}$ . The original results for the remaining points on the binodal curve are not given but only the values of constants calculated by means of empirical equations.

The binodal curve for the system di ammonium phosphate, allyl alcohol and water at 25° was determined by Ginnings and Dees, 1935, but the authors give only the values of constants calculated by means of empirical equations. The conclusion is drawn that allyl alcohol seems to be more difficult to salt out than either normal or iso propyl alcohol.

### THE SYSTEM MONOAMMONIUM HYDROGEN PHOSPHATE - UREA - WATER (Bliidin, 1941a, Polosin and Treshchov, 1953, 1953a)

The latter authors found no compound formation from the eutectic to +40°C.

#### Results at -10°

Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
$\text{NH}_4\text{H}_2\text{PO}_4$	$\text{CO}(\text{NH}_2)_2$		$\text{NH}_4\text{H}_2\text{PO}_4$	$\text{CO}(\text{NH}_2)_2$	
14.5	17.2	$\text{NH}_4\text{H}_2\text{PO}_4$	10.1	32.8	$\alpha\text{-CO}(\text{NH}_2)_2$
14.4	25.5	"	7.0	32.5	"

(Cont.)

## THE SYSTEM MONOAMMONIUM HYDROGEN PHOSPHATE - UREA - WATER--Cont.

Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.		
$\text{NH}_4\text{H}_2\text{PO}_4$	$\text{CO}(\text{NH}_2)_2$	Solid Phase	$\text{NH}_4\text{H}_2\text{PO}_4$	$\text{CO}(\text{NH}_2)_2$	Solid Phase
Results at 0°			Results at 15°		
17.1	16.2	$\text{NH}_4\text{H}_2\text{PO}_4$	21.2	15.8	$\text{NH}_4\text{H}_2\text{PO}_4$
18.4	7.8	"	22.6	7.9	"
16.2	25.0	"	20.1	24.0	"
14.9	34.0	"	16.8	37.3	"
9.6	37.8	$\alpha\text{-CO}(\text{NH}_2)_2$	18.1	33.0	"
8.9	37.2	"	5.2	45.9	$\alpha\text{-CO}(\text{NH}_2)_2$
			8.1	45.5	"
			11.2	45.1	"
Results at 5°			Results at 25°		
18.5	16.1	$\text{NH}_4\text{H}_2\text{PO}_4$			
19.6	8.0	"			
17.9	26.0	"	25.1	15	$\text{NH}_4\text{H}_2\text{PO}_4$
15.8	33.9	"	26.3	7.4	"
12.0	40.9	$\alpha\text{-CO}(\text{NH}_2)_2$	24.0	22.8	"
6.0	40.1	"	19.1	36.0	"
			21.6	31.3	"
			4.8	51.6	$\alpha\text{-CO}(\text{NH}_2)_2 +$ $\beta\text{-CO}(\text{NH}_2)_2$
			7.3	50.5	"
			10.2	49.5	"

## Eutectic composition:

(-16°)	12.8	28.6	$\text{NH}_4\text{H}_2\text{PO}_4 + \alpha\text{CO}(\text{NH}_4)_2$	(Blidin)
			+ Ice	
(-15.3°)	11.90	28.80	" " "	(Polosin and Treshchov)

Melting points in the system  $\text{NH}_4\text{H}_2\text{PO}_4 + (\text{NH}_4)_2\text{HPO}_4$  are given by Crepaz, 1949-50. A 1:1 compound is formed

AMMONIUM PERRHENATE  $\text{NH}_4\text{ReO}_4$ 

ReO

## SOLUBILITY IN WATER

t°	Solubility	Reference
0	2.76 gms./100 gms. $\text{H}_2\text{O}$	(Smith and Long, 1948)
20	12.0 gms./100 cc. sat. sol. (?)	(Noddak and Noddak, 1929)
30	8.72 gms./100 gms. $\text{H}_2\text{O}$	(Smith and Long, 1948)
50.3	16.06 "	" " "

Data for the extraction of  $\text{NH}_4\text{ReO}_4$  from 4N NaOH solution by pyridine are reported by Goishi and Libby, 1952



## N NITROGEN

### ReO AMMONIUM SULFO PERRHENATE $\text{NH}_4\text{ReO}_3\text{S}$

100 gms. sat. solution of ammonium sulfo perrhenate in water contain 58.5 gms.  $\text{NH}_4\text{ReO}_3\text{S}$  at  $20^\circ$ . (Feit, 1931.)

### S AMMONIUM SULFIDE $(\text{NH}_4)_2\text{S}$ $\text{NH}_4\text{HS}$

#### THE SYSTEM AMMONIA - HYDROGEN SULFIDE (Schefflan and McCrosky, 1932; also Scheffer, 1912)

The vapor pressure curve of  $\text{NH}_3 + \text{H}_2\text{S}$  was determined and also the freezing-points of their mixtures. The vapor pressure curve at  $0^\circ$  showed two regions of constant pressure, respectively at 80mm and 837mm. These correspond to the dissociation pressure of the compound  $\text{NH}_4\text{HS}$  and the pressure at which the solid compound is in equilibrium with solution and vapor at  $0^\circ$ . The vapor pressure temperature curve of the three phase system  $\text{NH}_4\text{HS}$  (solid) solution and vapor was determined by two methods. The freezing-points of various mixtures of  $\text{NH}_3 + \text{H}_2\text{S}$  were also determined.

These results show that ammonium sulfide,  $(\text{NH}_4)_2\text{S}$ , is stable only below  $-18^\circ$ . On heating at this temperature it decomposes into solid cryst.  $\text{NH}_4\text{HS}$  and melt.

Vapor Pressures of the Three Phase System		Freezing Points of the system $\text{NH}_3 + \text{H}_2\text{S}$		
$t^\circ$	Vapor Pressure in mm.	$t^\circ$ of f. pt.	Mola. $\text{NH}_3$ per 100 Mols. $\text{NH}_3 + \text{H}_2\text{S}$	Solid Phase
-21	435.5	-78.0	100	$\text{NH}_3$
-12	548.5	-83.5	97.5	"
-10	581.0	-88.0 <sup>1</sup>	95.0	" + $\text{H}_2\text{S}$
- 7.8	604.5	-72	92.5	$(\text{NH}_4)_2\text{S}$
- 7.5	631.5	-60	90	"
- 5.9	664.0	-48.3	87.5	"
- 5	686.0	-30	82.5	"
- 4	708.5	-22.5	80.0	"
- 2.5	780.0	-18.0	75.0	"
0	838.0	+11.0	72.5	$\text{NH}_4\text{HS}$
2.5	917.5	40	70	"
5	1002.0	79	65	"
6.5	1075.0	100.8	60	"
7.5	1120.0	114.5	55	"
9	1201.5	118.0 <sup>2</sup>	50	"
10	1246.5	-83.5	0	$\text{H}_2\text{S}$

<sup>1</sup>eutectic

<sup>2</sup>m. pt.

100 gms. liquid ammonia dissolve 120 gms.  $(\text{NH}_4)_2\text{S}$  at  $25^\circ$ . (Hunt and Boncyk, 1933.)

AMMONIUM ANTIMONY SULFIDE (Sulfoantimonate)  $(\text{NH}_4)_3\text{SbS}_4$ 

S

SOLUBILITY IN WATER AND IN AQUEOUS ALCOHOL  
(Donk, 1908)

t°	In Water		In Aqueous Alcohol at 10°	
	Gms. $(\text{NH}_4)_3\text{SbS}_4$ per 100 Gms. Sat. Sol.		Gms. per 100 Gms. Sat. Sol.	
		Solid Phase	$\text{C}_2\text{H}_5\text{OH}$	$(\text{NH}_4)_3\text{SbS}_4$
- 1.9	9.9	Ice	0	43.2
- 5	20	"	5.1	35.9
- 8	30.2	"	19.1	23.1
-13.5	41.6	Ice + $(\text{NH}_4)_3\text{SbS}_4 \cdot 4\text{H}_2\text{O}$	43.1	8.7
0	41.6	$(\text{NH}_4)_3\text{SbS}_4 \cdot 4\text{H}_2\text{O}$	53.1	4.1
+20	47.7	"	93.3	0
30	54.5	"		

AMMONIUM SULFITE  $(\text{NH}_4)_2\text{SO}_3$ 

SO

SOLUBILITY OF AMMONIUM SULFITE IN WATER  
(Ishikawa and Murooka, 1928, 1933)

The results of Vasilenko, 1950, are in good agreement.

t°	d. of sat. sol.	Gms. $(\text{NH}_4)_2\text{SO}_3$ per 100 gms. sat. sol.	Solid Phase
- 1.73	-	4.961	Ice
- 3.35	-	9.698	"
- 6.27	-	16.817	"
- 9.69	-	23.652	"
-12.96	-	28.855	" + $(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O}$
-11.52	-	29.16	$(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O}$
- 6.55	-	30.62	"
0	1.1792	32.40	"
+10	1.1896	35.05	"
15	1.1943	36.40	"
20	1.1995	37.80	
25	1.2042	39.29	$(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O}$
30	1.2097	40.77	"
40	1.2203	43.96	"
50	1.2306	47.26	"
60	1.2424	50.94	"
70	1.2558	54.71	"
80	1.2716	58.99	"
80.8 <sup>1</sup>	-	-	" + $(\text{NH}_4)_2\text{SO}_3$
85	-	59.53	$(\text{NH}_4)_2\text{SO}_3$
90	-	60.00	"
100	-	60.44	"

<sup>1</sup>transition point

# N NITROGEN

## THE SYSTEM AMMONIA - SULFUR DIOXIDE - WATER AT 25° (Hill, 1948)

The system was studied in the concentration range where the total pressure was less than one atmosphere. Only slight oxidation to sulfate occurred, and the solid phase was  $(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O}$  throughout. The solubility of ammonium sulfite read from the plot of these data is several percent less than that found by Ishikawa and Murooka above.

Additional results for the system  $\text{NH}_3\text{-SO}_2\text{-H}_2\text{O}$  at 0°, 20°, 30°, 40°, 50° and 60° are given by Terres and Hahn, 1927. Their results differ from these in solutions containing less than 20%  $\text{SO}_2$ .

SO	Gms. per 100 gms. Sat. Sol.			Density $\frac{25}{15}$	Gms. per 100 gms. Sat. Sol.			Density $\frac{25}{15}$
	NH <sub>3</sub>	SO <sub>2</sub>	SO <sub>3</sub>		NH <sub>3</sub>	SO <sub>2</sub>	SO <sub>3</sub>	
	23.8	6.5	0.2	0.964	12.1	21.0	-	-
	19.9	9.3	-	1.007	11.5	22.0	0.3	1.201
	17.4	13.5	nil	1.061	11.8	27.3	0.2	1.234
	16.1	15.9	0.3	1.101	12.4	33.3	0.3	1.278
	15.8	16.4	0.1	1.109	13.4	41.4	0.8	1.342
	13.8	19.0	nil	-	13.8	43.2	0.2	1.358
	13.8	19.2	0.1	1.150	14.1	44.9	0.4	1.371
	11.9	20.7	0.7	-	14.8	49.2	0.5	1.411

## THE SYSTEM AMMONIUM SULFITE - AMMONIUM BISULFITE - WATER (Vasilenko, 1949)

Gms. per 100 gms. Sat. Sol.

$(\text{NH}_4)_2\text{SO}_3$        $\text{NH}_4\text{HSO}_3$

Solid Phase

### Results at 0°

31.71	0.0	$(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O}$
22.58	19.50	"
15.40	39.17	"
10.78	56.29	"
9.06	60.76	$(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O} + (\text{NH}_4)_2\text{S}_2\text{O}_5$
7.20	63.99	$(\text{NH}_4)_2\text{S}_2\text{O}_5$
2.48	69.18	"
0.0	72.38*	"

### Results at 20°

37.40	0.0	$(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O}$
30.24	13.99	"
24.26	27.75	"
18.19	42.50	"
14.79	54.54	"
11.31	65.04	$(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O} + (\text{NH}_4)_2\text{S}_2\text{O}_5$
9.73	67.56	$(\text{NH}_4)_2\text{S}_2\text{O}_5$
6.48	70.57	"
4.61	71.27	"
3.54	73.84	"
1.71	74.26	"
0.0	75.95**	"

(Cont.)

## THE SYSTEM AMMONIUM SULFITE - AMMONIUM BISULFITE - WATER--Cont.

Gms. per 100 gms. Sat. Sol.

 $(\text{NH}_4)_2\text{SO}_3$   $\text{NH}_4\text{HSO}_3$ 

Solid Phase

Results at 30°

40.30	0.0	$(\text{NH}_4)_2\text{S}_2\text{O}_5$
30.77	18.81	"
21.99	38.26	"
16.13	55.94	"
12.75	66.73	" + $(\text{NH}_4)_2\text{S}_2\text{O}_5$
8.21	70.98	$(\text{NH}_4)_2\text{S}_2\text{O}_5$
4.09	74.45	"
1.72	76.85	"
0.0	79.31***	"

50

\*Contained excess  $\text{H}_2\text{SO}_3$  = 0.59 Wt. %\*\*Contained excess  $\text{H}_2\text{SO}_3$  = 1.31 Wt. %\*\*\*Contained excess  $\text{H}_2\text{SO}_3$  = 0.58 Wt. %

## COMPOSITIONS OF SOLUTIONS SATURATED WITH AMMONIUM SULFITE AND BISULFITE:

Gms. per 100 gms.  
Sat. Sol.

t°	$(\text{NH}_4)_2\text{SO}_3$ $\text{NH}_4\text{HSO}_3$		Solid Phase	
0	13.54	54.16	$(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O} + \text{NH}_4\text{HSO}_3$	(Terres and Hahn, 1927)
20	16.13	54.00	"	( " " " " )
25	11.59	66.88	$(\text{NH}_4)_2\text{SO}_3 + (\text{NH}_4)_2\text{S}_2\text{O}_5$	(Ishikawa and Haggisawa, 1933)
40	27.42	44.85	$(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O} + \text{NH}_4\text{HSO}_3$	(Terres and Hahn, 1927)
60	34.04	40.59	"	( " " " " )

## THE SYSTEM AMMONIUM SULFITE - AMMONIUM SULFATE - WATER

At -19°, 015°, -10°, 0°, +10°, +20°, Vasilenko, 1950; at +15°, 30°, and up to 100°, Ishikawa and Murooka, 1929.

A =  $(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O}$  B =  $(\text{NH}_4)_2\text{SO}_3$  C =  $(\text{NH}_4)_2\text{SO}_3$  I = ICE

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
$(\text{NH}_4)_2\text{SO}_3$	$(\text{NH}_4)_2\text{SO}_4$		$(\text{NH}_4)_2\text{SO}_3$	$(\text{NH}_4)_2\text{SO}_4$	

at -19°

0.0	39.3	I, C	13.8	24.6	A, I
3.1	36.6	C	10.4	28.3	I
6.6	33.6	C	6.8	32.0	I
10.0	30.8	C	3.2	35.8	I
11.0	29.8	C, A			

(Cont.)

**N NITROGEN**

THE SYSTEM AMMONIUM SULFITE - AMMONIUM SULFATE - WATER--Cont.

$$A = (\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O} \quad B = (\text{NH}_4)_2\text{SO}_3 \quad C = (\text{NH}_4)_2\text{SO}_4 \quad I = \text{ICE}$$
30

## THE SYSTEM AMMONIUM SULFITE - AMMONIUM SULFATE - WATER--Cont.

A =  $(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O}$     B =  $(\text{NH}_4)_2\text{SO}_3$     C =  $(\text{NH}_4)_2\text{SO}_4$     I = ICE

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
$(\text{NH}_4)_2\text{SO}_3$	$(\text{NH}_4)_2\text{SO}_4$		$(\text{NH}_4)_2\text{SO}_3$	$(\text{NH}_4)_2\text{SO}_4$	
at 30°, cont.			at higher temperatures		
12.66	33.88	C	(50°)	32.75    21.89	A, C
18.41	29.60	C	(70°)	42.28    17.71	A, C
24.64	25.21	C, A	(80°)	48.26    15.13	A, C
25.87	23.31	A	(90°)	49.14    15.01	B, C
28.04	19.61	A	(100°)	50.53    14.80	B, C
31.03	14.30	A			
33.33	11.19	A			
36.19	6.99	A			
38.86	2.83	A			
40.77	0.0	A			

50

THE SYSTEM  $(\text{NH}_4)_2\text{SO}_3 + \text{NH}_4\text{HSO}_4 + (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  AT 30°  
(Vasilenko, 1953)A =  $(\text{NH}_4)_2\text{SO}_3$     B =  $\text{NH}_4\text{HSO}_3$     C =  $(\text{NH}_4)_2\text{SO}_4$     D =  $(\text{NH}_4)_2\text{S}_2\text{O}_5$ 

Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
B	A	C		B	A	C	
0.0	24.33	25.74	C+A·H <sub>2</sub> O	65.88	11.68	3.46	D+A·H <sub>2</sub> O
5.01	23.15	22.27	" "	66.41	11.86	2.60	" "
11.05	22.68	20.36	" "	66.56	12.24	1.68	" "
20.52	20.69	16.37	" "	67.08	12.84	0.36	" "
27.80	19.13	14.00	" "	64.51	10.84	5.18	C+D
35.40	17.86	11.44	" "	65.80	9.10	5.50	" "
43.50	15.64	9.78	" "	68.27	6.29	5.67	" "
48.12	15.07	7.87	" "	70.11	3.30	5.93	" "
48.57	15.99	6.37	" "	72.14	1.87	6.36	" "
63.84	11.57	5.33	C+A·H <sub>2</sub> O+D	73.29	0.73	6.17	" "
				73.83	0.0	6.32	" "

THE SYSTEM  $(\text{NH}_4)_2\text{SO}_3 + 2\text{NaCl} \rightleftharpoons 2\text{NH}_4\text{Cl} + \text{Na}_2\text{SO}_3 (+\text{H}_2\text{O})$   
(Silberman and Ivanov, 1941)

Gms. per 100 gms. Sat. Sol.					Solid Phase
t°	$\text{Na}_2\text{SO}_3$	$(\text{NH}_4)_2\text{SO}_3$	$\text{NaCl}$	$\text{NH}_4\text{Cl}$	
60	-	-	11.96	25.30	$\text{NH}_4\text{Cl} + \text{NaCl}$
	-	35.82	-	16.74	$(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O} + \text{NH}_4\text{Cl}$
	2.36	-	24.23	-	$\text{NaCl} + \text{Na}_2\text{SO}_3$
	8.35	45.08	-	-	$(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O} + \text{Na}_2\text{SO}_3$
	12.84	0.52	-	30.84	$\text{Na}_2\text{SO}_3 + \text{NH}_4\text{Cl} + \text{NaCl}$
	4.25	35.11	-	15.79	$\text{Na}_2\text{SO}_3 + (\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O} + \text{NH}_4\text{Cl}$

(Cont.)

# N NITROGEN

THE SYSTEM  $(\text{NH}_4)_2\text{SO}_3 + 2\text{NaCl} \rightleftharpoons 2\text{NH}_4\text{Cl} + \text{Na}_2\text{SO}_3 (+\text{H}_2\text{O})$ --Cont.

t°	Gms. per 100 gms. Sat. Sol.				Solid Phase
	$\text{Na}_2\text{SO}_3$	$(\text{NH}_4)_2\text{SO}_3$	$\text{NaCl}$	$\text{NH}_4\text{Cl}$	
80	2.27	-	26.08	-	$\text{Na}_2\text{SO}_3 + \text{NaCl}$
	-	-	11.57	29.94	$\text{NaCl} + \text{NH}_4\text{Cl}$
	5.51	54.67	-	-	$\text{Na}_2\text{SO}_3 + (\text{NH}_4)_2\text{SO}_3$
	-	43.18	-	18.46	$(\text{NH}_4)_2\text{SO}_3 + \text{NH}_4\text{Cl}$
	6.31	27.80	-	20.00	$\text{Na}_2\text{SO}_3 + \text{NH}_4\text{Cl}$
	4.78	34.63	-	19.91	"
	4.91	41.22	-	18.34	$\text{Na}_2\text{SO}_3 + (\text{NH}_4)_2\text{SO}_3 + \text{NH}_4\text{Cl}$
	13.40	-	-	15.79	$\text{Na}_2\text{SO}_3 + \text{NH}_4\text{Cl} + \text{NaCl}$

80

THE SYSTEM AMMONIUM SULFITE - SODIUM SULFITE - WATER  
(Labash and Lusby, 1955)

Sat. Sol. Wt. %			Solid Phase
$\text{Na}_2\text{SO}_3$	$(\text{NH}_4)_2\text{SO}_3$	$(\text{NH}_4)_2\text{SO}_4$	
<u>Results at 20°</u>			
0.0	37.34	0.49	$(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O}$
4.74	33.52	1.10	"
9.91	30.91	0.62	"
14.79	27.55	1.00	"
14.98	27.43	0.96	" + ?
17.26	25.75	1.30	?
17.21	25.70	0.80	$\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$
17.97	20.87	0.88	$\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$
18.65	15.95	0.84	"
19.34	10.44	0.87	"
20.58	0.0	(0.77) <sup>a</sup>	"
<u>Results at 60°</u>			
(8.35) <sup>b</sup>	(45.08)	-	$(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O} + \text{Na}_2\text{SO}_3$
7.76	44.7	(0.74) <sup>a,c</sup>	?
7.69	45.0	(0.71) <sup>a,d</sup>	?

a) = %  $\text{Na}_2\text{SO}_4$

b) = Zilberman and Ivanov, 1941

c) = also contains 0.08%  $\text{NH}_3$

d) = also contains 0.08%  $\text{NH}_4\text{HSO}_3$

Results for the system  $(\text{NH}_4)_2\text{SO}_3 + 2\text{NaCl} \rightleftharpoons 2\text{NH}_4\text{Cl} + \text{Na}_2\text{SO}_3 (+\text{H}_2\text{O})$   
at 20° and 60° are given by Labash and Lusby, 1955a.

AMMONIUM BISULFITE  $\text{NH}_4\text{HSO}_3$ 

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SOLUBILITY OF AMMONIUM BISULFITE IN WATER  
(Vasilenko, 1948)

Solid Phase Ice		Solid Phase $(\text{NH}_4)_2\text{S}_2\text{O}_5$			
$t^\circ$	Gms. $\text{NH}_4\text{HSO}_3$ per 100 gms. Sat. Sol.	$t^\circ$	Gms. $\text{NH}_4\text{HSO}_3$ per 100 gms. Sat. Sol.	$t^\circ$	Gms. $\text{NH}_4\text{HSO}_3$ per 100 gms. Sat. Sol.
- 3.4	9.4	-24.8	63.6	4.6	73.5
- 6.0	16.8	-21.7	64.4	5.1	73.1
- 8.7	22.7	-21.0	65.0	13.8	75.6
-10.2	27.5	-19.0	65.5	15.7	76.6
-12.2	30.9	-16.7	66.3	20.0	77.0
-13.8	34.9	-17.0	66.4	*20.0	74.5
-16.6	40.3	-13.8	67.9	**20.0	76.95
-18.9	44.5	-10.0	68.4	***25.0	78.41
-21.5	58.4	- 9.2	69.5	*40.0	80.3
-24.2	51.3	- 3.3	70.7	**40.0	80.64
-25.0	53.2	- 4.0	71.2	*60.0	86.1
-26.2	54.4	- 0.2	72.3	**60.0	84.7
-29.0	57.8	0.0	72.0		
-31	60.5	*0.0	72.8		
		**0.0	71.8		

\*Terres and Hahn (1937)

\*\*Terres and Heinsen (1937)

\*\*\*Ishikawa and  
Hagisawa (1933)THE SYSTEM AMMONIUM BISULFITE - AMMONIUM SULFATE - WATER  
(Vasilenko, 1948)

The data were determined by the polythermal method. The eutectic temperature is  $-34.5^\circ$  (10.0%  $(\text{NH}_4)_2\text{SO}_4$ , 50.5%  $\text{NH}_4\text{HSO}_3$ ).



Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
$(\text{NH}_4)_2\text{SO}_4$	$\text{NH}_4\text{HSO}_3$		$(\text{NH}_4)_2\text{SO}_4$	$\text{NH}_4\text{HSO}_3$	
Results at 20°			Results at 0°		
42.8	0.0	A	41.0	0.0	A
36.5	9.6	A	34.5	9.9	A
29.0	21.3	A	26.5	22.1	A
21.5	34.2	A	19.5	35.1	A
13.3	52.0	A	12.8	50.3	A
10.3	58.1	A	10.0	56.3	A
9.9	58.1	A	9.1	59.1	A
9.4	60.7	A	8.9	58.8	A
8.0	65.5	A	7.9	64.2	A
7.30	66.8	A	7.4	65.3	A + B
6.9	68.6	A	6.6	65.6	B
5.9	71.2	A	3.0	69.3	B
6.0	71.8	A + B	2.0	70.6	B
0.0	77.0	B	0.0	72.0	B



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## THE SYSTEM AMMONIUM BISULFITE - AMMONIUM SULFATE - WATER--Cont.



	Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
	$(\text{NH}_4)_2\text{SO}_4$	$\text{NH}_4\text{HSO}_3$		$(\text{NH}_4)_2\text{SO}_4$	$\text{NH}_4\text{HSO}_3$	
	Results at $-10^\circ$			Results at $-19^\circ$ , Cont.		
	40.0	0.0	A	8.8	57.1	A + B
	35.5	10.0	A	7.2	58.9	B
	25.5	22.4	A	6.0	60.0	B
	18.5	35.5	A	3.8	62.1	B
30	12.5	49.1	A	2.8	63.6	B
	9.9	55.4	A	0.0	65.5	B
	9.0	58.1	A	0.0	44.5	Ice
	8.4	59.2	A	1.0	43.1	Ice
	8.0	60.8	A + B	8.4	33.0	Ice
	7.6	61.8	B	16.3	25.1	Ice
	6.3	62.5	B	30.0	10.5	Ice
	2.9	66.3	B			
	0.0	68.7	B			
	28.0	0.0	Ice	Results at $-31^\circ$		
	13.5	13.1	Ice			
	0.0	26.0	Ice	0.0	60.5	Ice + B
				2.6	59.0	B
				5.7	56.2	B
				6.7	54.8	B
				9.4	52.9	B
	39.25	0.0	Ice + A	9.8	52.0	A + B
	32.5	10.2	A	12.5	45.5	Ice + A
	24.5	22.7	A	8.7	49.0	Ice
	17.7	35.9	A	6.3	51.3	Ice
	12.4	48.7	A	5.3	53.0	Ice
	9.7	54.6	A	2.5	56.6	Ice
	8.8	57.2	A			

## THE SYSTEM $\text{NH}_4\text{HSO}_3 + \text{NaCl} \rightleftharpoons \text{NH}_4\text{Cl} + \text{NaHSO}_3 (+\text{H}_2\text{O})$ (Silberman and Ivanov, 1941)

$t^\circ$	Gms. per 100 gms. Sat. Sol.				Solid Phase
	$\text{NaHSO}_3$	$\text{NH}_4\text{HSO}_3$	$\text{NaCl}$	$\text{NH}_4\text{Cl}$	
25	21.10	-	16.94	-	$\text{NaHSO}_3 + \text{NaCl}$
	6.43	65.57	-	-	$\text{NaHSO}_3 + \text{NH}_4\text{HSO}_3$
	-	67.47	-	3.81	$\text{NH}_4\text{HSO}_3 + \text{NaCl}$
	27.48	-	1.24	17.84	$\text{NaHSO}_3 + \text{NH}_4\text{Cl} + \text{NaCl}$
	7.61	62.04	-	2.98	$\text{NH}_4\text{HSO}_3 + \text{NaHSO}_3 + \text{NH}_4\text{Cl}$
	-	-	16.82	16.16	$\text{NaCl} + \text{NH}_4\text{Cl}$
60	27.56	-	15.44	-	$\text{NaHSO}_3 + \text{NaCl}$
	-	61.80	-	12.28	$\text{NH}_4\text{HSO}_3 + \text{NH}_4\text{Cl}$
	6.34	74.50	-	-	$\text{NaHSO}_3 + \text{NH}_4\text{HSO}_3$
	23.34	14.40	-	19.41	$\text{NaHSO}_3 + \text{NH}_4\text{Cl} + \text{NaCl}$
	5.43	50.19	-	12.62	$\text{NaHSO}_3 + \text{NH}_4\text{HSO}_3 + \text{NH}_4\text{Cl}$
	-	-	11.96	25.30	$\text{NH}_4\text{Cl} + \text{NaCl}$

AMMONIUM SODIUM HYDROGEN SULFITE  $(\text{NH}_4)\text{Na}_2\text{H}(\text{SO}_3)_2\cdot 4\text{H}_2\text{O}$ 

30

100 gms.  $\text{H}_2\text{O}$  dissolve 42.3 gms. salt at  $12.4^\circ$  and 48.5 gms. at  $15^\circ$ . (Schwincker, 1889.)

AMMONIUM PYROSULFITE  $(\text{NH}_4)_2\text{S}_2\text{O}_5$ 

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100 gms. sat. solution of ammonium pyro sulfite in water contain 71.33 gms.  $(\text{NH}_4)_2\text{S}_2\text{O}_5$  at  $25^\circ$ . (Ishikawa and Hagisawa, 1931.) The authors also give results for the systems  $(\text{NH}_4)_2\text{S}_2\text{O}_5 + (\text{NH}_4)_2\text{SO}_3 + \text{H}_2\text{O}$  and  $(\text{NH}_4)_2\text{S}_2\text{O}_5 + \text{SO}_2 + \text{H}_2\text{O}$  at  $25^\circ$ .

100 gms. liquid sulfur dioxide dissolve 0.048 gm.  $(\text{NH}_4)_2\text{S}_2\text{O}_4$  at  $0^\circ$ : (Jander and Ruppolt, 1937.)

AMMONIUM SULFATE  $(\text{NH}_4)_2\text{SO}_4$ 

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## SOLUBILITY IN WATER

Average curve from the results of Rodebush, 1918; Sborgi and Bovalini, 1924; Sborgi, Bovalini and Medici, 1924; Sborgi, 1924; Nishizawa, 1920; Britton, 1922; Caven and Mitchell, 1924; Weston, 1922; Ishikawa and Murooka, 1929. Individual determinations by a number of other investigators are usually in good agreement with these results. Data for the solubility of ammonium sulfate at temperatures above  $100^\circ$  were determined by the synthetic method by Benrath, Gjedbo, Schieffers and Wunderlich, 1937.

$t^\circ$	Gms. $(\text{NH}_4)_2\text{SO}_4$ per 100 gms. sat. sol.	Solid Phase	$t^\circ$	Gms. $(\text{NH}_4)_2\text{SO}_4$ per 100 gms. sat. sol.
- 5	17.0	Ice " " " + $(\text{NH}_4)_2\text{SO}_4$ $(\text{NH}_4)_2\text{SO}_4$	100	50.8
-10	28.0		125	53.2
-15	36.0		150	55.5
-19*	39.8		175	57.5
-10	40.5		200	59.7
0	41.35	"	225	62.0
+ 5	41.65	"	250	64.2
10	42.05	"	275	66.7
15	42.45	"	300	69.2
20	42.85	"	325	71.5
25	43.3	"	350	74.0
30	43.75	"	375	76.5
40	44.7	"	400	78.7
50	45.8	"		
60	46.64	"		
70	47.54	"		
80	48.47	"		
90	49.44	"		
100	50.42			
108.5**	51.53			

\*eutectic

\*\*b. pt.

# N NITROGEN

## THE SYSTEM AMMONIUM SULFATE - HYDROGEN PEROXIDE - WATER AT 20° (Pani and Terrey, 1955)

	Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> O <sub>2</sub>		(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> O <sub>2</sub>	
	42.93	0.0	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	44.94	18.74	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + 1:1
	43.17	3.04	"	44.50	19.85	1:1
	43.44	8.02	"	43.85	22.29	"
	43.54	9.23	"	42.88	23.71	"
	43.61	10.00	"	41.43	27.90	"
	43.77	11.44	"	40.81	30.20	"
	44.00	12.73	"	40.28	35.63	"
	44.35	14.79	"	40.02	41.37	"
SO	44.22	17.03	"	40.32	42.18	"
				40.40	45.62	"

1:1 = (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>·H<sub>2</sub>O<sub>2</sub>

## THE SYSTEM AMMONIUM SULFATE - SULFURIC ACID - WATER

Additional results for this system are given by D'Anis, 1909, 1913. Results for the solubility of mixtures of ammonium sulfate and lithium sulfate in concentrated H<sub>2</sub>SO<sub>4</sub> containing traces of H<sub>2</sub>O at 30°, are given by Van Dorp, 1913-14, and by Gillespie and Oubridge, 1956. See also Terres and Schmidt, 1927.



(Results of Van Dorp, 1910 and 1911 at 30°)

Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
H <sub>2</sub> SO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>		(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	
0	44.3	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	40	32.8	NH <sub>4</sub> HSO <sub>4</sub>
10	43.6	"	45	26.1	"
13.2	44.1	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + 3.1	50	20.9	"
15	42.9	3.1	55	17.6	"
20	41.0	"	60	17.8	"
25	40.8	"	61.7	20.0	"
30	43.0	"	62.9	30.0	"
33.8	45.5	3.1 + NH <sub>4</sub> HSO <sub>4</sub>	62.2	37.0	"
35	42.3	NH <sub>4</sub> HSO <sub>4</sub>			

(Results of Locuty and Laffitte, 1933, 1934)

Gms. per 100 gms. sat. sol.			Solid Phase
H <sub>2</sub> SO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>		
At 30°:	0.0	44.03	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
	13.11	44.71	" + MC(4.1) + (3.1)
	25.31	41.48	MC(4.1) + (3.1)
	33.88	45.44	" + NH <sub>4</sub> HSO <sub>4</sub>
	59.27	17.62	NH <sub>4</sub> HSO <sub>4</sub>
	61.5	38.5	"

(Cont.)

## THE SYSTEM AMMONIUM SULFATE - SULFURIC ACID - WATER--Cont.

(Results of Locuty and Laffitte, 1933, 1934--Cont.)

Gms. per 100 gms. sat. sol.			Solid Phase
$H_2SO_4$	$(NH_4)_2SO_4$		
At 50°:			
0.0	45.79	$(NH_4)_2SO_4$	
15.25	47.82	" + (4.1)	
17.92	46.29	(4.1)	
24.60	45.51	MC(4.1) + (3.1)	
34.35	50.96	(3.1) + $NH_4H SO_4$	
54.28	25.5	$NH_4HSO_4$	
60.5	39.5	"	
At 70°:			
0.0	58.08	$(NH_4)_2SO_4$	
17.5	50.5	" + MC(4.1) + (3.1)	
24.62	49.02	(3.1)	
34.92	54.97	" + $NH_4HSO_4$	
55.02	31.15	$NH_4HSO_4$	
59.45	40.55	"	

30

(Results of Siskin and Pochvalensky, 1938 at 98.3°)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$H_2SO_4$	$(NH_4)_2SO_4$	Solid Phase	$H_2SO_4$	$(NH_4)_2SO_4$	Solid Phase
0.0	49.45	$(NH_4)_2SO_4$	35.9	58.53	(3.1) + $NH_4HSO_4$
8.75	48.87	"	39.39	52.36	$NH_4 \cdot HSO_4$
14.73	49.95	"	44.4	46.94	"
20.45	54.27	" + (3.1)	47.18	42.78	"
23.0	53.28	(3.1)	52.8	41.26	"
27.66	54.01	"	54.0	42.3	"
29.81	54.7	"	54.55	43.71	"
32.43	56.23	"	55.16	44.15	"
34.21	57.68	"	55	45	"
35.5	57.5	"			

Data for the system  $(NH_4)_2SO_4 - H_3PO_4 - H_2O$  at 25° and 75° are given by Uno, 1940a.

## SOLUBILITY OF AMMONIUM SULFATE IN AMMONIA SOLUTIONS

(Guyer, Bieler, and Orelli, 1940)

The results are presented in the form of diagrams only, and the following data were read from the curves: (Gms.  $(NH_4)_2SO_4$  per 100 gms. of solvent)

% $NH_3$ in Solvent	-30°	-10°	0°	23°
5	24	-	22	26
10	18	14(15% $NH_3$ )	14	21
20	8	5	4.5	16
30	2.5	1.5	3	11
40	1	1	2.5	7
60			2	2.5
80			1.5	1.5

# N NITROGEN

Other data for the solubility of ammonium sulfate in aqueous ammonia solutions from 5° to 35° are given by Belopol'skii, Lebedev, and Trifonova, 1931.

## Results at 25°

(D'Ans and Schreiner, 1910)

(Hill and Loucks, 1937)

Sat. Sol. Wt. %		Sat. Sol. Wt. %	
NH <sub>3</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	NH <sub>3</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
0.0	43.34	0.0	43.41
3.48	34.36	12.84	26.80
6.64	28.15	18.33	19.31
11.72	21.01	21.39	15.68
18.22	153.3	22.62	13.97
24.28	103.0	23.34	13.42
32.24	0.0		

Equilibrium data in the system NH<sub>3</sub> - SO<sub>2</sub> - H<sub>2</sub>O between 0° and 100° is reported by Terres and Schmidt, 1927. The solubility of (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> in the presence of excess NH<sub>3</sub> and SO<sub>2</sub> was determined. Freeth gives complete data for the quaternary equilibrium in the system (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> + NH<sub>4</sub>ClO<sub>4</sub> + Na<sub>2</sub>SO<sub>4</sub> + NaClO<sub>4</sub> + H<sub>2</sub>O at 25° and at 60°.

THE SYSTEM AMMONIUM SULFATE - AMMONIUM SULFAMATE - WATER  
Venido, Ito and Kobayashi, 1954; Ricci and Selikson, 1952, at 25°)

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Solid Phase	NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Solid Phase
at 0°					
0.0	41.4	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	0.0	45.8	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
19.8	29.5	"	22.1	31.9	"
31.5	23.1	"	58.6	12.4	"
43.4	17.5	" + NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>	64.9	9.8	"
43.3	17.9	NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>	72.1	7.2	" + NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>
43.3	17.9	"	73.8	5.6	NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>
48.8	12.9	"	78.3	0.0	"
52.8	7.1	"			
57.6	0.0	"			
at 25°					
0.0	43.43	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	0.0	47.8	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
60.0	10.14	" + NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>	40.5	22.4	"
68.90	0.0	NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>	68.7	9.5	"
at 30°					
0.0	43.8	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	72.7	7.9	"
21.1	30.7	"	79.5	5.2	" + NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>
39.1	20.3	"	81.1	3.6	NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>
51.4	14.3	"	84.1	0.0	"
59.0	11.1	"			
62.6	9.2	" + NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>			
66.8	4.8	NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>			
68.7	2.6	"			
70.1	0.0	"			
at 50°					
0.0	41.4	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	0.0	45.8	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
19.8	29.5	"	22.1	31.9	"
31.5	23.1	"	58.6	12.4	"
43.4	17.5	" + NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>	64.9	9.8	"
43.3	17.9	NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>	72.1	7.2	" + NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>
43.3	17.9	"	73.8	5.6	NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>
48.8	12.9	"	78.3	0.0	"
52.8	7.1	"			
57.6	0.0	"			
at 70°					
0.0	43.43	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	0.0	47.8	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
60.0	10.14	" + NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>	40.5	22.4	"
68.90	0.0	NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>	68.7	9.5	"
at 30°					
0.0	43.8	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	72.7	7.9	"
21.1	30.7	"	79.5	5.2	" + NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>
39.1	20.3	"	81.1	3.6	NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>
51.4	14.3	"	84.1	0.0	"
59.0	11.1	"			
62.6	9.2	" + NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>			
66.8	4.8	NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>			
68.7	2.6	"			
70.1	0.0	"			

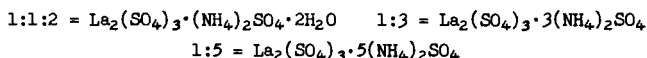
THE SYSTEM AMMONIUM SULFATE - AMMONIUM TUNGSTATE - WATER AT 25°  
(Zvorykin and Perel'man, 1955)

Sat. Sol. Wt. %		Wet Residue Wt. %	
$(\text{NH}_4)_2\text{SO}_4$	$(\text{NH}_4)_2\text{W}_2\text{O}_7$	$(\text{NH}_4)_2\text{SO}_3$	$(\text{NH}_4)_2\text{W}_2\text{O}_7$
0.0	1.40	-	-
8.25	trace	0.0	89.87
9.38	"	6.24	49.81
16.75	"	8.8	40.36
28.1	0.0055	8.8	54.04
36.99	trace	10.24	55.49
42.33	"	37.8	40.03
42.5	0.019	73.40	0.66
42.9	0.356	75.78	0.56
42.93	trace	36.7	21.02
44.0	0.0	-	-

50

Data for the system  $(\text{NH}_4)_2\text{SO}_4 \cdot \text{CdSO}_4 - \text{NH}_3 - \text{H}_2\text{O}$  at 25° are given by Urazov and Kirakosyan, 1953. Three congruently soluble double salts are found:  $[\text{Cd}(\text{NH}_3)_2(\text{H}_2\text{O})_2]\text{SO}_4 \cdot (\text{NH}_4)_2\text{SO}_4$ ,  $[\text{Cd}(\text{NH}_3)_5\text{H}_2\text{O}]\text{SO}_4 \cdot \text{NH}_4)_2\text{SO}_4$ , and  $[\text{Cd}(\text{NH}_3)_4(\text{H}_2\text{O})_2]\text{SO}_4 \cdot (\text{NH}_4)_2\text{SO}_4$ .

THE SYSTEM AMMONIUM SULFATE - LANTHANUM SULFATE - WATER  
(Urazov, Tulinova, Plyushchev and Chuikina, 1955, 1957)



## Results at 25°

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
$\text{La}_2(\text{SO}_4)_3$	$(\text{NH}_4)_2\text{SO}_4$	Solid Phase	$\text{La}_2(\text{SO}_4)_3$	$(\text{NH}_4)_2\text{SO}_4$	Solid Phase
2.12	0.0	$\text{La}_2(\text{SO}_4)_3 \cdot 9\text{H}_2\text{O}$	0.981	0.0	$\text{La}_2(\text{SO}_4)_3 \cdot 9\text{H}_2\text{O}$
2.11	0.757	" + 1:1:2	0.981	0.449	" + 1:1:2
0.402	21.21	1:1:2 + 1:3	0.164	27.77	1:1:2 + 1:3
0.138	33.70	1:3 + 1:5	0.019	45.57	1:3 + 1:5
0.002	43.50	1:5 + $(\text{NH}_4)_2\text{SO}_4$	0.001	48.38	1:5 + $(\text{NH}_4)_2\text{SO}_4$
0.0	43.54	$(\text{NH}_4)_2\text{SO}_4$	0.0	48.23	$(\text{NH}_4)_2\text{SO}_4$

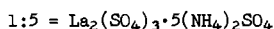
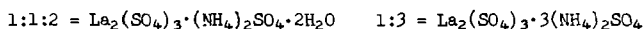
## Results at 50° (1957)

Sat. Sol. Wt. %		Wet Residue Wt. %		Solid Phase
$\text{La}_2(\text{SO}_4)_3$	$(\text{NH}_4)_2\text{SO}_4$	$\text{La}_2(\text{SO}_4)_3$	$(\text{NH}_4)_2\text{SO}_4$	
1.260	-	-	-	$\text{La}_2(\text{SO}_4)_3 \cdot 9\text{H}_2\text{O}$
1.260	0.235	58.25	0.05	"
1.260	0.481	49.30	3.13	" + 1:1:2
0.763	0.552	53.15	12.35	1:1:2
0.341	1.030	48.94	11.95	"
0.180	2.720	41.97	11.16	"
0.175	4.480	-	-	"
0.119	12.400	41.47	15.52	"

(Cont.)

# N NITROGEN

## THE SYSTEM AMMONIUM SULFATE - LANTHANUM SULFATE - WATER--Cont.

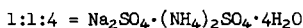
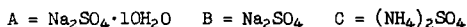


Results at 50° (1957)

	Sat. Sol. Wt. %		Wet Residue Wt. %		Solid Phase
	$\text{La}_2(\text{SO}_4)_3$	$(\text{NH}_4)_2\text{SO}_4$	$\text{La}_2(\text{SO}_4)_3$	$(\text{NH}_4)_2\text{SO}_4$	
SO	0.114	15.310	-	-	1:1:2
	0.235	21.650	57.90	19.01	"
	0.285	22.400	{ 29.11	26.00	" + 1:3
	0.202	25.150	{ 33.96	29.14	" + "
	0.099	28.620	{ 39.51	36.04	1:3
	0.079	30.020	{ 41.82	37.58	"
	0.059	35.980	-	-	"
	0.061	37.530	20.74	37.76	"
	0.027	38.590	26.28	39.20	"
	0.020	41.980	33.64	40.06	"
	0.002	42.970	{ 40.21	47.72	" + 1:5
	0.003	43.250	{ 37.02	46.24	" + "
	0.002	45.120	23.94	48.79	1:5
	0.002	45.960	35.50	51.41	"
	0.004	46.060	37.42	52.16	"
	-	46.160	{ 19.37	77.20	1:5 + $(\text{NH}_4)_2\text{SO}_4$
			{ 14.96	82.38	" + "
			0.00	84.92	$(\text{NH}_4)_2\text{SO}_4$
			-	-	

## THE SYSTEM AMMONIUM SULFATE - SODIUM SULFATE - WATER

This system has been studied in great detail by Dawson, 1918; Matignon and Meyer, 1917-1918 and Levi, 1924. Levi presents a diagram constructed from all available determinations at that time.

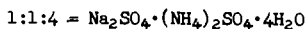
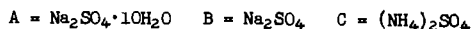


Results of Dawson, 1918

t°	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	t°	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
	$\text{Na}_2\text{SO}_4$	$(\text{NH}_4)_2\text{SO}_4$			$\text{Na}_2\text{SO}_4$	$(\text{NH}_4)_2\text{SO}_4$	
-19.5*	5.29	63.5	ICE+A+C	+15	22.9	33.3	A+1:1:4
-18	5.40	63.5	A+C	20	31.5	28.9	" "
-16	5.32	63.6	A+C+1:1:4	25	40.9	22.1	" "
-13	5.68	64.9	C+1:1:4	26.5	45.2	21.0	A+1:1:4+B
-10	6.33	65.6	" "	35.0	41.7	28.7	B+1:1:4
0	7.81	66.7	" "	40	40.5	34.7	" "
+15	10.85	69.6	" "	50	37.2	50.5	" "
25	14.6	71.0	" "	55	36.0	62.0	" "
40	19.7	75.1	" "	25	32.9	30.5	1:1:4
50	25.8	76.1	" "	35	37.3	34.7	"
-13	6.52	58.6	A+1:1:4	54.3	34.3	77.7	1:1:4+B+C
-10	7.78	56.1	" "	75	36.1	84.3	B+C
0	12.05	46.6	" "	100	37.9	95.0	" "

\*Eutectic

## THE SYSTEM AMMONIUM SULFATE - SODIUM SULFATE - WATER--Cont.

Isothermal data

-5°, Belopolskii and Shpunt, 1935a  
 0°, Belopolskii, Shpunt, and Serebrennikova, 1934  
 7°, Belopolskii and Shpunt, 1935  
 15°, 35°, Fedotieff and Kolossof, 1923  
 25°, 60°, Freeth, 1924

Sat. Sol. Wt. %			Solid Phase	Gms. per 100 gms. H <sub>2</sub> O			Solid Phase	30	
Na <sub>2</sub> SO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	density		Na <sub>2</sub> SO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	density			
at -5°									
4.53	13.79	1.119	A+Ice	0.0	73.49	1.245	C		
6.08	32.67	1.233	A+1:1:4	2.86	73.13	1.253	C		
4.08	38.20	1.253	1:1:4+C	3.95	72.80	1.259	C		
0.0	40.80	1.226	C	5.26	72.17	1.261	C		
0.0	15.0	-	C+Ice	7.79	71.06	1.272	C		
				12.77	69.70	1.286	C+1:1:4		
				14.05	65.01	1.280	1:1:4		
				16.46	54.60	1.276	"		
6.56	8.80	-	A	18.57	48.98	1.276	"		
6.86	16.43	1.158	A	21.24	42.29	1.276	"		
7.22	23.46	1.204	A	22.87	36.92	1.278	"		
7.66	28.60	1.233	A+1:1:4	24.47	34.28	1.279	"		
7.25	29.77	-	1:1:4	25.44	33.89	1.289	"		
6.33	30.76	1.239	1:1:4	26.29	32.79	1.286	1:1:4+A		
5.52	33.59	-	1:1:4	22.91	30.95	1.265	A		
4.43	37.84	1.243	1:1:4+C	18.02	11.98	1.187	A		
3.0	38.80	-	C	13.26	0.00	1.111	A		
1.54	40.07	-	C						
at 15°									
at 0°									
at 35° <sup>a</sup>									
				0.0	80.74	1.250	C		
7.55	0.0	-	A	6.98	78.30	1.272	C		
8.70	10.96	-	A	13.80	77.95	1.306	C		
9.64	19.36	-	A	18.67	74.10	1.307	C		
10.60	25.77	-	A+1:1:4	20.13	73.22	1.308	C+1:1:4		
8.52	29.48	-	1:1:4	23.63	56.11	1.305	1:1:4		
6.82	33.73	-	1:1:4	27.14	48.59	1.312	"		
5.63	37.74	-	1:1:4+C	28.84	44.91	1.313	"		
0.0	42.0	-	C	30.46	42.43	1.314	"		
				36.61	35.12	1.328	"		
				39.18	32.15	1.338	"		
				42.13	30.75	1.344	1:1:4+B		
21.78	7.4	-	A	43.35	26.64	1.342	B		
24.5	12.5	-	A	45.16	19.61	1.340	B		
25.76	14.1	-	A+1:1:4	46.01	14.27	1.333	B		
23.90	15.8	-	1:1:4	47.64	6.91	1.327	B		
14.12	27.42	-	1:1:4	49.53	0.00	1.325	B		
8.00	38.70	-	1:1:4+C						
6.65	39.16	-	C						
3.35	41.23	-	C						
				<sup>a</sup> See also Shevchuk and Lepeshkov,					
				1956					

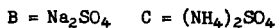
<sup>a</sup>See also Shevchuk and Lepeshkov, 1956

(Cont.)



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## THE SYSTEM AMMONIUM SULFATE - SODIUM SULFATE - WATER--Cont.



### Isothermal data, cont.

At 60°		density	Solid Phase	
Sat. Sol.	Wt. %			
$Na_2SO_4$	$(NH_4)_2SO_4$			
31.20	0.0	-	B	Data for the quaternary system $(NH_4)_2SO_4 - Na_2SO_4 - NH_3 - H_2O$ from 0° to 15° are given by Belopol'skii and Aleksandrov, 1933.
26.94	9.70	-	B	
18.70	29.48	-	B	
16.33	36.91	-	B + C	
10.70	40.30	-	C	
SO 0.0	46.80	-	C	

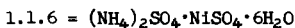
## THE SYSTEM $(NH_4)_2SO_4 - Na_2SO_4 - ZnSO_4 - H_2O$ AT 35° (Shevchuk and Lepeahkov, 1956)

Sat. Sol. Wt. %			Solid Phase
$(NH_4)_2SO_4$	$Na_2SO_4$	$ZnSO_4$	
34.87	10.33	0.10	$(NH_4)_2SO_4 + (NH_4)_2SO_4 \cdot Na_2SO_4 \cdot 4H_2O + (NH_4)_2SO_4 \cdot ZnSO_4 \cdot 6H_2O$
16.21	22.57	0.45	$Na_2SO_4 + (NH_4)_2SO_4 \cdot Na_2SO_4 \cdot 4H_2O + (NH_4)_2SO_4 \cdot ZnSO_4 \cdot 6H_2O$
3.68	25.96	5.26	$Na_2SO_4 + Na_2SO_4 \cdot ZnSO_4 \cdot 4H_2O + (NH_4)_2SO_4 \cdot ZnSO_4 \cdot 6H_2O$
0.71	6.26	34.08	$ZnSO_4 \cdot 7H_2O + Na_2SO_4 \cdot ZnSO_4 \cdot 4H_2O + (NH_4)_2SO_4 \cdot ZnSO_4 \cdot 6H_2O$

## THE SYSTEM AMMONIUM SULFATE - NICKEL SULFATE - WATER

### Results of Hill and Taylor, 1938 at 25°

The previous determinations upon this system at 25° by Caven and Gardner, 1933, are considered by Hill and Taylor to be incorrect.



Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$NiSO_4$	$(NH_4)_2SO_4$		$NiSO_4$	$(NH_4)_2SO_4$	
0.0	43.42	$(NH_4)_2SO_4$	3.82	3.27	1.1.6
0.023	43.36	" + 1.1.6	12.32	1.94	"
0.048	35.20	1.1.6	18.23	1.49	"
0.079	29.44	"	22.75	1.23	"
0.125	23.91	"	26.20	1.01	"
0.209	17.87	"	28.92	0.83	" + $NiSO_3 \cdot 7H_2O$
0.352	12.57	"	28.97	0.0	$NiSO_4 \cdot 7H_2O$

## THE SYSTEM AMMONIUM SULFATE - NICKEL SULFATE - WATER AT--Cont.

## Results of Benrath, 1932 at various temperatures

Gms. per 100 gms. sat. sol.				Gms. per 100 gms. sat. sol.			
t°	$\text{NiSO}_4$	$(\text{NH}_4)_2\text{SO}_4$	Solid Phase	t°	$\text{NiSO}_4$	$(\text{NH}_4)_2\text{SO}_4$	Solid Phase
0	trace	41.2	$1.1.6 + (\text{NH}_4)_2\text{SO}_4$	46	0.29	45.32	$1.1.6 + (\text{NH}_4)_2\text{SO}_4$
"	24.45	1.22	" + $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$	"	32.95	1.94	" + $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}^a$
25	0.61	43.7	" + $(\text{NH}_4)_2\text{SO}_4$	54	35.35	2.02	" + "
"	29.5	1.20	" + $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$	80	0.51	48.68	" + $(\text{NH}_4)_2\text{SO}_4$
29	32.02	1.29	" + "	"	41.84	3.02	" + $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}^b$
			$\text{NiSO}_4 \cdot 6\text{H}_2\text{O}^a$	100	1.10	49.9	" + $(\text{NH}_4)_2\text{SO}_4$
			"	"	46.91	3.31	" + $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}^b$ <b>SO</b>

$1.1.6 = (\text{NH}_4)_2\text{SO}_4 \cdot \text{NiSO}_4 \cdot 6\text{H}_2\text{O}$

1.1.6 = (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>·NiSO<sub>4</sub>·6H<sub>2</sub>OSOLUBILITY OF AMMONIUM NICKEL SULFATE IN WATER  
(Hill and Taylor, 1938)

G. (NH <sub>4</sub> ) <sub>2</sub> Ni(SO <sub>4</sub> ) <sub>2</sub> per 100 gms.			G. (NH <sub>4</sub> ) <sub>2</sub> Ni(SO <sub>4</sub> ) <sub>2</sub> per 100 gms.		
t°	Water	Solution	t°	Water	Solution
0	1.0	0.99	40	12.0	10.72
10	4.0	3.85	50	14.5	12.96
20	6.5	6.10	60	17.0	14.53
25	7.57	7.04*	70	20.0	16.66
30	9.0	8.45			

\*(Average curve from Tobler, Locke, at 25°.)

THE SYSTEM AMMONIUM NICKEL SULFATE - AMMONIUM ZINC SULFATE - WATER AT 25°  
(Hill and Taylor, Jr., 1938)

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. solid phase	
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·ZnSO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·NiSO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·ZnSO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·NiSO <sub>4</sub>
12.24	0.0	73.09	0.0
9.29	1.54	45.80	27.19
8.27	2.16	37.08	35.86
6.93	2.75	28.75	44.06
5.11	3.94	13.87	58.99
1.97	5.70	5.72	66.89
0.0	7.09	0.0	72.63

# N NITROGEN

## 50 AMMONIUM LEAD SULFATE $(\text{NH}_4)_2\text{SO}_4 \cdot \text{PbSO}_4$

### SOLUBILITY IN WATER (Barre, 1909)

t°	Gms. $(\text{NH}_4)_2\text{SO}_4$ per 100 Gms.		Solid Phase
	Sat. Solution	Water	
20	12.17	13.86	$(\text{NH}_4)_2\text{SO}_4 \cdot \text{PbSO}_4$
50	16.15	19.25	"
75	19.52	24.31	"
100	22.74	29.42	"

### THE SYSTEM AMMONIUM SULFATE - PRASEODYMIUM SULFATE - WATER AT 25° (Zambonini and Restaino, 1929)

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
$\text{Pr}_2(\text{SO}_4)_3$	$(\text{NH}_4)_2\text{SO}_4$			$\text{Pr}_2(\text{SO}_4)_3$	$(\text{NH}_4)_2\text{SO}_4$		
0.11	43.12	$(\text{NH}_4)_2\text{SO}_4 + 1.5$		0.69	14.91	1.1.8	
0.30	40.13	1.5		0.68	7.07	"	
0.66	35.63	"		3.52	0.98	"	
0.64	32.40	" + 1.1.8		3.55	0.53	"	
0.67	19.88	1.1.8		8.24	0.50	" + $\text{Pr}_2(\text{SO}_4)_3 \cdot 8\text{H}_2\text{O}$	

1.5 =  $\text{Pr}_2(\text{SO}_4)_3 \cdot 5(\text{NH}_4)_2\text{SO}_4$ ; 1.1.8 =  $\text{Pr}_2(\text{SO}_4)_3 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 8\text{H}_2\text{O}$

### THE SYSTEM AMMONIUM SULFATE - RUBIDIUM SULFATE - WATER AT 35° (Calvo and Simons, 1952)

Roozeboom type I solid solutions are formed.

Sat. Sol. Wt. %		original mixture wt. %		wt. % $(\text{NH}_4)_2\text{SO}_4$ in solid solution
$(\text{NH}_4)_2\text{SO}_4$	$\text{Rb}_2\text{SO}_4$	$(\text{NH}_4)_2\text{SO}_4$	$\text{Rb}_2\text{SO}_4$	
44.33	00.0	-	-	100.0
38.21	4.81	41.05	7.10	69.8
31.85	9.98	33.45	13.97	48.3
29.26	12.16	30.34	16.00	42.0
25.51	15.35	27.21	22.01	27.1
17.23	22.25	17.03	25.34	13.1
13.05	25.71	8.00	87.69	7.6
5.99	31.37	5.94	34.80	5.0
0.0	36.27	-	-	0.0

AMMONIUM STRONTIUM SULFATE  $(\text{NH}_4)_2\text{SO}_4 \cdot 3\text{SrSO}_4$ 

30

SOLUBILITY IN WATER  
(Barre, 1909)

t°	Gms. $(\text{NH}_4)_2\text{SO}_4$ per 100 Gms.		Solid Phase
	Sat. Solution	Water	
50	43.99	78.54	$(\text{NH}_4)_2\text{SO}_4 \cdot \text{SrSO}_4 + \text{SrSO}_4$
75	45.40	83.15	"
100	46.27	66.2	"

THE SYSTEM AMMONIUM SULFATE - THORIUM SULFATE - WATER AT 25°  
(Rosenheim and Zickermann, 1932)

30

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{Th}(\text{SO}_4)_2$	$(\text{NH}_4)_2\text{SO}_4$	Solid Phase	$\text{Th}(\text{SO}_4)_2$	$(\text{NH}_4)_2\text{SO}_4$	Solid Phase
1.46	43.13	$(\text{NH}_4)_2\text{SO}_4$	2.59	33.42	$2 \cdot 1 \cdot 3\frac{1}{2}$
1.36	42.46	" + $3 \cdot 1 \cdot 3$	3.40	29.23	"
1.24	44.35	$3 \cdot 1 \cdot 3$	5.26	24.30	"
1.73	42.80	"	6.66	22.10	"
2.08	41.85	"	8.98	19.05	" + $1 \cdot 1 \cdot 5$
1.83	41.53	$2 \cdot 1 \cdot 3\frac{1}{2}$	9.28	18.80	$1 \cdot 1 \cdot 5$
1.92	41.12	"	10.16	18.80	$1 \cdot 1 \cdot 5$
2.03	39.96	"	12.47	15.80	"
2.33	37.56	"	11.04	14.60	" + $\text{Th}(\text{SO}_4)_2$
			14.50	10.00	" " excess

$3 \cdot 1 \cdot 3 = 3(\text{NH}_4)_2\text{SO}_4 \cdot \text{Th}(\text{SO}_4)_2 \cdot 3\text{H}_2\text{O}$ ;  $2 \cdot 1 \cdot 3\frac{1}{2} = 2(\text{NH}_4)_2\text{SO}_4 \cdot \text{Th}(\text{SO}_4)_2 \cdot 3\frac{1}{2}\text{H}_2\text{O}$ ;  $1 \cdot 1 \cdot 5 = (\text{NH}_4)_2\text{SO}_4 \cdot \text{Th}(\text{SO}_4)_2 \cdot 5\text{H}_2\text{O}$ .

THE SYSTEM AMMONIUM SULFATE - TITANYL SULFATE - WATER AT 20°  
(Motov, 1957)

The compound  $(\text{NH}_4)_2\text{TiO}(\text{SO}_4)_2 \cdot \text{H}_2\text{O}$  is congruently soluble;  
 $(\text{NH}_4)_2\text{TiO}(\text{SO}_4)_2$  is incongruently soluble.

Sat. Sol. Wt. %			Solid Phase
$\text{TiOSO}_4$	$(\text{NH}_4)_2\text{SO}_4$	$\text{H}_2\text{SO}_4$	
54.15	0.0	0.0	$\text{TiOSO}_4 \cdot 2\text{H}_2\text{O}$
52.89	1.04	-	"
50.23	4.38	-	"
50.45	9.55	-	" + $(\text{NH}_4)_2\text{TiO}(\text{SO}_4)_2$
47.27	9.83	-	$(\text{NH}_4)_2\text{TiO}(\text{SO}_4)_2$
33.33	13.57	-	" + $(\text{NH}_4)_2\text{TiO}(\text{SO}_4)_2 \cdot \text{H}_2\text{O}$
22.34	18.46	-	$(\text{NH}_4)_2\text{TiO}(\text{SO}_4)_2 \cdot \text{H}_2\text{O}$
13.43	26.99	0.11	" + gelled $\text{TiO}_2$ phase
1.82	38.80	2.54	" + "
1.26	42.70	2.44	$(\text{NH}_4)_2\text{TiO}(\text{SO}_4)_2 \cdot \text{H}_2\text{O}$ + gelled $\text{TiO}_2$ + $(\text{NH}_4)_2\text{SO}_4$
0.86	42.28	2.12	gelled $\text{TiO}_2$ + $(\text{NH}_4)_2\text{SO}_4$
0.68	42.37	1.28	solid solution of gelled $\text{TiO}_2$ + $(\text{NH}_4)_2\text{SO}_4$
0.26	42.79	0.96	"
0.13	42.93	0.35	"
0.0	43.05	-	$(\text{NH}_4)_2\text{SO}_4$

THE SYSTEM  $(\text{NH}_4)_2\text{SO}_4 - \text{TiO}_2 - \text{H}_2\text{SO}_4 - \text{H}_2\text{O}$  AT  $20^\circ$ --Cont.  
(Motov, 1957a)

Considerable additional data for this system are reported by Goroshchenko and Andreeva, 1957. Motov also gives many additional results.

SO	Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %		
	$\text{TiO}_2$	$\text{H}_2\text{SO}_4$	$(\text{NH}_4)_2\text{SO}_4$		$\text{TiO}_2$	$\text{H}_2\text{SO}_4$	$(\text{NH}_4)_2\text{SO}_4$
	0.065	0.43	42.93	S.S.	Solid Phase		
	0.13	1.12	42.79	S.S.	$(\text{NH}_4)_2\text{TiO}_2(\text{SO}_4)_2 \cdot \text{H}_2\text{O}$		
	0.42	2.66	42.75	S.S.			
	0.43	2.66	42.28	gel + N	16.38	22.96	39.71
	0.63	3.21	42.70	$\text{D} \cdot \text{H}_2\text{O}$ + gel + N	17.71	25.11	33.87
	0.19	6.19	42.44	$\text{D} \cdot \text{H}_2\text{O}$ + N	22.02	28.58	35.57
	0.14	9.06	42.36	$\text{D} \cdot \text{H}_2\text{O}$ + N	18.80	26.63	37.20
	0.08	13.41	41.83	$\text{D} \cdot \text{H}_2\text{O}$ + N			
	0.05	19.37	38.55	$\text{D} \cdot \text{H}_2\text{O}$ + S	Solid Phase		
	0.012	32.47	42.50	$\text{D} \cdot \text{H}_2\text{O}$ + S + H	$(\text{NH}_4)_2\text{TiO}_2(\text{SO}_4)_2$		
	0.004	32.92	41.03	$\text{D} \cdot \text{H}_2\text{O}$ + H			
	0.06	25.06	24.69	$\text{D} \cdot \text{H}_2\text{O}$ + D	17.00	28.90	32.96
	0.007	41.80	26.42	D + H	20.68	30.01	34.53
	0.003	46.35	20.26	D + H	14.53	31.80	31.61
	0.006	55.24	14.40	D + H	12.76	33.04	24.53
	0.007	59.55	14.85	D + H	21.37	30.42	33.39
					10.34	22.05	19.23
S.S. =	solid solution of $\text{TiO}_2$ + $(\text{NH}_4)_2\text{SO}_4$						
gel =	gelled $\text{TiO}_2$						
$\text{D} \cdot \text{H}_2\text{O}$ =	$(\text{NH}_4)_2\text{TiO}(\text{SO}_4)_2 \cdot \text{H}_2\text{O}$						
D =	$(\text{NH}_4)_2\text{TiO}(\text{SO}_4)_2$						
N =	$(\text{NH}_4)_2\text{SO}_4$						
H =	$\text{NH}_4\text{HSO}_4$						
S =	$(\text{NH}_4)_3\text{HSO}_4$						

THE SYSTEM AMMONIUM SULFATE - URANYL SULFATE  
- WATER AT  $25^\circ$   
(Colani, 1928)

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.		
$\text{UO}_2\text{SO}_4$	$(\text{NH}_4)_2\text{SO}_4$			$\text{UO}_2\text{SO}_4$	$(\text{NH}_4)_2\text{SO}_4$	Solid Phase
0.0	43.25	$(\text{NH}_4)_2\text{SO}_4$		16.46	7.46	1.1.2
1.89	42.13	"		19.23	6.80	"
4.53	40.36	"		31.84	4.49	"
9.34	40.59	"		35.70	4.15	" + 1.2.5
10.00	40.65	" + 1.1.2		36.96	3.89	1.2.5
9.70	37.18	1.1.2		47.25	2.00	"
10.29	30.09	"		59.00	0.84	"
10.81	17.65	"		61.32	0.38	" + $\text{UO}_2\text{SO}_4 \cdot 3\text{H}_2\text{O}$
12.98	9.76	"		61.28	0.25	$\text{UO}_2\text{SO}_4 \cdot 3\text{H}_2\text{O}$
				61.18	0	"

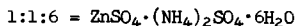
1.1.2 =  $(\text{NH}_4)_2\text{SO}_4 \cdot \text{UO}_2\text{SO}_4 \cdot 2\text{H}_2\text{O}$ ; 1.2.5 =  $(\text{NH}_4)_2\text{SO}_4 \cdot 2\text{UO}_2(\text{SO}_4)_3 \cdot 5\text{H}_2\text{O}$

AMMONIUM VANADIUM SULFATE (Alum)  $(\text{NH}_4)_2\text{V}_2(\text{SO}_4)_4 \cdot 24\text{H}_2\text{O}$ 

100 cc.  $\text{H}_2\text{O}$  dissolve 31.69 gms. anhydrous or 78.50 gms. hydrated salt at  $25^\circ$ . (Locke.)

## THE SYSTEM AMMONIUM SULFATE - ZINC SULFATE - WATER

Results for equilibrium in this system at  $0^\circ$ ,  $17.5^\circ$ ,  $40.5^\circ$ ,  $64.5^\circ$  and  $100^\circ$  are also given by Benrath, 1931.

Results at  $25^\circ$ 

(Data of Craven and Gardner, 1933) (Data of Hill and Taylor, Jr., 1938)

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Gm. Mols. per 1000 gms. $\text{H}_2\text{O}$			Gm. Mols. per 1000 gms. $\text{H}_2\text{O}$		
$\text{ZnSO}_4$	$(\text{NH}_4)_2\text{SO}_4$	Solid Phase	$\text{ZnSO}_4$	$(\text{NH}_4)_2\text{SO}_4$	Solid Phase
0.0	5.820	$(\text{NH}_4)_2\text{SO}_4$	0.0	43.42	$(\text{NH}_4)_2\text{SO}_4$
0.0183	3.742	1:1:6	0.09	43.40	" + 1:1:6
0.0291	2.993	"	0.23	34.02	1:1:6
0.0795	1.913	"	0.47	25.24	"
0.0930	1.288	"	1.23	14.65	"
0.1708	0.8511	"	2.96	8.42	"
0.3176	0.6054	"	6.73	5.47	"
0.6220	0.4680	"	8.53	4.93	"
1.429	0.3248	"	16.07	3.29	"
2.100	0.2628	"	26.21	2.02	"
3.160	0.1703	"	36.22	0.98	" + $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$
3.560	0.1313	" + $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$	36.72	0.0	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$
3.571	0.0	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$			

Results at  $35^\circ$ 

(Karnaukov and Shevchuk, 1953)

(Shevchuk and Druzhinin, 1958)

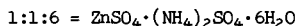
(Shevchuk and Lepeshkov, 1956)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{ZnSO}_4$	$(\text{NH}_4)_2\text{SO}_4$	Solid Phase	$\text{ZnSO}_4$	$(\text{NH}_4)_2\text{SO}_4$	Solid Phase
40.10	-	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$	5.76	7.93	1:1:6
39.90	1.33	" + 1:1:6	1.86	16.42	"
39.87	1.38	1:1:6	0.56	22.57	"
38.08	1.55	"	0.55	25.97	"
35.34	1.87	"	1.27	38.16	"
30.43	2.14	"	2.69	40.68	"
26.81	2.66	"	2.74	40.70	" + $(\text{NH}_4)_2\text{SO}_4$
21.48	3.33	"	2.72	40.71	" + "
18.00	3.80	"	-	44.10	$(\text{NH}_4)_2\text{SO}_4$
7.52	6.69	"			

(Cont.)

# N NITROGEN

## THE SYSTEM AMMONIUM SULFATE - ZINC SULFATE - WATER--Cont.



### Results at 50°

(Shevchuk and Druzhinin, 1958)

	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	ZnSO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>		ZnSO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	
	43.20	-	ZnSO <sub>4</sub> ·6H <sub>2</sub> O	8.83	9.40	1:1:6
SO	43.10	3.11	"	3.05	20.20	"
	43.00	5.22	"	1.20	30.13	"
	43.08	5.02	" + 1:1:6	0.45	38.80	"
	43.81	5.32	" + "	0.50	42.33	"
	41.68	5.82	1:1:6	0.41	43.19	"
	39.78	5.22	"	0.52	43.48	1:1:6 + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
	37.63	4.64	"	0.51	43.31	"
	33.58	5.35	"	0.20	43.36	"
	24.80	6.10	"	0.23	43.23	"
	15.30	6.99	"	-	45.81	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>

## SOLUBILITY OF AMMONIUM ZINC SULFATE IN WATER

(Tobler, Locke; values in parentheses by Benrath, 1931)

### Solid Phase Hexahydrate

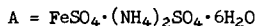
t°	Gms. (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·ZnSO <sub>4</sub> per 100 gms. H <sub>2</sub> O		t°	Gms. (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ·ZnSO <sub>4</sub> per 100 gms. H <sub>2</sub> O	
0	7.0	(7.3)	40	20	-
10	9.5	-	50	25	(25.30)
17	-	(11.86)	60	30	-
20	12.5	-	70	35	(38.19)
25	14.1	-	80	42	(46.75)
30	16.0	-	90		(58.1)
35	-	(17.95)	100		(72.5)

## THE SYSTEM AMMONIUM ZINC SULFATE - AMMONIUM FERROUS SULFATE - WATER AT 20°

(Shant'eva and Gorshtein, 1957)

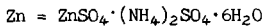
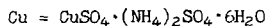
- continuous Solid Solutions are formed -

sat. sol. wt. %		wet residue wt. %		calc. composition of solid phase	
A	B	A	B	A	B
0.65	14.2	1.25	91.6	1.30	98.7
0.68	14.3	1.28	91.3	1.30	98.7
3.11	12.1	6.02	78.4	6.70	93.3
3.13	12.0	6.17	86.6	6.45	93.6
5.06	11.9	10.03	81.8	10.6	89.6
5.15	11.8	9.41	78.2	10.6	89.4
7.04	10.0	14.30	73.8	15.6	84.4
10.30	8.82	22.16	74.4	22.7	77.3
15.33	5.92	38.74	59.1	39.4	60.6
27.16	0.85	84.71	10.8	88.5	11.5



## THE SYSTEM AMMONIUM ZINC SULFATE - AMMONIUM COPPER SULFATE - WATER AT 20°

See also Vol. I, pp. 987-8  
(Gorshtein and Silant'eva, 1956)



sat. sol. wt. %		wet residue wt. %		calc. composition of solid phase	
Cu	Zn	Cu	Zn	Cu	Zn'
19.55	2.22	74.16	21.0	77.73	22.27
18.97	2.18	73.36	20.3	78.05	21.95
17.37	3.08	65.13	27.4	70.07	29.93
17.55	3.22	62.84	27.0	69.44	30.56
14.86	5.07	52.36	40.6	55.79	44.21
14.50	5.06	60.10	42.7	53.57	46.43
10.76	7.76	32.43	59.2	34.80	65.20
10.04	7.40	30.25	61.5	32.37	67.63
6.90	10.0	19.90	76.5	20.48	79.52
6.89	10.4	18.35	69.1	20.40	79.60
3.87	12.5	10.54	84.0	11.03	88.97
3.80	12.7	9.14	80.0	9.93	90.07
2.78	13.5	7.84	87.6	8.13	91.87
2.82	13.4	8.06	83.7	8.65	91.35

SO

## SOLUBILITY OF AMMONIUM SULFATE IN AQUEOUS METHANOL SOLUTIONS AT 30°

(Aravamudan, 1956)

Solvent wt. % CH <sub>3</sub> OH	sat. sol. wt. %		Solvent wt. % CH <sub>3</sub> OH	sat. sol. wt. %	
	CH <sub>3</sub> OH	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>		CH <sub>3</sub> OH	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
-	-	43.92	44.77	41.63	6.93
4.86	2.86	41.14	50.17	47.99	4.35
7.58	4.61	39.20	55.09	53.56	2.78
14.16	9.33	34.10	59.89	58.81	1.80
17.12	11.74	31.41	63.53	62.70	1.30
19.60	13.91	29.03	69.98	69.50	0.67
24.71	18.78	24.00	73.77	73.45	0.44
29.85	24.19	18.99	79.79	79.60	0.23
27.36	32.85	12.05	83.79	83.66	0.16
41.37	37.58	9.17			

## SOLUBILITY OF AMMONIUM SULFATE IN AQUEOUS ETHANOL SOLUTIONS

Traube and Neuberg, 1897; Bodlander, 1891; Schreinemakers 1897;  
de Bruyn 1900; Linebarger, 1892; Wibaut, 1909 (30°); Schreinemakers and  
de Baat, 1907 (50°).

When ammonium sulfate is added to aqueous solutions of alcohol, it is found that for certain concentrations and temperatures the solutions separate into two liquid layers, the upper of which contains the larger percentage of alcohol.

## Results at 30°

Two liquid layers are formed at concentrations of alcohol between 5.8 and 62%. At a concentration of 62% alcohol the liquid is homogeneous and contains 1.3 gms. (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> per 100 gms. sat. solution. At 90.4% alcohol no (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> is dissolved.



# N NITROGEN

## SOLUBILITY OF AMMONIUM SULFATE IN AQUEOUS ETHANOL SOLUTIONS--Cont.

### Results at 30°

Upper Layer			Lower Layer		
Gms. per 100	Gms. Sat. Solution		Gms. per 100	Gms. Sat. Solution	
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	C <sub>2</sub> H <sub>5</sub> OH	H <sub>2</sub> O	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	C <sub>2</sub> H <sub>5</sub> OH	H <sub>2</sub> O
2.2	56.6	41.2	37.1	5.8	57.1
2.6	54.5	42.9	35.7	6.3	58
3.4	52.3	44.3	33.8	7.4	58.8
13.2	31.8	55	21.7	18.4	59.9
17	25	58	17	25	58

50

### Results at 50°

Between the concentrations 4.1 and 64.5% C<sub>2</sub>H<sub>5</sub>OH the mixtures separate into two layers. The percentage composition of each member of several such conjoined layers, is as follows:

Upper Layer			Upper Layer		
Gms. per 100	Gms. Sat. Solution		Gms. per 100	Gms. Sat. Solution	
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	C <sub>2</sub> H <sub>5</sub> OH	H <sub>2</sub> O	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	C <sub>2</sub> H <sub>5</sub> OH	H <sub>2</sub> O
1.2	64.5	34.3	41.1	4.1	54.8
1.6	60	38.4	36.8	6	57.2
3.8	50	46.2	30.8	9	60.2
7.4	40	52.6	26.6	12	61.4
10	34.4	55.6	23.6	15	61.4

Homogeneous solutions:

Gms. per 100	Gms. Sat. Solution	
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	C <sub>2</sub> H <sub>5</sub> OH	H <sub>2</sub> O
43.02	2.32	54.66
41.1	4.1	54.8
1.2	64.5	34.3
0.2	75.5	24.3

### average results at other temperatures

Two determinations at 0° by deWaal (1910) gave 30 gms. (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> per 100 gms. sat. solution in 9.41% alcohol and 0.14 gm. (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> in 73.03% alcohol. Between these concentrations of alcohol two liquid layers are formed.

Upper Layer Results		Lower Layer Results		
Grams per 100 Gms. Solution at 10°-40°		Gms. (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> per 100 g. Solution at:		
C <sub>2</sub> H <sub>5</sub> OH	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Gms. C <sub>2</sub> H <sub>5</sub> OH per 100 Gms. Solution	6.5°	15° 33°
100	0.0	0	42.0	42.6 44
80	0.1	2.5	39.0	40.2 ?
70	0.3	5.0	36.2	37.2 ?
(Cont.)		770		

## SOLUBILITY OF AMMONIUM SULFATE IN AQUEOUS ETHANOL SOLUTIONS--Cont.

Upper Layer Results		Lower Layer Results			
Grams per 100 Gms. Solution at 10°-40°		Gms. C <sub>2</sub> H <sub>5</sub> OH per 100 Gms. Solution	Gms. (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> per 100 g. Solution at:		
C <sub>2</sub> H <sub>5</sub> OH	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>		6.5°	15°	33°
60	1.4	7.5	33.2	34.5	42
50	3.2	10.0	30.0	31.0	35
45	4.8	12.5	27.2	28.0	?
40	6.6	15.0	24.6	25.2	?
35	9.2	17.5	22.0	22.4	?
30	12.2	20.0	20.0	20.0	?
25	14.6				

80

Data for the System (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>SO<sub>4</sub> + C<sub>2</sub>H<sub>5</sub>OH at 18° are given by Dunclicliff, Aggarval and Hoon, 1928.)

SOLUBILITY OF AMMONIUM SULFATE IN AQUEOUS PROPYL ALCOHOL SOLUTIONS  
AT 20°  
(Linebarger, 1892)

Gms. per 100 Gms. Solution		Gms. per 100 Gms. Solution	
C <sub>3</sub> H <sub>7</sub> OH	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	C <sub>3</sub> H <sub>7</sub> OH	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
70	0.4	40	3.2
60	1.0	30	4.8
50	2.0	20	6.7

THE SYSTEM AMMONIUM SULFATE - ISO PROPYL ALCOHOL - WATER AT 25°  
(Ginnings and Chen, 1931)

The binodal curve of this system was determined by observing the appearance and disappearance of clouding in a mixture of weighed amounts of the salt and one of the liquids upon addition of weighed amounts of the other. A tie line, \*, was located by determination of the salt in two liquid phases in contact with each other and the plait point, PP, was found by plotting.

Gms. per 100 gms. homogeneous mixture		Gms. per 100 gms. homogeneous mixture	
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	iso C <sub>3</sub> H <sub>7</sub> OH	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	iso C <sub>3</sub> H <sub>7</sub> OH
45.58	3.12*	8.98	18.96
31.45	6.85	5.35	24.20
22.20	9.95	3.93	27.54
18.6	11.6 PP	0.97	41.50*
14.2	14.10		

## N NITROGEN

### THE SYSTEM AMMONIUM SULFATE - TERTIARY BUTYL ALCOHOL - WATER AT 30° (Ginnings and Robbins, 1930)

In a later paper Ginnings, Herring and Webb, 1933, give the value of 3.2 gms.  $(\text{NH}_4)_2\text{SO}_4$  + 35.4 gms. ter.  $(\text{CH}_3)_3\text{COH}$  + 61.4 gms.  $\text{H}_2\text{O}$  for the plait point of this system at 25° but do not give the original results for the other points on the binodal curve.

The binodal curve, tie lines, \*, and plait point, PP, for this system were determined as mentioned above.

50	Gms. per 100 gms. homogeneous mixture		Gms. per 100 gms. homogeneous mixture		Gms. per 100 gms. homogeneous mixture	
	$(\text{NH}_4)_2\text{SO}_4$	ter. $(\text{CH}_3)_3\text{COH}$	$(\text{NH}_4)_2\text{SO}_4$	ter. $(\text{CH}_3)_3\text{COH}$	$(\text{NH}_4)_2\text{SO}_4$	ter. $(\text{CH}_3)_3\text{COH}$
	-	99*	3.7	32.OPP	13.0	8.9
	-	82*	4.0	28.2	14.1	7.7
	0.4	63.4	4.6	24.6	18.2	5.3
	-	60.0*	5.1	- *	26.1	2.5
	1.4	48.8	5.7	19.8	27.4	- *
	-	42 *	6.5	17.4	28.7	1.8
	3.2	34.3	12.1	- *	32.1	1.4
					37.8	0.8*

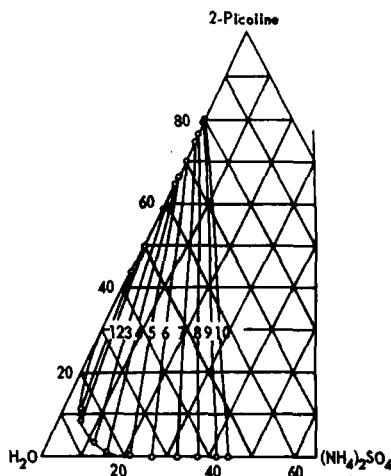
The binodal curves of the system ammonium sulfate + allyl alcohol + water at 25° have been determined by Ginnings and Dees, 1935. The authors do not give their original experimental results but only the values of a series of arbitrary constants calculated from them by means of empirical equations. In the case of allyl alcohol it is concluded that this alcohol is more difficult to salt out than either normal or iso propyl alcohol.

### THE SYSTEM AMMONIUM SULFATE - URETHAN - WATER AT 25° (Palitsch, 1928, 1929)

Gms. Mols. per 1000 gms. $\text{H}_2\text{O}$		Solid Phase
$(\text{NH}_4)_2\text{SO}_4$	$\text{NH}_2\text{COOC}_2\text{H}_5$	
5.805	0.0	$(\text{NH}_4)_2\text{SO}_4$
5.778	0.029	"
5.763	0.106	" + $\text{NH}_2\text{COOC}_2\text{H}_5$
4.0	0.387	$\text{NH}_2\text{COOC}_2\text{H}_5$
3.7	0.351	lower liquid layer
0.06	47.86	upper liquid layer
0.0	53.09	$\text{NH}_2\text{COOC}_2\text{H}_5$

The phase diagram for the system  $(\text{NH}_4)_2\text{SO}_4$  - pyridine - water at 25° is given by Peakin, 1940, but without numerical data. The ammonium sulfate decreases the solubility of pyridine in water to a minimum of about 22% when the saturated solution contains 15% salt. Additional results are shown graphically by Arakawa, Kawaguchi and Kato, 1958, and by Ginnings, Webb and Hinohara, 1933.

THE SYSTEM  $(\text{NH}_4)_2\text{SO}_4$  - 2 PICOLINE -  $\text{H}_2\text{O}$  AT  $30^\circ$   
(Arakawa, Kawaguchi and Kato, 1958)



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THE SYSTEM AMMONIUM SULFATE - ACETONE - WATER AT  $25^\circ$   
(Bell, 1905; Linebarger, 1892)

(Data recalculated to wt. %)

$(\text{NH}_4)_2\text{SO}_4$	acetone	$(\text{NH}_4)_2\text{SO}_4$	acetone
0	77	22	10
2	48	30	4
4.5	35.5	42	1
12	20.5 Plait Point		

THE SYSTEM AMMONIUM SULFATE -  $\epsilon$ -CAPROLACTAM - WATER  
(Vecera and Sladky, 1955, 1955a)

Sat. Sol. Wt. %		TWO-LIQUID DATA WT%			
		I		II	
caprolactam	$(\text{NH}_4)_2\text{SO}_4$	$\epsilon$ -cap.l.	$(\text{NH}_4)_2\text{SO}_4$	$\epsilon$ -cap.l.	$(\text{NH}_4)_2\text{SO}_4$
Results at $30^\circ$					
87.5	0	72.5	0.5	0	43.8
67.6	0.8	67.5	0.7	0.8	39.9
58.0	1.8	62.1	1.3	1.4	36.3
48.5	3.6	57.0	1.9	2.3	33.0
34.3	8.2				
25.5	12.5				
14.7	18.1				
7.1	24.1				
3.4	29.6				
2.8	31.4				
1.4	36.3				

(Cont.)

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## THE SYSTEM AMMONIUM SULFATE - $\epsilon$ -CAPROLACTAM - WATER--Cont.

Sat. Sol. Wt. %		TWO-LIQUID DATA WT%			
		I		II	
$\epsilon$ -caprolactam	$(\text{NH}_4)_2\text{SO}_4$	$\epsilon$ -cap.l.	$(\text{NH}_4)_2\text{SO}_4$	$\epsilon$ -cap.l.	$(\text{NH}_4)_2\text{SO}_4$
Results at 50°					
94.8	0	75.7	0.3	0	45.8
73.8	0.4	70.6	0.7	1.1	38.1
67.6	0.8	63.8	1.2	2.0	34.5
57.7	2.0	59.5	1.7	2.8	31.2
47.5	4.0				
33.0	8.8				
25.1	12.2				
13.8	18.3				
8.2	22.7				
3.7	29.3				
1.1	38.6				

100 gms. 952 formic acid dissolve 25.4 gms.  $(\text{NH}_4)_2\text{SO}_4$  at 16.5°.  
(Aschan, 1913.)

100 gms. liquid Sulfur Dioxide ( $\text{SO}_2$ ) dissolve 0.067 gm.  $(\text{NH}_4)_2\text{SO}_4$  at 0°. (Jander and Wickert, 1936. Jander and Ruppolt, 1937.)

F. pt. data for  $(\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{SO}_4$  are given by Kendall and Landon, 1920, and by Cambi and Bozza, 1923.

## SO AMMONIUM PERSULFATE $(\text{NH}_4)_2\text{S}_2\text{O}_8$

### SOLUBILITY IN WATER (Jatkar and Seshadri, 1953)

t°	Gms. $(\text{NH}_4)_2\text{S}_2\text{O}_8$ per		t°	Gms. $(\text{NH}_4)_2\text{S}_2\text{O}_8$ per	
	100 gms sat. sol.	100 cc. sat. sol.		100 gms sat. sol.	100 cc. sat. sol.
0	37.0(36.7) <sup>a</sup>	45.0	25	45.5	56.1
5	38.5	45.6	40	50.9	63.9
10	40.1	46.1	60	56.1	74.1
15	-	(52.0) <sup>b</sup>	80	62.0	81.6
20	43.4	52.6			
		(54.2) <sup>b</sup>			

<sup>a</sup>Marshall, 1891

<sup>b</sup>Gall, Church and Brown, 1943

SOLUBILITY OF AMMONIUM PERSULFATE IN SULFURIC ACID SOLUTIONS  
(Jatkar and Seshadri, 1953)

See also the results of Gall, Church and Brown, 1943, below.

Expressed as g.  $(\text{NH}_4)_2\text{S}_2\text{O}_8/100$  g. of solution

Temp., °C	Conc. $\text{H}_2\text{SO}_4$				
	1N	2N	4N	6N	8N
0	34.3	29.6	25.8	14.9	17.4
5	36.0	30.1	24.7	16.9	17.3
10	37.2	30.4	26.1	18.3	17.0
15	39.0	31.3	27.0	20.2	16.6
20	39.2	32.5	27.7	22.1	15.5
25	42.1	33.1	28.2	24.6	14.5
40	47.1	35.1	31.0	29.8	--

30

THE SYSTEMS  $(\text{NH}_4)_2\text{S}_2\text{O}_8 -$   
 $(\text{NH}_4)_2\text{SO}_4 - \text{H}_2\text{O}$  AND  $(\text{NH}_4)_2\text{S}_2\text{O}_8 - (\text{NH}_4)_2\text{SO}_4 - \text{H}_2\text{SO}_4 - \text{H}_2\text{O}$

Results of Jatkar and Seshadri at 25°

A =  $(\text{NH}_4)_2\text{SO}_4$

B =  $(\text{NH}_4)_2\text{S}_2\text{O}_8$

In $\text{H}_2\text{O}$			in 4N $\text{H}_2\text{SO}_4$		
Sat. Sol.	Wt. %	Solid Phase	Sat. Sol.	Wt. %	Solid Phase
$(\text{NH}_4)_2\text{SO}_4$	$(\text{NH}_4)_2\text{S}_2\text{O}_8$		$(\text{NH}_4)_2\text{SO}_4$	$(\text{NH}_4)_2\text{S}_2\text{O}_8$	
43.5	nil	A	39.8	nil	A
40.7	7.0	A	35.7	4.4	A
40.2	9.8	A + B	30.0	7.1	A
36.1	11.1	B	27.5	8.9	A
33.2	13.4	B	23.9	11.7	A + B
28.7	17.2	B	22.2	14.3	B
24.0	19.8	B	19.8	16.6	B
19.2	24.2	B	17.0	19.4	B
13.5	29.1	B	13.9	23.0	B
8.0	33.6	B	10.5	25.9	B
nil	45.5	B	nil	32.8	B

Results of Gall, Church and Brown at 15°, 20°

It was found that solutions of the persulfate decomposed upon standing to yield  $\text{H}_2\text{SO}_5$  and  $(\text{NH}_4)_2\text{SO}_4$  and that  $\text{H}_2\text{O}_2$  was then produced. The amount of  $\text{H}_2\text{SO}_5$  and  $\text{H}_2\text{O}_2$  present at varying lengths of time were determined and an extrapolation was then made to zero time in order to find the amount of undecomposed persulfate originally present. The authors present their original data, and the following rounded values read from plots of the data. Densities are also given.

(Cont.)

# N NITROGEN

THE SYSTEMS  $(\text{NH}_4)_2\text{S}_2\text{O}_8$  -  
 $(\text{NH}_4)_2\text{SO}_4$  -  $\text{H}_2\text{O}$  AND  $(\text{NH}_4)_2\text{S}_2\text{O}_8$  -  $(\text{NH}_4)_2\text{SO}_4$  -  $\text{H}_2\text{SO}_4$  -  $\text{H}_2\text{O}$  - Cont.

Results of Gell, Church and Brown at 15°, 20°--Cont.

(Gms.  $(\text{NH}_4)_2\text{S}_2\text{O}_8$  per liter of Saturated Solution)

Gms. $\text{H}_2\text{SO}_4$ per liter Sat. Sol.	Gms. $(\text{NH}_4)_2\text{SO}_4$ per liter Sat. Sol.				
	0	25	50	75	100

Results at 15°

	0	520*	496	474	451	428
	50	448	428	408	389	369
30	100	388	370	352	335	318
	150	334	318	303	286	271
	200	288	274	258	242	227
	250	247	233	218	203	190
	300	212	197	182	166	154
	350	178	162	148	132	120
	400	145	132	116	101	88

Results at 20°

	0	542**	518	496	475	452
	50	481	461	441	421	401
	100	426	406	390	371	352
	150	374	356	340	324	307
	200	326	310	295	278	263
	250	281	265	250	235	219
	300	239	224	208	194	178
	350	190	183	169	155	139
	400	162	146	131	116	100

\*density = 1.254      \*\*density = 1.266

Data for the solubility of  $(\text{NH}_4)_2\text{S}_2\text{O}_8$  in aq.  $\text{NH}_4\text{HSO}_4$  and in aq.  $(\text{NH}_4)_2\text{SO}_4$  +  $\text{H}_2\text{SO}_4$  solutions are reported by Wasilewski and Kobylezyk, 1955

100 gms. of a saturated solution of ammonium persulfate in furfural contain 0.1 gms.  $(\text{NH}_4)_2\text{S}_2\text{O}_8$  at 25°. (Trimble, 1941).

## 30 AMMONIUM POLYTHIONATES $(\text{NH}_4)_2\text{S}_x\text{O}_6$

SOLUBILITY OF AMMONIUM DITHIONATE IN WATER  
 (de Baat, 1926)

t°	Gms. $(\text{NH}_4)_2\text{S}_2\text{O}_6$ per 100 gms. sat. sol.	Solid Phase
0	57.05	$(\text{NH}_4)_2\text{S}_2\text{O}_6 \cdot \frac{1}{2}\text{H}_2\text{O}$
10	60.14	"
20	62.43	"
30	64.10	"

THE SYSTEM AMMONIUM DITHIONATE - STRONTIUM DITHIONATE - WATER AT 30°  
(de Baat, 1926)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{SrS}_2\text{O}_6$	$(\text{NH}_4)_2\text{S}_2\text{O}_6$	Solid Phase	$\text{SrS}_2\text{O}_6$	$(\text{NH}_4)_2\text{S}_2\text{O}_6$	Solid Phase
0.98	63.73	$(\text{NH}_4)_2\text{S}_2\text{O}_6 \cdot \frac{1}{2}\text{H}_2\text{O}$	6.47	34.57	$\text{SrS}_2\text{O}_6 \cdot 4\text{H}_2\text{O}$
2.17	60.66	" + $\text{SrS}_2\text{O}_6 \cdot 4\text{H}_2\text{O}$	8.79	24.52	"
2.71	56.76	$\text{SrS}_2\text{O}_6 \cdot 4\text{H}_2\text{O}$	10.73	16.55	"
4.45	45.04	"	14.90	0.0	"

SOLUBILITY OF AMMONIUM TRI AND TETRATHIONATES, (SEPARATELY) IN WATER  
(Kurténacker and Laszlo, 1938)

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Results for:

Trithionate		Tetrathionate	
t°	Gms. $(\text{NH}_4)_2\text{S}_3\text{O}_6$ per 100 gms. sat. sol.	t°	Gms. $(\text{NH}_4)_2\text{S}_4\text{O}_6$ per 100 gms. sat. sol.
0	53.2	0	51.2
20	56.4	20	54.3
30	58.4	30	56.2

THE SYSTEM AMMONIUM TRITHIONATE - AMMONIUM TETRATHIONATE - WATER  
(Kurténacker and Laszlo, 1938)

The tri and tetrathionates decompose while being shaken with water, especially at 20°. The decomposition products include thiosulfate, pentathionate, sulfate and free acid. Determinations are given for the percentage of pentathionate and thiosulfate. The maximum amount of thiosulfate was 0.2 percent.

Results at 0°

Gms. per 100 gms. sat. sol.			Solid Phase
$(\text{NH}_4)_2\text{S}_3\text{O}_6$	$(\text{NH}_4)_2\text{S}_4\text{O}_6$	$(\text{NH}_4)_2\text{S}_3\text{O}_6$	
1.2	51.0	0.0	$(\text{NH}_4)_2\text{S}_4\text{O}_6$
1.1	48.9	0.8	"
15.5	30.5	3.9	"
27.8	21.5	0.9	"
41.2	16.7	0.7	"
46.7	76.1	0.0	$(\text{NH}_4)_2\text{S}_3\text{O}_6$
52.1	1.0	0.0	"
53.0	0.9	0.0	"

(Cont.)



# N NITROGEN

## THE SYSTEM AMMONIUM TRITHIONATE - AMMONIUM TETRATHIONATE - WATER--Cont.

Results at 20°

Gms. per 100 gms. sat. sol.			Solid Phase
(NH <sub>4</sub> ) <sub>2</sub> S <sub>3</sub> O <sub>6</sub>	(NH <sub>4</sub> ) <sub>2</sub> S <sub>4</sub> O <sub>6</sub>	(NH <sub>4</sub> ) <sub>2</sub> S <sub>5</sub> O <sub>6</sub>	
0.0	54.2	0.0	(NH <sub>4</sub> ) <sub>2</sub> S <sub>4</sub> O <sub>6</sub>
1.0	52.9	0.0	"
9.0	43.3	1.6	"
19.6	32.2	4.5	"
39.9	19.0	1.8	"
45.5	15.9	1.8	-
53.0	5.2	0.0	(NH <sub>4</sub> ) <sub>2</sub> S <sub>3</sub> O <sub>6</sub>
56.0	2.0	0.0	"

## SOM AMMONIUM SULFAMATE NH<sub>4</sub>SO<sub>3</sub>NH<sub>2</sub>

### SOLUBILITY OF AMMONIUM SULFAMATE IN WATER

(Cupery, 1938; Ricci and Selikson, 1947, 1952; Uchido, Itto and Kobayashi, 1954)

The anhydrous salt is the solid phase (R. and S.)

t°	Gms. NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub> per 100 gms.		t°	Gms. NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub> per 100 gms.	
	H <sub>2</sub> O	Sat. Sol.		H <sub>2</sub> O	Sat. Sol.
0	-	57.6 (UIK)	30	232.4	70.0 (C)
0.2	134.8	58.4 (C)	-	-	70.1 (UIK)
9	-	62.26(RS)	35	265.3	72.9 (RS)
10	166.6	62.5 (C)	40	279.5	73.7 (C)
20	200.2	66.7 (C)	50	357	78.1 (C)
	203.0	67.0 (RS)	-	-	78.3 (UIK)
25	221.5	68.90(RS)	70	-	84.1 (UIK)
	-	68.9 (UIK)			

## THE SYSTEM AMMONIUM SULFAMATE - SULFAMIC ACID - WATER AT 25° (Ricci and Selikson, 1947)

Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>	HSO <sub>3</sub> NH <sub>2</sub>		NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>	HSO <sub>3</sub> NH <sub>2</sub>	
68.87	0.0	NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub>	60.72	15.26	HSO <sub>3</sub> NH <sub>2</sub>
65.99	5.73	"	47.39	16.19	"
63.59	11.00	"	29.89	17.06	"
62.96	13.65	"	12.18	17.72	"
62.19	15.16	NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub> + HSO <sub>3</sub> NH <sub>2</sub>	0.0	18.78	"

Melting points in the system NH<sub>4</sub>SO<sub>3</sub>NH<sub>2</sub> + NaSO<sub>3</sub>NH<sub>2</sub> are given by Laning and van der Meulen, 1948.

AMMONIUM IMIDODISULFATE (IMIDOSULFAMATE)  $(\text{NH}_4\text{SO}_3)_2\text{NH}$ 

SON

## SOLUBILITY IN WATER

(Uchida, Ito and Kobayashi, 1954; Uchida and Ito, 1955)

The salt hydrolyzes in water above 30°.

t°	Gms. $(\text{NH}_4)_2\text{SO}_3)_2\text{NH}$ per 100 gms. $\text{H}_2\text{O}$	
	in water	in 0.03M $\text{NH}_3$
0	23.4	-
5	27.6	-
10	32.1	32.4
15	36.8	-
20	41.5	41.4
25	46.0	-
30	50.8	50.8
40	-	60.5
50	-	70.4
60	-	80.4

SON

THE SYSTEM  $(\text{NH}_4\text{SO}_3)_2\text{NH} - \text{NH}_3 - \text{H}_2\text{O}$ 

(Uchida, Ito and Kobayashi, 1954; Uchida and Ito, 1955)

t°	Sat. Sol. Wt. %		wet residue wt. %		Solid Phase
	$(\text{NH}_4\text{SO}_3)_2\text{NH}$	$\text{NH}_3$	$(\text{NH}_4\text{SO}_3)_2\text{NH}$	$\text{NH}_3$	
0	18.9	0.0	-	-	$(\text{NH}_4\text{SO}_3)_2\text{NH}$
	23.2	0.6	58.6	0.3	"
	31.1	1.6	54.3	2.1	$(\text{NH}_4\text{SO}_3)_2\text{NH} + (\text{NH}_4\text{SO}_3)_2\text{NNH}_4 \cdot \text{H}_2\text{O}$
	30.9	1.6	54.0	2.8	"
	17.7	4.3	34.3	5.0	$(\text{NH}_4\text{SO}_3)_2\text{NNH}_4 \cdot \text{H}_2\text{O}$
	11.2	6.2	-	-	"
	5.6	10.3	32.0	9.2	"
	1.0	24.5	21.7	20.1	"
	33.7	0.0	-	-	$(\text{NH}_4\text{SO}_3)_2\text{NH}$
	37.7	0.9	60.3	0.6	"
30	43.6	2.1	53.5	2.1	$(\text{NH}_4\text{SO}_3)_2\text{NH} + (\text{NH}_4\text{SO}_3)_2\text{NNH}_4 \cdot \text{H}_2\text{O}$
	43.7	2.1	60.8	2.6	"
	35.0	4.3	43.2	4.6	$(\text{NH}_4\text{SO}_3)_2\text{NNH}_4 \cdot \text{H}_2\text{O}$
	24.0	7.7	-	-	"
	8.2	15.3	41.4	11.7	"
	3.1	25.8	39.2	17.5	"

# N NITROGEN

## SeO AMMONIUM SELENITE $(\text{NH}_4)_2\text{SeO}_3$

SOLUBILITY OF AMMONIUM SELENITE IN WATER  
(Janickis, 1934; Janickis and Gutmanaitis, 1936)

t°	d. of sat. sol.	Gms. (NH <sub>4</sub> ) <sub>2</sub> SeO <sub>3</sub> per 100 gms. sat. sol.	Solid Phase	t°	Gms. (NH <sub>4</sub> ) <sub>2</sub> SeO <sub>3</sub> per 100 gms. sat. sol.	Solid Phase
- 0.105	1.0002	0.326	Ice	- 8.5	47.18	A
- 0.260	1.0036	0.812	"	+ 1.0	49.21	"
- 0.875	1.019	3.20	"	14.0	51.99	"
- 2.06	1.051	7.75	"	25.0	54.70	"
SeO- 8.81	1.197	27.24	"	35.2	57.13	"
-15.95	1.297	39.88	"	43.0	59.90	"
-21.9	-	44.8	Ice + A	50	62.31	"
-20.9	-	45.12	A	70	69.08	

A =  $(\text{NH}_4)_2\text{SeO}_3 \cdot \text{H}_2\text{O}$

## AMMONIUM TETRA SELENITE $(\text{NH}_4)_3(\text{SeO}_3)_2$

SOLUBILITY OF AMMONIUM TETRASELENITE IN WATER  
(Janickis, 1934; Janickis and Gutmanaitis, 1936)

t°	d. of sat. sol.	Gms. (NH <sub>4</sub> )H <sub>3</sub> (SeO <sub>3</sub> ) <sub>2</sub> per 100 gms. sat. sol.	Solid Phase	t°	Gms. (NH <sub>4</sub> )H <sub>3</sub> (SeO <sub>3</sub> ) <sub>2</sub> per 100 gms. sat. sol.	Solid Phase
- 0.147	1.002	0.549	Ice	-14.8	60.08	Ice+A
- 0.335	1.0075	1.365	"	-10.3	64.58	A
- 0.595	1.0165	2.71	"	- 5.8	68.70	"
- 1.055	1.034	5.32	"	+ 0.1	73.61	"
- 2.435	1.063	12.94	"	8.8	79.30	"
- 4.385	1.174	24.73	"	18.0	85.11	"
- 8.06	1.345	40.89	"	30.0	91.62	"
-12.85	1.511	54.60	"			

A =  $(\text{NH}_4)_3(\text{SeO}_3)_2$

AMMONIUM PYRO SELENITE  $(\text{NH}_4)_2\text{Se}_2\text{O}_5$ 

SeO

SOLUBILITY OF AMMONIUM PYROSELENITE IN WATER  
(Janickis, 1934; Janickis and Gutmanaitis, 1936)

Gms.				Gms.			
t°	d. of sat. sol.	(NH <sub>4</sub> ) <sub>2</sub> Se <sub>2</sub> O <sub>5</sub> per 100 gms. sat. sol.	Solid Phase	t°	(NH <sub>4</sub> ) <sub>2</sub> Se <sub>2</sub> O <sub>5</sub> per 100 gms. sat. sol.	Solid Phase	
- 0.148	1.002	0.547	Ice	+15.0	66.65	A	
- 0.373	1.0075	1.36	"	20	69.50	"	
- 0.697	1.019	2.69	"	25	73.24	"	
- 1.365	1.035	5.29	"	30	79.74	"	
- 3.18	1.090	12.57	"	32	82.29	"	SeO
- 6.23	1.178	23.35	"	32	86.23	B	
-13.0	1.351	40.7	"	33.2	86.35	"	
-16.9	-	49.0	Ice + A	34.0	86.43	"	
-15.0	-	49.62	A	45.1	87.23	"	
-10.0	-	52.86	"	57.2	88.78	"	
0.0	-	56.84	"	70.1	90.50	"	
A = (NH <sub>4</sub> ) <sub>2</sub> Se <sub>2</sub> O <sub>5</sub> ·3H <sub>2</sub> O				B = (NH <sub>4</sub> ) <sub>2</sub> Se <sub>2</sub> O <sub>5</sub>			

A =  $(\text{NH}_4)_2\text{Se}_2\text{O}_5 \cdot 3\text{H}_2\text{O}$ B =  $(\text{NH}_4)_2\text{Se}_2\text{O}_5$ AMMONIUM SELENATE  $(\text{NH}_4)_2\text{SeO}_4$ 

## SOLUBILITY IN WATER

(solid phase is anhydrous)

20°	54.1	gms. per 100 gms. sat. sol.	(Pani and Terrey, 1955)
25°	54.02	"	(King and Beckman, 1945)
30°	55.12	"	(King, 1937)

SOLUBILITY OF AMMONIUM SELENATE IN AQUEOUS SOLUTIONS  
OF SELENIC ACID AT 30°  
(King, 1937)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
(NH <sub>4</sub> ) <sub>2</sub> SeO <sub>4</sub> H <sub>2</sub> SeO <sub>4</sub>			(NH <sub>4</sub> ) <sub>2</sub> SeO <sub>4</sub> H <sub>2</sub> SeO <sub>4</sub>		
55.12	0.0	(NH <sub>4</sub> ) <sub>2</sub> SeO <sub>4</sub>	44.74	34.52	(NH <sub>4</sub> ) <sub>2</sub> SeO <sub>4</sub> ·H <sub>2</sub> SeO <sub>4</sub>
53.82	3.56	"	34.41	42.50	"
53.03	5.39	"	24.13	50.53	"
53.22	9.08	"	23.41	50.77	"
54.40	10.75	"	20.04	55.26	-
53.11	12.73	-	18.47	58.61	(NH <sub>4</sub> ) <sub>2</sub> SeO <sub>4</sub> ·H <sub>2</sub> SeO <sub>4</sub>
50.48	14.88	3(NH <sub>4</sub> ) <sub>2</sub> SeO <sub>4</sub> ·H <sub>2</sub> SeO <sub>4</sub>	17.27	60.74	"
48.40	19.24		17.40	61.08	"
46.36	24.18	"	17.20	63.28	"
45.49	28.08	"	23.79	67.38	"
43.92	34.13	-	29.72	66.23	"

# N NITROGEN

## THE SYSTEM AMMONIUM SELENATE - HYDROGEN PEROXIDE - WATER AT 20° (Pani and Terrey, 1955)

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
$(\text{NH}_4)_2\text{SeO}_4$	$\text{H}_2\text{O}_2$		$(\text{NH}_4)_2\text{SeO}_4$	$\text{H}_2\text{O}_2$	
54.1	0.0	$(\text{NH}_4)_2\text{SeO}_4$	54.0	15.57	1:1
54.5	2.62	"	52.5	18.66	"
54.7	5.26	"	52.5	19.23	"
54.7	7.96	"	51.6	21.79	"
54.8	10.71	"	50.5	25.98	"
55.7	12.87	" + 1:1			

1:1 =  $(\text{NH}_4)_2\text{SeO}_4 \cdot \text{H}_2\text{O}_2$

## TeO AMMONIUM TECHNETATE $\text{NH}_4\text{TcO}_4$

Data for the extraction of  $\text{NH}_4\text{TcO}_4$  from 4N NaOH by pyridine are given by Goishi and Libby, 1952.

## VO AMMONIUM METAVANADATE $\text{NH}_4\text{VO}_3$

### SOLUBILITY IN WATER

t°	(Meyer, 1909)	(Andreev, 1954)	(Lachartre, 1924)*
	gms. per 100 cc. sat. sol.	gms. per 100 gms. sat. sol.	gms. per 100 gms. sat. sol.
10.5-12.5	-	0.440	-
15	-	-	0.518
18	0.435	-	-
25	0.608	-	-
32	-	-	1.04
35	1.077	1.140	-
45	1.571	-	-
50	-	-	1.61
55	1.997	-	-
60	-	2.490	-
70	3.047	-	3.60
96	-	-	6.50

\*In the original, results by Lachartre are about ten times too high as compared with other determinations. The decimal points were moved one place to the left.

THE SYSTEM AMMONIUM VANADATE - AMMONIUM CHLORIDE - WATER  
(Andreev, 1954)

t°	Sat. Sol. Wt. %		Wet Residue Wt. %		Solid Phase
	NH <sub>4</sub> VO <sub>3</sub>	NH <sub>4</sub> Cl	NH <sub>4</sub> VO <sub>3</sub>	NH <sub>4</sub> Cl	
10.5 - 14.5	0.440	-	-	-	NH <sub>4</sub> VO <sub>3</sub>
	0.085	0.261	-	-	-
	0.018	0.550	77.07	-	NH <sub>4</sub> VO <sub>3</sub>
	-	2.270	-	-	-
	-	25.300	-	-	NH <sub>4</sub> Cl
35	1.140	-	-	-	NH <sub>4</sub> VO <sub>3</sub>
	0.497	0.296	83.19	-	NH <sub>4</sub> VO <sub>3</sub>
	0.171	0.721	-	-	-
	0.149	1.067	-	-	-
	0.080	1.574	44.65	2.00	NH <sub>4</sub> VO <sub>3</sub>
	0.026	2.540	30.44	1.84	NH <sub>4</sub> VO <sub>3</sub>
	0.006	4.470	-	-	-
	trace	8.980	-	-	-
	-	11.440	21.44	9.22	NH <sub>4</sub> VO <sub>3</sub>
	-	29.820	20.13	7.65	NH <sub>4</sub> VO <sub>3</sub> + NH <sub>4</sub> Cl
	-	30.400	-	-	NH <sub>4</sub> Cl
60	2.490	-	-	-	NH <sub>4</sub> VO <sub>3</sub>
	0.551	1.340	-	-	-
	0.210	2.490	57.77	0.49	NH <sub>4</sub> VO <sub>3</sub>
	trace	20.060	-	-	-
	-	34.860	-	-	-
	-	35.600	-	-	NH <sub>4</sub> Cl

VO

SOLUBILITY IN WATER AND IN AQUEOUS AMMONIUM SALT AND AMMONIUM  
HYDROXIDE SOLUTIONS  
(Meyer, 1909)

t°	Gms. per 1000 cc. in Each Solvent							
	Water	0.05 n NH <sub>4</sub> Cl	0.1 n NH <sub>4</sub> Cl	0.05 n NH <sub>4</sub> NO <sub>3</sub>	0.1 n NH <sub>4</sub> NO <sub>3</sub>	0.0668 n NH <sub>3</sub>	0.245 n NH <sub>3</sub>	0.588 n NH <sub>3</sub>
18	4.35	1.66	0.41	1.67	0.58	5.58	7.97	12.06
25	6.08	2.63	1.17	2.77	1.23	7.06	8.58	12.66
35	10.77	5.21	2.69	-	-	-	-	-
45	15.71	8.88	5.40	-	-	-	-	-
55	19.97	11.18	7.40	-	-	-	-	-
70	30.47	-	-	-	-	-	-	-

100 cc. anhydrous hydrazine dissolve 2 gms. ammonium metavanadate  
at room temp. (Welsh and Broderson, 1915.)

## N NITROGEN

### VO AMMONIUM BIVANADATE $(\text{NH}_4)_2\text{O}(\text{V}_2\text{O}_5) \cdot 3\text{H}_2\text{O}$

100 gms. sat. solution in water contain 2.80 gms.  $(\text{NH}_4)_2\text{O}(\text{V}_2\text{O}_5)_2$  at 16°. (Lachartre, 1924.)

### WO AMMONIUM PARATUNGSTATE $5(\text{NH}_4)_2\text{O} \cdot 12\text{WO}_3$

#### SOLUBILITY OF AMMONIUM PARA TUNGSTATE IN WATER (Rosenheim and Wolff, 1936)

t°	Gms. $5(\text{NH}_4)_2\text{O} \cdot 12\text{WO}_3$ per 100 gms.		t°	Gms. $5(\text{NH}_4)_2\text{O} \cdot 12\text{WO}_3$ per 100 gms.	
	sat. sol.	Solid Phase		sat. sol.	Solid Phase
17	1.064	$5(\text{NH}_4)_2\text{O} \cdot 12\text{WO}_3 \cdot 11\text{H}_2\text{O}$	49	4.341	$5(\text{NH}_4)_2\text{O} \cdot 12\text{WO}_3 \cdot 11\text{H}_2\text{O}$
25	1.586	"	53	3.280	$5(\text{NH}_4)_2\text{O} \cdot 12\text{WO}_3 \cdot 7\text{H}_2\text{O}$
29	2.014	"	62	6.145	"
35	2.424	"	70	7.971	"
45	3.467	"			

#### SOLUBILITY IN AMMONIA SOLUTIONS AT 19° (Dawihl, 1940)

The solubility of ammonium paratungstate increased with increasing amounts of free ammonia in solution, and also with time. There was no evidence of a constant value having been attained after 14 months contact with the solutions, although the temperature variation ( $\pm 2^\circ$ ) was large enough to make the accuracy of the results  $\pm 0.2\%$  (abs.). Some typical results were as follows: (in gms. satl per 100 gms. Saturated Solution).

Time	% $\text{NH}_3$			
	0	0.94	6.25	12.0
4 days	1.5	1.6	1.5	1.4
4 months	1.1	2.5	6.3	5.7
13 months	1.1	3.2	12.1	13.3

### $\text{N}_2\text{H}$ HYDRAZINE $\text{N}_2\text{H}_4$

#### FREEZING POINTS IN THE SYSTEM HYDRAZINE - WATER

The results of Hill and Sumner, 1951 and Mohr and Audrieth, 1949 are in excellent agreement. The earlier data of Semishin, 1938 differ somewhat. The values below were selected from the many determinations listed by the authors.

## FREEZING POINTS IN THE SYSTEM HYDRAZINE - WATER--Cont.

(Mohr and Andrieth, 1949)

(Hill and Sumner, 1951)

Gms. $N_2H_4$ per 100 gms. Sat. Sol.	Freezing Point	Solid Phase	Gms. $N_2H_4$ per 100 gms. Sat. Sol.	Freezing Point	Solid Phase	
5.40	- 3.80°	Ice	13.3	-11.0	Ice	
11.9	- 9.80°	"	21.4	-23.4	"	
14.3	-12.7°	"	29.8	-46.7	"	
19.0	-20.4°	"	36.8	-67.3	"	
24.1	-30.8°	"	38.9	-82	"	
27.5	-41.6°	"	39.6	-84	"	
29.6	-46.3°	"	42.1	-83	1:1	$N_2H$
35.6	-65.9°	"	43.3	-78	"	
45.0	-75.8°	1:1	47.7	-66.7	"	
49.3	-61.7°	"	54.7	-56.0	"	
59.9	-52.6°	"	60.5	-53.2	"	
64.0	-51.7**	"	62.2	-52.0	"	
66.5	-52.2°	"	64.0	-51.5*	"	
69	-54°	1:1 + $N_2H_4$	68.0	-52.4	"	
72.6	-40.2°	$N_2H_4$	70.1	-49.2	"	
81.0	-20.4°	"	66.0	-29.8	$N_2H_4$	
90.1	- 8.70°	"	87.7	-11.2	"	
100.0	+2.0°	"	96.9	- 2.8	"	

\*Melting point of  $N_2H_4 \cdot H_2O$  (1:1)DISTRIBUTION OF HYDRAZINE BETWEEN WATER AND BENZENE  
(Georgievics, 1915)

Gms. $NH_2 \cdot NH_2$ per		Gms. $NH_2 \cdot NH_2$ per	
25 cc. $H_2O$ Layer	75 cc. $C_6H_6$ Layer	25 cc. $H_2O$ Layer	75 cc. $C_6H_6$ Layer
0.4137	0.027	1.7601	0.0626
0.6676	0.0335	2.3336	0.1101
1.0862	0.0355	4.75	0.137

Freezing point data are given for:

 $N_2H_4$  +  $CH_3OH$  (Corcoran, Kruse and Skolnik, 1953; Epstein, 1939) $N_2H_4$  +  $C_2H_5OH$  (Corcoran, Kruse and Skolnik, 1953) $N_2H_4$  +  $CO(NH_2)_2$  Semishin, 1939 $N_2H_4$  + phenol Semishin, 1939a

$N_2H_4$  + Thymol, + Acetamide, + Diphenylamine, Acetic Acid, Butyric Acid, Valeric Acid, Benzoic Acid, Salicylic Acid, Lauric Acid (in part), Palmitic Acid (in part). Semishin, 1943

 $N_2H_4$  +  $N_2H_5N_3$  (Dresser, Browne, and Mason, 1933.) $N_2H_4$  +  $N_2H_5N_3$  +  $NH_3$  (Howard, Jr., and Browne, 1934.) $N_2H_5N_3$  +  $NH_3$  " " "



# N NITROGEN

## $\text{N}_2\text{H}_4$ HYDRAZINE PERCHLORATE $\text{N}_2\text{H}_4(\text{HClO}_4)_2 \cdot 3\text{H}_2\text{O}$

### SOLUBILITY IN WATER (Carlson, 1910)

t°	Sp. Gr. Sat. Sol.	Gms. $\text{N}_2\text{H}_4(\text{HClO}_4)_2$ per 100 cc. Sat. Sol.
18	1.264	41.72
35	1.391	66.9

## $\text{N}_2\text{H}_4$ HYDRAZINE NITRATE $\text{N}_2\text{H}_4\text{HNO}_3$

### SOLUBILITY IN WATER (Sommer, 1914)

t°	Gms. $\text{N}_2\text{H}_4\text{HNO}_3$ per 100 Gms.		t°	Gms. $\text{N}_2\text{H}_4\text{HNO}_3$ per 100 Gms.	
	Sat. Sol.	Water		Sat. Sol.	Water
10	63.63	174.9	40.02	85.86	607.2
15	68.47	217.2	45.02	88.06	737.6
20.01	72.70	266.3	50.01	91.18	1034
25.01	76.61	327.5	55.01	93.58	1458
30.01	80.09	402.2	60.02	95.51	2127
35.01	83.06	400.3			

Melting point diagrams for the systems of hydrazine nitrate with the following salts have been determined by Barlot and Marsaule, 1948:

$\text{KNO}_3$ ,  $\text{CaNO}_3$ ,  $\text{RbNO}_3$ ,  $\text{NaNO}_3$ ,  $\text{LiNO}_3$ ,  $\text{NH}_4\text{NO}_3$ .

## $\text{N}_2\text{H}_4$ HYDRAZINE TRI NITRO METHYL CRESYLATE $\text{N}_2\text{H}_5\text{OC}_6\text{H}(\text{NO}_2)_3\text{CH}_3 \cdot \text{H}_2\text{O}$

### SOLUBILITY OF TRI NITRO METHYL CRESYLATE IN WATER AND IN AQUEOUS SOLUTIONS OF ETHYL ALCOHOL (Gilbert and Huffman, 1932)

#### Results for Water

t°	Gm. Mols. $\text{N}_2\text{H}_5\text{OC}_6\text{H}(\text{NO}_2)_3\text{CH}_3$ per liter sat. sol.
15	0.08473
20	0.1158
25	0.1506
30	0.2053

(Cont.)

SOLUBILITY OF TRI NITRO METHYL CRESYLATE IN WATER AND IN  
AQUEOUS SOLUTIONS OF ETHYL ALCOHOL--Cont.

Results for Aq. Alcohol at 20°

Wt. Percent C <sub>2</sub> H <sub>5</sub> OH in Aq. Solvent	Gm. Mols. Cresylate per liter sat. sol.	Wt. Percent C <sub>2</sub> H <sub>5</sub> OH in Aq. Solvent	Gm. Mols. Cresylate per liter sat. sol.
5.0	0.1015	60.	0.2297
15	0.08996	69.4	0.2189
25	0.1089	79.70	0.1843
34.5	0.1509	96.0	0.0710
50	0.2170	99.8(Vol%)	0.0517

HYDRAZINE PICRATE, N<sub>2</sub>H<sub>5</sub>OC<sub>6</sub>H<sub>2</sub>(NO<sub>2</sub>)<sub>3</sub> · 1/2H<sub>2</sub>O

N<sub>2</sub>H

SOLUBILITY OF HYDRAZINE PICRATE IN AQUEOUS SOLUTIONS OF SALTS AT 20°  
(Gilbert, 1929)

Gms. Mols. Salts per liter aqueous solvent	Gm. Mols. N <sub>2</sub> H <sub>5</sub> OC <sub>6</sub> H <sub>2</sub> (NO <sub>2</sub> ) <sub>3</sub> per liter sat. sol.
Water alone	0.01396
0.020 NH <sub>4</sub> Cl	0.01499
0.050 "	0.01586
0.080 "	0.01655
0.100 "	0.01690
0.090 " + 0.01 NH <sub>4</sub> Pic.	0.01313
0.080 " + 0.02 "	0.01188
0.070 " + 0.03 "	0.01108
0.104 " + 0.005 "	0.01497
0.102 " + 0.003 "	0.01566
0.100 " + 0.012 "	0.01360
0.100 " + 0.01745 "	0.01387
0.05 " + 0.01 "	0.01209
0.100 " + 0.01 "	0.01388
0.100 " + 0.005 "	0.01495
0.100 NaNO <sub>3</sub>	0.01611
0.100 NaPic.	0.04322
0.090 NH <sub>4</sub> Cl + 0.009793 N <sub>2</sub> H <sub>5</sub> Cl	0.01231
0.080 " + 0.01950 "	0.00903
0.070 " + 0.02952 "	0.00690
0.100 NaPic.	0.00314 (15°)
0.050 " + 0.05 NaCl	0.00413 (15°)
0.100 NaCl	0.01176 (15°)

NH<sub>4</sub>Pic. (Picrate) NH<sub>4</sub>OC<sub>6</sub>H<sub>2</sub>(NO<sub>2</sub>)<sub>3</sub>; NaPic (Picrate), NaOC<sub>6</sub>H<sub>2</sub>(NO<sub>2</sub>)<sub>3</sub>.

The author also gives results for the Solubility of Croceo Dinitro Tetrammine Cobalti Picrate and Flavo Tetra Rhodano Diammine Chromiate in aqueous solutions of NaCl and Na Picrate. He also gives results for Tri ethyl amine Picrate and Tri propyl amine picrate in these salt solutions.

# N NITROGEN

## SOLUBILITY OF HYDRAZINE PICRATE IN AQUEOUS SOLUTIONS OF ETHYL ALCOHOL AT 20° (Gilbert and Huffman, 1932)

Wt. % $C_2H_5OH$ in Aq. Solvent	Gm. Mols. $N_2H_5OC_6H_2(NO_3)_3$ per liter sat. sol.	Wt. % $C_2H_5OH$ in Aq. Solvent	Gm. Mols. $N_2H_5OC_6H_2(NO_3)_3$ per liter sat. sol.
0.0 ( $=H_2O$ )	0.01396	60	0.01901
10	0.01160	69.4	0.01616
15	0.01076	79.7	0.01176
25	0.01113	96.0	0.00525
34.5	0.01448	99.8 (Vol. %)	0.00694
51	0.01890		

Data for the Solubility of Hydrazine Picrate at 15° in dilute aqueous solutions of NaCl + HCl in presence of acetone were determined by Gilbert 1929(a), in connection with studies of the hydrolysis of hydrazine by acetone.

## HYDRAZINE SULFATE $N_2H_6SO_4$ , BISULFATE $(N_2H_5)_2SO_4$

Results of Sommer and Weise, 1916

Data for the Bisulfate				Data for the Sulfate			
t°	Gms. $(N_2H_5)_2SO_4$ per 100 gms. sat. sol.	Mols. $(N_2H_5)_2SO_4$ per liter	Solid Phase	t°	Gms. $N_2H_6SO_4$ per 100 gms. sat. sol.	Mols. $N_2H_6SO_4$ per liter	Solid Phase
25	66.91	12.48	A	20	2.794	0.220	C
35	71.28	15.32	A	25	3.302	0.260	C
45	78.54	22.59	A	30	3.746	0.299	C
50	82.33	28.76	A + B	40	3.987	0.404	C
55	83.40	31.01	B	50	6.538	0.538	C
60	84.72	34.22	B	60	8.322	0.698	C
				70	10.465	0.902	C
				80	12.580	1.107	C

A =  $(N_2H_5)_2SO_4 \cdot H_2O$     B =  $(N_2H_5)_2SO_4$     C =  $N_2H_6SO_4$

## SOLUBILITY OF HYDRAZINE SULFATE IN WATER ABOVE 100° (Benrath, 1942)

t°	Gms. $N_2H_4 \cdot H_2SO_4$ per 100 gms. sat. sol.	t°	Gms. $N_2H_4 \cdot H_2SO_4$ per 100 gms. sat. sol.	t°	Gms. $N_2H_4 \cdot H_2SO_4$ per 100 gms. sat. sol.
94	14	143	35	186	55
108	20	152	40	198	60
118	25	163	45	208	65
129	30	174	50	216	70

SOLUBILITY OF BIVALENT HYDRAZINE SULFATE (II) IN AQUEOUS SOLUTIONS  
OF ACIDS AT 25°  
(Sommer and Weise, 1916)

In aq. $\text{H}_2\text{SO}_4$		In aq. $\text{HCl}$		In aq. $\text{CH}_3\text{COOH}$	
Gms. $\text{H}_2\text{SO}_4$ per liter	Gms. $\text{N}_2\text{H}_6\text{SO}_4$ per 100 gms. sat. sol.	Gms. $\text{HCl}$ per liter	Gms. $\text{N}_2\text{H}_6\text{SO}_4$ per 100 gms. sat. sol.	Gms. $\text{CO}_3\text{COOH}$ per liter	Gms. $\text{N}_2\text{H}_6\text{SO}_4$ per 100 gms. sat. sol.
0.4897	3.143	0.00	3.302	0.5157	3.198
4.887	2.680	0.3645	3.156	6.8963	3.147
26.59	1.541	3.645	2.876	33.306	2.903
49.00	1.026	18.25	2.652	63.00	2.737
116.18	0.518	36.45	2.639	117.38	2.323
144.18	0.4318	66.08	2.615		

HYDROXYLAMINE  $\text{NH}_2\text{OH}$  $\text{N}_2\text{H}$ 

SOLUBILITY IN VARIOUS SOLVENTS  
(de Bruyn, 1892)

Solvent	t°	Gms. $\text{NH}_2\text{OH}$ per 100 Gms. Solution
Methyl Alcohol (abs.)	5	35
Ethyl Alcohol (abs.)	15	15
Ether (dry)	(b. pt.)	1.2
Ethyl Acetate	(b. pt.)	1.6

HYDROXYLAMINE HYDROCHLORIDE  $\text{NH}_2\text{OH} \cdot \text{HCl}$  $\text{N}_2\text{H}$ 

THE SYSTEM HYDROXYLAMINE - WATER  
(Mathiev, 1949)

Results at high pressures are also given.

t°	Wt. % $\text{NH}_2\text{OH} \cdot \text{HCl}$ in solution	Solid Phase	t°	Wt. % $\text{NH}_2\text{OH} \cdot \text{HCl}$ in sat. sol.	Solid Phase
- 0.57	1.072	ICE	+17	45.5	$7\text{NH}_2\text{OH} \cdot \text{HCl}$
- 0.93	1.725	"	25.1	48.55	"
- 2.72	5.099	"	48.7	57.314	"
- 5.33	9.482	"	55	58.983	"
- 9.40	15.431	"	59	60.709	"
-17.10	24.96	"	60.6	62.074	"
-20.95	29.39	"	68	65.377	"
-22.92	31.446	"	89.6	74.224	"
-22.6	32.957	$\text{NH}_2\text{OH} \cdot \text{HCl}$	98.4	78.061	"
- 0.9	39.7	"	150.5m.p.	100.0	"

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## SOLUBILITY OF HYDROXYLAMINE HYDROCHLORIDE IN ALCOHOLS (de Bruyn, 1892)

	t°	Gms. $\text{NH}_2(\text{OH}) \cdot \text{HCl}$ per 100 gms. Solvent
Abs. Methanol	19.75	16.4
Aps. Ethanol	19.75	4.43

## $\text{N}_2\text{H}$ IMIDOSULFAMIDE $\text{NH}_2\text{SO}_2\text{NHSO}_2\text{NH}_2$

### SOLUBILITY IN VARIOUS SOLVENTS AT 20° (Kirsanov and Zolotov, 1950)

Solvent	Gms. $\text{NH}_2\text{SO}_2\text{NHSO}_2\text{NH}_2$ per 100 gms. sat. sol.
$\text{H}_2\text{O}$	29.1 - 30.4
Acetone	33.6 - 35.9
Ethanol	8.9 - 9.7
Ethylacetate	4.79
Ethyl ether	0.526
1:3 acetone:benzene	0.64

## NO NITRIC OXIDE NO

### SOLUBILITY IN WATER (Winkler, 1901)

$\beta$  is the Bunsen Absorption Coefficient which shows the volume of gas (reduced to 0° and 760 mm) absorbed by one volume of the liquid when the pressure of the gas less that of the liquid is 760mm.

$\beta'$  is the volume of gas (reduced to 0 and 760mm) which is absorbed by one volume of the liquid when the total pressure is 760 mm.

$q$  is the weight of gas in grams dissolved by 100 gms. of solvent at the indicated temperature and total pressure of 760 mm.

t°	$\beta$	$\beta'$	$q$	t°	$\beta$	$\beta'$	$q$
0	0.0738	0.0734	0.00984	40	0.0351	0.0325	0.00440
5	0.0646	0.0641	0.00860	50	0.0315	0.0277	0.00376
10	0.0571	0.0564	0.00757	60	0.0295	0.0237	0.00324
15	0.0515	0.0506	0.00680	70	0.0281	0.0195	0.00267
20	0.0471	0.0460	0.00618	80	0.0270	0.0144	0.00199
25	0.0430	0.0419	0.00564	90	0.0265	0.0082	0.00114
30	0.0400	0.0384	0.00517	100	0.0263	0.0000	0.00000

## SOLUBILITY OF NITRIC OXIDE IN AQUEOUS SULPHURIC ACID SOLUTIONS

Results at 0°

(Manchot and Reinburger, 1926)

Gms. H <sub>2</sub> SO <sub>4</sub> per 100 gms. sol.	Cc. NO dissolved per		Gms. H <sub>2</sub> SO <sub>4</sub> per 100 gms. sol.	Cc. NO dissolved per	
	100 gms. sol.	100 cc. sol.		100 gms. sol.	100 cc. sol.
0.0	7.38	7.38	76.7	1.8	3.1
8.8	6.5	6.9	78.0	1.9	3.2
18.2	5.2	5.9	88.3	2.0	3.5
28.0	4.5	5.4	89.1	2.1	3.7
38.6	3.8	4.9	90.0	2.3	4.1
48.0	2.9	4.0	90.4	2.4	4.3
52.6	2.4	3.4	91.9	2.4	4.3
58.7	2.2	3.3	92.4	2.5	4.6
66.5	1.9	3.0	95.0	3.8	7.1
70.8	1.9	3.0	95.9	4.2	7.7

NO

Results at 18°

(Lunge, 1885; Tower, 1906)

Wt. % H <sub>2</sub> SO <sub>4</sub> in Solution	Sp. Gr. at 15°	Tension of H <sub>2</sub> O Vapor	Solubility Coefficient* of NO at 18°
98	1.84	--	0.0227 (0.035, L.)
90	1.82	0.1 mm.	0.0193
80	1.733	0.4 "	0.0117
70	1.616	1.5 "	0.0113
60	1.503	3.1 "	0.0118 (0.017, L.)
50	1.399	6.2 "	0.0120

\*Volume of NO (at 760 mm.) per 1 volume of aqueous H<sub>2</sub>SO<sub>4</sub>.Results at 20°

(Pinkus and Jacobi, 1927)

Wt. % H <sub>2</sub> SO <sub>4</sub>	cc NO (at 0° and 760 mm.) per 1.0cc aq. H <sub>2</sub> SO <sub>4</sub>
43.8	0.0136
54.6	0.0125
64.1	0.0096

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### SOLUBILITY OF NITRIC OXIDE IN SULFURIC ACID SOLUTIONS OF NITROSYL SULFURIC ACID (Zeitlin, 1946)

Solvent		Ml. NO (measured at 18°, 760 mm.) Absorbed per ml. of Solvent	
Density at 15°	% N <sub>2</sub> O <sub>3</sub>	40°	70°
1.695	1.18	1.47	1.61
1.697	4.3	6.40	6.20
1.667	1.11	2.85	2.93
1.669	3.86	10.10	10.20

## NO

### SOLUBILITY OF NITRIC OXIDE IN SALT SOLUTIONS

Data for the solubility of nitric oxide in aqueous solutions of FeSO<sub>4</sub>, NiSO<sub>4</sub>, CoSO<sub>4</sub> and MnCl<sub>2</sub> at 20° are given by Usher (1908); Hufner (1907) and Manchot and Zecheulmayer (1906).

The abs. coef.  $\beta$  for NO in sat. sq. NiSO<sub>4</sub> at 20° is 0.0245; for sat. CoSO<sub>4</sub> it is 0.0288 and for sat. aq. MnCl<sub>2</sub> it is 0.0082.

### SOLUBILITY OF NITRIC OXIDE IN METHANOL (Riccoboni, 1941)

The volume of NO absorbed by one volume of methanol was determined at partial pressures of NO ranging from 400 to 1400 mm. At each temperature the volume dissolved was a linear function of the pressure.

Temperature	0°	10°	20°	30°
Ml. NO per ml. CH <sub>3</sub> OH at 1 atm. pressure of NO	0.3635	0.3622	0.3506	0.347

### SOLUBILITY OF NITRIC OXIDE IN ETHANOL (Carius, 1855)

The ethyl alcohol had a density of 0.792 at 20°.

t°	$\beta$	t°	$\beta$
0	0.3161	15	0.2748
5	.2999	20	.2659
10	.2861	25	.2595

### SOLUBILITY OF NITRIC OXIDE IN OTHER ORGANIC SOLVENTS (Klemenc and Spitzer-Neumann, 1929)

$\ell$  = Ostwald coefficient ml gas per ml of solvent, both at the same temperature and pressure.

<u>Benzene</u>		<u>Nitrobenzene</u>		<u>Carbon Tetrachloride</u>	
t°	$\ell$	t°	$\ell$	t°	$\ell$
8.8	0.275	20	0.188	8.8	0.339
14.6	0.284	40	0.190	19.6	0.345
24.6	0.300	60	0.193	34.0	0.375
34.6	0.318	90	0.188		

Data for the Solubility of Nitric Oxide in nitrosyl chloride ( $\text{NOCl}$ ), pentane and in toluene are given by Trantz and Gerwig, 1925.

Results for vapor pressures and the temperature - composition equilibrium in the system  $\text{NO} + \text{NO}_2$  are given by Purcell and Cheesman, 1932.

Data for equilibrium between nitrogen monoxide, dioxide and trioxide, showing the range of existence of  $\text{N}_2\text{O}_3$  in the stoichiometric gas mixture, are given by Abel and Proisl, 1929.

Equilibrium constants for the reaction  $2\text{NO} + \text{O}_2 \rightleftharpoons 2\text{NO}_2$  and the system  $3\text{NO}_2 + \text{H}_2\text{O} \rightleftharpoons 2\text{HNO}_3 + \text{NO}$  at  $0^\circ$  are given by Epstein (1939).

Freezing-point data are given for mixtures of:

Nitric Oxide + Methyl Ether (Baume and Germann, 1914.)  
 " " + Brom benzene (Pascal and Garnier, 1923.)  
 " " + Nitrogen Tetroxide ( $\text{NO}_2$ ) (v. Wittorff, 1904.)

## NITROGEN DIOXIDE $\text{NO}_2$

## NITROGEN TETROXIDE $\text{N}_2\text{O}_4$

## NITROGEN TRIOXIDE $\text{N}_2\text{O}_3$

### SYSTEMS WITH WATER

Results for the temperatures of the freezing-points and the region of separation into two liquid layers in the system  $\text{N}_2\text{O}_3 + \text{H}_2\text{O}$  and the pseudo binary system  $\text{N}_2\text{O}_4 + \text{H}_2\text{O}$  are given by Lowry and Lemon, 1936. Similar results for the formation of two liquid layers in mixtures of nitrogen peroxide and water ( $\text{N}_2\text{O}_4 + \text{H}_2\text{O}$ ) are given by Lowry, Lloyd and Lloyd, 1936.

Results for the solubility of nitrogen tetroxide in aqueous ferrous bromide solutions are given by Thomas, 1896.

5 cc. of  $\text{NO}_2$  dissolve in 1 cc. of  $\text{H}_2\text{SO}_4$  containing 7.2-8.3%  $\text{HNO}_3$  at room temperature. (Kirichenko, 1940).

Freezing points have been determined for the following:

$\text{NO}_2$ + Sulfur Dioxide ( $\text{SO}_2$ )	Terres and Constantinescu, 1934.)
$\text{N}_2\text{O}_4$ + Bromoform ( $\text{CHBr}_3$ )	(Pascal, 1923.)
" + Chloroform ( $\text{CHCl}_3$ )	" "
" + Methyl Iodide ( $\text{CH}_3\text{I}$ )	" "
" + Carbon Tetrachloride ( $\text{CCl}_4$ )	" "
" + Nitro Trichlor Methane ( $\text{CCl}_3\text{NO}_2$ )	" "
" + Brom benzene ( $\text{C}_6\text{H}_5\text{Br}$ )	" "
" + 2,4,6 Tri nitro toluene ( $\text{C}_6\text{H}_2\text{CH}_3(\text{NO}_2)_3$ )	(Pascal, 1923.)
" + o Nitro toluene ( $\text{C}_6\text{H}_4\text{CH}_3\text{NO}_2$ )	(Breithaupt.)
" + Camphor ( $\text{C}_{10}\text{H}_{16}\text{O}$ )	(Pascal, 1923; Pascal and Garnier, 1923.)
" + Diethylether	(Rubin, Sisler and Shechter, 1952)
" + Tetrahydro furan	( " " )
" + Dioxane	( " " )
" + Dichloro diethyl ether	( " " )

(Cont.)



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### Freezing Points--Cont.

$N_2O_4$ + Diethyl nitrosamine	(Addison, Conduit and Thompson, 1951)
" + nitromethane	(Addison, Hodge and Lewis, 1953)
$N_2O_4$ + $N_2O_3$	(Baume and Robert, 1919; Whittaker, Sprague, Skolnik and Smith)
$N_2O_4$ + $H_2O_5$	(Lowry and Lemon, 1935)
$N_2O_4$ + $HNO_3$	(Berl and Saenger, 1929)

## NO NITROSYL CHLORIDE NOCl

Melting points for the system NOCl - diethylnitrosamine are given by Addison, Conduit and Thompson, 1951

## NO NITROSYL SULFURIC ACID $HO \cdot SO_2 \cdot O \cdot NO$

SOLUBILITY OF NITROSYL SULFURIC ACID IN STRONG SOLUTIONS OF SULFURIC ACID  
(Elliott, Kleist, Wilkins and Webb, 1926)

Constant agitation in a thermostat was employed.

t°	Gms. $HO \cdot SO_2 \cdot O \cdot NO$ per 100 gms. sat. solution in aq. $H_2SO_4$ of						
	56.7 %	62.1 %	73.1 %	74.9 %	84.1 %	90.4 %	99.8 %
0	-	11.9	17.3	19.7	30.5	35.1	-
20.9	19.3	22.6	27.0	31.4	42.4	49.2	62.0
37.3	29.9	34.3	39.4	40.8	50.2	58.5	66.1
49.6	35.6	39.3	46.4	46.2	56.5	61.6	67.8

## NO NITROUS OXIDE $N_2O$

### SOLUBILITY IN WATER

cc. $N_2O$  dissolved in 1cc. $H_2O$ , both at the same temperature and pressure (Ostwald solubility coefficient)

t°	Carius 1855	Geffcken 1904	Kunerth 1922	others
0	1.305	-	-	1.297(0.2, Markham and Kobe, 1941)
5	1.095	1.067	-	
10	0.920	0.9101	-	
15	0.778	0.7784	-	
18	-	-	0.703	
20	0.670	0.6756	0.675	0.6739 (Knopp, 1904)
22	-	-	0.638	
24	-	-	0.617	
25	0.596	0.5942	-	0.599 (Orcutt and SeEVERS, 1937) 0.588 (Markham and Kobe, 1941)
26	-	-	0.587	
28	-	-	0.561	
30	-	-	0.530	
32	-	-	0.513	
34	-	-	0.478	
36	-	-	0.449	
40	-	-	-	0.411 (Markham and Kobe, 1941)

Mannheimer, 1956 reports the compositions of two liquid layers in the system  $\text{N}_2\text{O} - \text{H}_2\text{O}$  at  $26^\circ$  to be 96.0 %  $\text{H}_2\text{O}$  in one phase and 0.51 %  $\text{H}_2\text{O}$  in the other

# SOLUBILITY OF NITROUS OXIDE ( $\text{N}_2\text{O}$ ) IN AQUEOUS SOLUTIONS OF ACIDS AT $25^\circ$

The Bunsen Coefficient  $\beta$  is the volume of gas (reduced to  $0^\circ$  and 760 mm pressure) absorbed by one volume of the solvent when the partial pressure of the gas equals 760 mm mercury.

Acid	$d_{25}$ of aq. acid	Gms. acid per 100 cc. sol.	Abs. coef. $\beta$ per 100 cc. sol.	Acid	$d_{25}$ of aq. acid	Gms. acid per 100 cc. sol.	Abs. coef. $\beta$ per 100 cc. sol.	NO
$\text{HNO}_3$	1.0351	6.932	54.1	$\text{H}_2\text{SO}_4$	1.0680	11.084	44.2	
"	1.0731	14.242	55.1	"	1.1630	26.974	38.7	
"	1.1191	22.938	56.2	"	1.2687	45.415	38.2	
$\text{HCl}$	1.0168	3.9387	51.2	"	1.3363	58.853	39.9	
"	1.0335	7.7318	50.1					
"	1.0741	16.703	49.9	$\text{H}_3\text{PO}_4$	1.0593	11.473	46.4	
"	1.1050	23.706	52.1	"	1.0964	18.631	43.8	
$\text{HIO}_4$	1.1740	20.421	38.7	"	1.2557	49.520	35.3	
"	1.4066	47.023	23.8					

# SOLUBILITY OF NITROUS OXIDE IN AQUEOUS SULPHURIC ACID (Lunge - Ber. 14, 2188, '81; see also Geffcken's results.)

Sp. Gr. of $\text{H}_2\text{SO}_4$	1.84	1.80	1.705	1.45	1.25
Vols. $\text{N}_2\text{O}$ dissolved by 100 vols. $\text{H}_2\text{SO}_4$	75.7	66.0	39.1	41.6	33.0

100 vols. of KOH solution of 1.12 Sp. Gr. absorb 18.7 vols.  $\text{N}_2\text{O}$ .  
100 vols. of NaOH solution of 1.10 Sp. Gr. absorb 23.1 vols.  $\text{N}_2\text{O}$ .

# SOLUBILITY OF NITROUS OXIDE IN AQUEOUS SOLUTIONS OF ACIDS (Geffcken)

Results in terms of the Ostwald Solubility Expression ( $\ell$ ).

Gms. HCl per Liter	$\text{N}_2\text{O}$ Dissolved		Gms. $\text{HNO}_3$ per Liter	$\text{N}_2\text{O}$ Dissolved		Gms. $\text{H}_2\text{SO}_4$ per Liter	$\text{N}_2\text{O}$ Dissolved	
	$\ell_{15}$	$\ell_{25}$		$\ell_{15}$	$\ell_{25}$		$\ell_{15}$	$\ell_{25}$
18.22	0.755	0.577	36.52	0.777	0.597	24.52	0.734	0.566
36.45	0.738	0.568	63.05	0.777	0.602	49.04	0.699	0.543
72.90	0.716	0.557	126.10	0.775	0.611	98.08	0.645	0.509
						147.12	0.602	0.482
						196.16	0.562	0.463

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## SOLUBILITY OF NITROUS OXIDE IN AQUEOUS SOLUTIONS OF: (Roth)

t°	Phosphoric Acid					Oxalic Acid	
	Coefficient of Abs. in H <sub>3</sub> PO <sub>4</sub> Solutions of:					Coefficient of Abs. in (COOH) <sub>2</sub> Solutions of:	
	3.38%	4.72%	8.84%	9.89%	13.35%	0.812%	3.70%
5	1.057	1.0365	0.9883	0.9635	0.9171	1.1450	1.1094
10	0.8827	0.8665	0.8296	0.8101	0.7711	0.9526	0.9264
15	0.7388	0.7258	0.6977	0.6826	0.6505	0.7940	0.7745
20	0.6253	0.6147	0.5926	0.5810	0.5555	0.6694	0.6538
25	0.5427	0.5329	0.5143	0.5054	0.4860	0.5784	0.5643

## SOLUBILITY OF NITROUS OXIDE IN AQUEOUS SOLUTIONS OF SALTS

$\alpha$  or  $\beta$  = ML. N<sub>2</sub>O (measured at 0°, 760 mm.) dissolved in 1 ml. of solution (Bunsen absorption coefficient).

$\lambda$  = ML.N<sub>2</sub>O (measured at t° and p of experiment) dissolved in 1 ml of solution (Ostwald coefficient)

### Results by Gordon in terms of coefficient of absorption

Salt	Concentration of Salt		Coefficient of Absorption of N <sub>2</sub> O $\beta$ at			
	Grams per 100 Grams Solution	Gram Mols. per Liter				
			5°	10°	15°	20°
Calcium Chloride	5.79	0.547	0.819	0.697	0.591	0.500
"	9.86	0.364	0.668	0.586	0.509	0.435
"	13.99	1.416	0.510	0.441	0.380	0.328
Lithium Chloride	1.35	0.319	0.986	0.831	0.700	0.594
"	3.85	0.928	0.878	0.743	0.629	0.536
"	11.48	2.883	0.606	0.512	0.437	0.382
Lithium Sulphate	2.37	0.219	0.934	0.792	0.670	0.569
"	5.46	0.521	0.795	0.665	0.557	0.474
"	8.56	0.836	0.646	0.555	0.477	0.415
Magnesium Sulphate	5.90	0.521	0.766	0.664	0.561	0.471
"	7.66	0.687	0.708	0.586	0.488	0.414
"	10.78	0.997	0.569	0.491	0.417	0.346
Potassium Chloride	4.90	0.676	0.879	0.751	0.643	0.555
"	7.64	1.037	0.799	0.693	0.591	0.494
"	14.58	2.147	0.654	0.574	0.500	0.430
"	22.08	3.414	0.544	0.459	0.390	0.339
Potassium Sulphate	2.62	0.154	0.986	0.831	0.701	0.605
"	4.78	0.285	0.918	0.763	0.637	0.542
Sodium Chloride	6.20	1.107	0.800	0.682	0.585	0.509
"	8.88	1.614	0.713	0.603	0.510	0.434
"	12.78	2.391	0.634	0.532	0.449	0.386
Sodium Sulphate	5.76	0.427	0.808	0.677	0.584	0.495
"	8.53	0.646	0.692	0.574	0.482	0.416
"	12.44	0.974	0.559	0.486	0.417	0.354
Strontium Chloride	3.31	0.215	0.928	0.788	0.671	0.578
"	5.73	0.380	0.848	0.709	0.610	0.550
"	13.24	0.939	0.644	0.547	0.463	0.390

(Cont.)

## SOLUBILITY OF NITROUS OXIDE IN AQUEOUS SOLUTIONS OF SALTS—Cont.

$\alpha$  or  $\beta$  = Ml.  $N_2O$  (measured at  $0^\circ$ , 760 mm.) dissolved in 1 ml. of solution (Bunsen absorption coefficient).

$\bar{\alpha}$  = Ml.  $N_2O$  (measured at  $t^\circ$  and  $p$  of experiment) dissolved in 1 ml of solution (Ostwald coefficient)

Results by Knopp, in terms of the coefficient of absorption  $\beta$ 

Salt	Formula	Conc. of Salt per Liter		Coef. of Absorption of $N_2O$ at $20^\circ$
		Normality	Grams	
Potassium Nitrate	$KNO_3$	0.1061	10.74	0.6173
"	"	0.2764	27.94	0.6002
"	"	0.5630	56.97	0.5713
"	"	1.1683	118.2	0.5196
Sodium Nitrate	$NaNO_3$	0.1336	11.37	0.6089
"	"	0.3052	25.97	0.5876
"	"	0.6286	53.50	0.5465
"	"	1.1200	95.30	0.4926

Results of (Manchot, Jahrstorfer and Zepter, 1924) at  $25^\circ$ 

Salt	$d_{25}$ of salt solution	Gms. anhy. salt per 100 cc. solution	Abs. coef. $\beta$ for 100 cc. solution
None (=H <sub>2</sub> O)	-	0.0	53.14
$NH_4Cl$	1.0146	5.724	46.6
"	1.0312	12.037	41.1
"	1.0594	23.005	34.7
KCl	1.0334	5.8157	45.3
"	1.0540	9.3200	41.0
"	1.0850	14.763	35.5
"	1.1385	23.934	28.1
"	1.1734	30.123	24.0
NaCl	1.0438	6.723	39.0
"	1.0874	13.504	28.5
"	1.1600	25.255	17.2
$CaCl_2$	1.0786	10.322	33.9
"	1.1655	22.087	20.2
$BaCl_2$	1.1090	12.914	37.4
"	1.2290	27.348	26.1
$NH_4Br$	1.0535	10.225	47.4
"	1.1088	20.745	42.3
"	1.2122	40.803	35.8
KBr	1.0891	13.211	43.0
"	1.1752	25.590	35.1
"	1.3380	49.696	24.7
NaBr	1.0849	11.578	40.1
"	1.1645	22.334	30.9
"	1.3338	45.902	17.8
$NH_4NO_3$	1.0249	7.125	49.8
"	1.0527	14.809	46.4
"	1.1040	29.058	40.9
"	1.2116	54.236	30.8
$KNO_3$	1.0586	10.313	44.8

(Cont.)

# N NITROGEN

## SOLUBILITY OF NITROUS OXIDE IN AQUEOUS SOLUTIONS OF SALTS--Cont.

$\alpha$  or  $\beta$  = Ml.  $N_2O$  (measured at  $0^\circ$ , 760 mm.) dissolved in 1 ml. of solution (Bunsen absorption coefficient).

$\bar{\alpha}$  = Ml.  $N_2O$  (measured at  $t^\circ$  and  $p$  of experiment) dissolved in 1 ml. of solution (Ostwald coefficient)

Results of (Manhot, Jahrstorfer and Zepter, 1924) at  $25^\circ$ --Cont.

	Salt	$d_{25}$ of 4 salt solution	Gms. anhy. salt per 100 cc. solution	Abs. coef. $\beta$ for 100 cc. solution
0	$KNO_3$	1.1231	21.739	38.3
	$NaNO_3$	1.0560	9.181	42.3
	"	1.0677	11.136	40.3
	"	1.1141	18.447	33.5
	"	1.1543	25.588	27.7
	"	1.2152	35.704	21.6
	$Mg(NO_3)_2$	1.0935	14.389	39.2
	"	1.1846	28.630	28.5
	$Ca(NO_3)_2$	1.1503	22.398	32.2
	"	1.2927	44.796	19.4
	$Zn(NO_3)_2$	1.1223	15.909	39.7
	"	1.2433	31.818	29.1
	$Cd(NO_3)_2$	1.1435	18.465	35.0
	"	1.2874	36.93	27.0
	$Cu(NO_3)_2$	1.1028	12.944	35.6
	"	1.2049	25.888	27.8
	$Al(NO_3)_3$	1.0703	10.22	36.1
	"	1.1414	20.44	29.3
	$(NH_4)_2SO_4$	1.0896	17.786	27.1
	"	1.1393	28.807	17.5
	$K_2SO_4$	1.0762	10.440	35.5
	$Na_2SO_4$	1.0550	6.600	36.5
	"	1.1141	13.879	24.8
	$MgSO_4$	1.0992	10.835	29.5
	"	1.1925	21.430	15.9
	$ZnSO_4$	1.1403	15.337	29.9
	"	1.2699	29.705	16.9
	$MnSO_4$	1.226	14.194	30.6
	"	1.2460	29.143	17.0
	$FeSO_4$	1.1017	10.938	34.0
	"	1.2011	21.845	21.6
	$CoSO_4$	1.1131	12.217	27.5
	"	1.2218	24.433	17.1
	$NiSO_4$	1.1355	14.499	24.6
	"	1.2642	28.998	13.8
	$Al_2(SO_4)_3$	1.1558	17.688	22.4
	"	1.2381	27.875	13.4
	$Fe_2(SO_4)_3$	1.2240	26.390	25.9
	"	1.4319	52.781	13.1
	$Cr_2(SO_4)_3$	1.1657	22.356	31.8
	"	1.3280	44.712	18.2
	$Na_2HPO_4$	1.0470	5.661	37.6
	$Na_3PO_4$	1.0348	3.6088	40.7
	$KIO_4$	1.0008	0.3608	52.1

(Cont.)

## SOLUBILITY OF NITROUS OXIDE IN AQUEOUS SOLUTIONS OF SALTS--Cont.

$\alpha$  or  $\beta$  = Ml.  $N_2O$  (measured at  $0^\circ$ , 760 mm.) dissolved in 1 ml. of solution (Bunsen absorption coefficient).

$\ell$  = Ml.  $N_2O$  (measured at  $t^\circ$  and  $p$  of experiment) dissolved in 1 ml of solution (Ostwald coefficient)

Results by Geffcken in terms of the Ostwald expression ( $\ell$ )

Salt	Formula	Conc. of Salt per Liter		Solubility of $N_2O$	
		Gram Equiv.	Grams	$\ell_{15}$	$\ell_{25}$
Ammonium Chloride	$NH_4Cl$	0.5	26.76	0.730	0.557
Ammonium Chloride	$NH_4Cl$	1.0	53.52	0.691	0.529
Caesium Chloride	$CsCl$	0.5	84.17	0.710	0.544
Lithium Chloride	$LiCl$	0.5	21.24	0.697	0.535
Lithium Chloride	$LiCl$	1.0	42.48	0.623	0.483
Potassium Bromide	$KBr$	0.5	59.55	0.697	0.536
Potassium Bromide	$KBr$	1.0	119.11	0.627	0.485
Potassium Chloride	$KCl$	0.5	37.3	0.686	0.527
Potassium Chloride	$KCl$	1.0	74.6	0.616	0.475
Potassium Iodide	$KI$	0.5	83.06	0.702	0.541
Potassium Iodide	$KI$	1.0	166.12	0.633	0.492
Potassium Hydroxide	$KOH$	0.5	28.08	0.668	0.514
Potassium Hydroxide	$KOH$	1.0	56.16	0.559	0.436
Rubidium Chloride	$RbCl$	0.5	60.47	0.695	0.533
Rubidium Chloride	$RbCl$	1.0	120.95	0.625	0.483

## Results by Roth, in terms of the coefficient of absorption

Grams NaCl per 100 Grams Solution	Coefficient of Absorption of $N_2O$ $\beta$ at:				
	$5^\circ$	$10^\circ$	$15^\circ$	$20^\circ$	$25^\circ$
0.99	1.0609	0.8812	0.7339	0.0191	0.5363
1.808	1.0032	0.8383	0.7026	0.6962	0.5190
3.886	0.9131	0.7699	0.6495	0.5520	0.4775
5.865	0.8428	0.7090	0.5976	0.5088	0.4424

## Results of Markham and Kobe, 1941

$S$  = Ml.  $N_2O$  (measured at  $0^\circ$ , 760 mm.) dissolved in that volume of solution which contains one gram of water.

Moles Added Salt per 1000 gms. $H_2O$	$KCl$		$NaCl$		$KNO_3$	
	$\beta$	$S$	$\beta$	$S$	$\beta$	$S$
$0.2^\circ$						
0.2					1.2183	1.2267
0.5					1.1355	1.1556
1	0.9880	1.0140	0.9178	0.9327	1.0174	0.0545
2	.7784	0.8212	.6675	.6902		
3	.6349	.6893	.5053	.5330		

(Cont.)

# N NITROGEN

## SOLUBILITY OF NITROUS OXIDE IN AQUEOUS SOLUTIONS OF SALTS—Cont.

S = ml.  $N_2O$  (measured at  $0^\circ$ , 760 mm.) dissolved in that volume of solution which contains one gram of water.

Moles Added Salt per 1000 gms. $H_2O$	KCl		NaCl		$KNO_3$	
	$\beta$	S	$\beta$	S	$\beta$	S
<u>25°</u>						
1	0.4329	0.4466	0.4026	0.4127	0.4552	0.4749
2	.3580	.3803	.3166	.3299	.3961	.4299
3	.3030	.3315	.2502	.2662	.3524	.3978
<u>40°</u>						
1	.2885	.2995	.2719	.2797	.3100	.3254
2	.2416	.2613	.2181	.2288	.2761	.3018
3	.2077	.2286	.1743	.1866	.2475	.2814
<u>0.2°</u>						
0.5	$Mg(NO_3)_2$		$MgSO_4$		$Na_2SO_4$	
	$\beta$	S	$\beta$	S	$\beta$	S
1	1.0139	1.0316	0.8778	0.8777		
2	0.7921	0.8215	.6019	.6039		
3	.5238	.5664	.2771	.2820		
0.5	.3618	.4079				
<u>25°</u>						
0.5	.4488	.4593	.3840	.3858	0.3565	0.3612
1	.3850	.4023	.2790	.2816	.2476	.2547
2	.2785	.3042	*.1442	.1478	.1721	.1797
3	.2104	.2403				
<u>40°</u>						
0.5	.3061	.3150	.2612	.2638	.2425	.2472
1	.2620	.2756	.1945	.1969	.1722	.1791
2	.1989	.2188	*.1018	.1049	.1226	.1297
3	.1556	.1793				

\*1.5 Molal salt solutions

The authors also present empirical equations expressing their results.

## SOLUBILITY OF NITROUS OXIDE IN AQUEOUS SOLUTIONS OF ORGANIC COMPOUNDS

In Propionic Acid Solutions at 20°

(Knopp)

Gms. $C_2H_5COOH$ per liter	15.15	60.42	158.4	176.6	344.0
Coef. of Absorp- tion of $N_2O$	0.6323	0.6369	0.6504	0.6534	0.7219

In glycerol solutions

(Roth, 1897)

(Henkel, 1905, 1912)

t°	Coefficient of Absorption of $N_2O$ in Glycerol Solutions of:				Results at 15°		Results at 20°	
	3.46	6.73	12.12	16.24	Per	Ab-	Per	Ab-
	Per	Per	Per	Per	cent	sorp-	cent	sorp-
	cent	cent	cent	cent	Gly-	tion	Gly-	tion
					cerol	Coef.	cerol	Coef.
5	1.097	1.055	0.999	0.959	0	0.7327	0	0.6288
10	0.917	0.887	0.841	0.810	2.49	0.7181	2.36	0.6131
15	0.767	0.745	0.710	0.686	3.28	0.7103	4.88	0.5993
20	0.647	0.630	0.605	0.585	7.17	0.6844	6.88	0.5903
25	0.556	0.542	0.527	0.508	10.52	0.6668	9.86	0.5633
					14.05	0.6410	15.82	0.5315
					17.08	0.6220		

In urea solutions

(Roth, 1897)

(Manchot, Jahrstorfer and  
Zepter, 1924)

t°	Coefficient of Absorption of $N_2O$ in Urea Solutions of:					$d_{25}$ of aq. sol. of Urea	Mol. $CO(NH_2)_2$ per 1000 cc. sol.	Ab. coef. a per 100 cc. sol.
	3.31%	4.07%	6.37%	7.30%	9.97%			
5	1.104	1.096	1.088	1.101	1.069	1.0134	0.97	51.0
10	0.921	0.920	0.909	0.921	0.901	1.0287	1.95	49.2
15	0.771	0.773	0.761	0.772	0.761	1.0619	4.05	46.3
20	0.653	0.656	0.644	0.655	0.651	1.005	5.89	44.5
25	0.569	0.567	0.570	0.569				

In Chloral Hydrate Solutions

(Knopp, 1904)

Normality of $C_2HCl_3O \cdot H_2O$	Gms. $C_2HCl_3O \cdot H_2O$ per Liter	Coef. of Abs. of $N_2O$
0.184	30.43	0.618
0.445	73.60	0.613
0.942	155.8	0.596
1.165	192.7	0.589
1.474	243.8	0.579
1.911	316.4	0.567



SOLUBILITY OF NITROUS ACID IN WATER AND IN ORGANIC SOLVENTS  
(Kunerth, 1922)

An apparatus similar to that of Mc Daniel (J. Phys. Chem., 15, 587, 1911) was used. The  $N_2O$  was frozen by means of liquid air and ethyl alcohol and all other gases pumped off. The  $N_2O$  sublimed from the frozen gas was dried over  $P_2O_5$ . Its density was found to be 1.968 gms. per liter at standard temp. and pressure. In the present determinations the  $N_2O$  was sat. with the vapor of the solvent before being shaken with the solvent for the solubility determination. Hence it was not necessary to allow for the vapor pressure of the solvent.

Sol- vent	Cc. $N_2O$ dissolved per 1 cc. solvent (both at same temp. and pressure) at:									
	18°	20°	22°	24°	26°	28°	30°	32°	34°	36°
(1)	0.703	0.675	0.638	0.617	0.587	0.561	0.530	0.513	0.478	0.449
(2)	6.30	6.03	5.78	5.50	5.21	4.84	4.46	4.07	3.66	3.26
(3)	5.00	4.85	4.70	4.55	4.39	4.25	4.11	3.98	3.84	3.75
(4)	-	3.58	3.50	3.45	3.34	3.25	3.17	3.10	3.02	2.94
(5)	3.38	3.32	3.27	3.23	3.19	3.07	2.98	2.88	-	-
(6)	3.07	2.99	2.91	2.85	2.77	2.68	2.61	2.52	2.43	2.33
(7)	3.23	3.15	3.07	3.00	2.93	2.85	2.78	2.72	2.65	2.57
(8)	1.50	1.48	1.45	1.42	1.40	1.37	1.35	1.32	1.31	1.28
(9)	5.24	5.14	5.05	4.93	4.83	4.71	4.60	4.49	4.39	4.30
(10)	2.87	2.81	2.75	2.69	2.64	2.58	2.52	2.46	2.42	2.37
(11)	2.52	2.47	2.43	2.37	2.32	2.27	2.24	2.19	2.16	2.12
(12)	5.70	5.60	5.51	5.26	5.07	4.83	4.57	4.29	4.03	3.70
(1)	Water.		(5)	Methyl Alcohol.		(9)	Amyl Acetate.			
(2)	Acetone. <sup>a</sup>		(6)	Ethyl Alcohol. <sup>c</sup>		(10)	Ethylene Bromide.			
(3)	Acetic acid.		(7)	Benzaldehyde.		(11)	Iso Amyl Alcohol.			
(4)	Pyridine.		(8)	Aniline.		(12)	Chloroform.			

<sup>a</sup>See data of Horiuti, below

<sup>c</sup>see data of Carius, below

SOLUBILITY OF NITROUS OXIDE IN SEVERAL ORGANIC SOLVENTS  
(Horiuti, 1928, 1931)

The author also gives results for the coefficient of dilation of  $N_2O$  in these solvents at 25°.

t°	cc $N_2O$ per 1cc solvent (Ostwald Solubility Expression <sup>l</sup> ) in:				
	Carbon Tetrachloride	Chloro Benzene	Benzene	Acetone	Methyl Acetate
- 1.4	-	-	-	9.30	-
+10	5.26	3.891	4.453	7.64	8.035
15	4.89	3.638	-	-	-
20	4.57	3.382	-	-	-

(Cont.)

## SOLUBILITY OF NITROUS OXIDE IN SEVERAL ORGANIC SOLVENTS—Cont.

cc N<sub>2</sub>O per 100 solvent (Ostwald Solubility Expression *l*) in:

t°	Carbon Tetrachloride	Chloro Benzene	Benzene	Acetone	Methyl Acetate
25	4.285	3.174	3.686	5.95	6.27
30	4.005	2.981	-	-	-
35	3.775	2.801	-	-	-
40	3.565	2.650	3.123	4.73	4.95
45	-	2.520	-	-	-
50	-	2.400	-	-	-
55	-	2.279	-	-	-

<sup>b</sup>see data of Kunerth, above

0

Results of Carius, 1855 in Ethanol

(see data of Kunerth, above)

t°	Vols. N <sub>2</sub> O (at 0° and 760 mm.) per 1 Vol. Alcohol
0	4.178
5	3.844
10	3.541
15	3.268
20	3.025
24	2.853
25	2.813

One liter cyclohexanol (C<sub>6</sub>H<sub>11</sub>OH) dissolve 235.84 cc Nitrous oxide (N<sub>2</sub>O) at 26° and 766mm pressure. Cauquil, 1927.

In Petroleum  $\beta$  = 2.49 at 10°, 2.11 at 20° (Oniewasz and Walfisz, 1887)

The solubility of nitrous oxide in olive and sesame oils from 17 to 37° was determined by Meyer and Gottlieb-Billroth, 1921.

## SOLUBILITY OF NITROUS OXIDE IN HUMAN BLOOD

t°	(ml. N <sub>2</sub> O 0°, 760 mm. per ml. Blood)	
38	0.417	Siebeck (1909)
37.5	.416	Orcutt and SeEVERS (1937)
37.5	.415	Cullen and Cook (1948)

For additional results see Findlay and Creighton, 1910-1922.

Data for the influence of colloids and fine suspensions on the solubility of nitrous oxide in water at 25° are given by Findlay and Creighton (1910), and Findlay and Howell (1914).

## N NITROGEN

Results for solutions of ferric hydroxide, dextrin, arsenious sulfide, starch, gelatin, glycogen, egg albumen, serum albumen, silicic acid and suspensions of charcoal and of silica are given.

Data for the solubility of  $N_2O$  in liquid  $NO_2$  are given by Rocker, 1952.

## Na SODIUM

### SOLUBILITY OF SODIUM IN AMMONIA (Kraus and Lucasse, 1922)

t°	Mol. % Na	t°	Mol. % Na	t°	Mol. % Na	t°	Mol. % Na
-59.7	1.62	-47.5	2.50	-41.7	3.83	-44.4	5.47
-55.9	1.81	-46.4	2.64	-41.6	4.18	-47.4	6.27
-51.9	2.09	-44.6	2.87	-41.8	4.46	-51.0	7.09
-48.6	2.38	-42.8	3.18	-42.5	4.97	-60.0	8.34

### (Results of Ruff and Geisel, 1906)

t°	Mols. $NH_3$ Required to Dissolve 1 Gm. Atom Na.	t°	Mols. $NH_3$ Required to Dissolve 1 Gm. Atom Na.
-105	4.98	- 30	5.52
- 70	5.20	0	5.87
- 50	5.39	+ 22	6.14

The eutectic temperature in the system Sodium - Ammonia is about  $-110^\circ$ . (Birch and MacDonald, 1947).

### SOLUBILITY OF SODIUM IN MELTED SODIUM HYDROXIDE (von Hevesy, 1909)

t°	480°	600°	610°	670°	760°	800°
Gms. Na per 100 Gms. NaOH	25.3	10.1	9.9	9.5	7.0	6.9

Saturation could not be reached at temperatures below  $480^\circ$ . The saturated mixtures were cooled by plunging the container in water and the solidified contents analyzed.

SOLUBILITY OF SODIUM IN MELTED SODIUM HYDROXIDE CONTAINING OTHER  
METALS AT 480°  
(von Heveey, 1909)

Added Metal	Gms. Added Metal per 100 Gms. NaOH	Gms. Dissolved Na per 100 Gms. Solvent
Thallium	5.40	23.13
"	8.30	23.54
"	12.42	21.29
"	31.37	20.91
Cadmium	2.87	24.34
"	3.16	24.29
Gold	6.03	23.92
"	8.22	23.39
Zinc	30.37	25.38

Phase diagrams for the systems Na + NaCl, Na + NaBr, Na + NaF, and Na + NaI are given by Bredig, Johnson and Smith, 1955.

Cubicciotti (1949) studied the system Na - NaI - NH<sub>3</sub> at -33°. Two liquid layers are formed, and Na + NaI are miscible in all proportions only when the mole fraction of NH<sub>3</sub> is greater than 0.97.

Sienko, 1949 found that the addition of NaI to mixtures of Na + NH<sub>3</sub> increased the miscibility of the compounds.

SODIUM ALUMINATES  $x\text{Na}_2\text{O} \cdot y\text{Al}_2\text{O}_3 \cdot z\text{H}_2\text{O}$

A10

THE SYSTEM  $\text{Na}_2\text{O} - \text{Al}_2\text{O}_3 - \text{H}_2\text{O}$

Sprauer and Pearce, 1940 at 25°

In agreement with the data of Jucatis, 1934, below.

Gms. per 100 gms. Sat. Sol.

$\text{Na}_2\text{O}$	$\text{Al}_2\text{O}_3$	Solid Phase
38.5	0.65	$\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 2.5\text{H}_2\text{O} + 3\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{H}_2\text{O}$
36.0	0.97	$\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 2.5\text{H}_2\text{O}$
28.8	2.16	"
26.0	6.05	"
21.1	15.5	"
20.9	23.6	$\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 2.5\text{H}_2\text{O} + \text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$
20.1	23.4	"
18.6	9.7	$\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$

Results of Jucatis, 1934 at 30°

The mixtures were prepared from crystalline  $\text{Al}(\text{OH})_3$ , pure NaOH and  $\text{H}_2\text{O}$ . They were shaken continually for some 3 months. The saturated solutions and moist residues were analyzed and the composition of the solid phase identified by plotting according to the Schreinemaker method. The original results were plotted and the following values read from the curve.

# Na SODIUM

## THE SYSTEM $\text{Na}_2\text{O} - \text{Al}_2\text{O}_3 - \text{H}_2\text{O}$ --Cont.

Results of Jucatis, 1934 at 30°--Cont.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
21.3	22.0	$\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 2\frac{1}{2}\text{H}_2\text{O}$	37.5	1.0	$\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 2\frac{1}{2}\text{H}_2\text{O}$
21.7	16.0	"	37.7	1.4	" + $3\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{H}_2\text{O}$
22.3	12.0	"	38.0	0.9	$3\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{H}_2\text{O}$
23.5	8.0	"	39.5	0.5	"
26.7	4.0	"	40.5	0.4	"
30.0	2.2	"	42.0	0.3	"
35.0	0.9	"	43.0	0.3	"
36.5	0.7	"	44.7	1.0	"

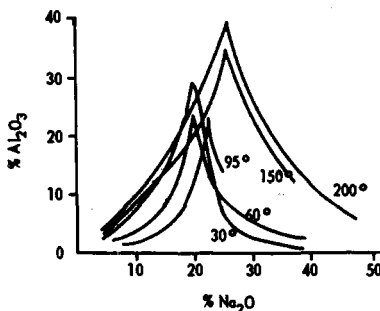
AlO

Results at 30° not in agreement with these are given by Goudriaan, 1922.

Results of Vol'f and Kuznetsov, 1953, 1955 at various temperatures:

Compositions of saturated solutions in wt. %. Solutions in columns headed 5.5, 9.5, 12 and 20 were prepared by adding  $\text{Al}_2\text{O}_3$  to  $\text{Na}_2\text{O}$  solutions of these concentrations.

t°	5.5		9.6		12		20	
	$\text{Na}_2\text{O}$	$\text{Al}_2\text{O}_3$	$\text{Na}_2\text{O}$	$\text{Al}_2\text{O}_3$	$\text{Na}_2\text{O}$	$\text{Al}_2\text{O}_3$	$\text{Na}_2\text{O}$	$\text{Al}_2\text{O}_3$
30	5.4	0.9	9.40	1.70	11.6	2.4	17.90	6.60
45	-	-	9.06	3.50	-	-	16.89	9.08
60	5.3	2.1	9.00	4.00	11.0	5.15	16.70	10.70
60	-	-	8.71	6.58	-	-	15.95	14.21
95	5.15	3.7	8.60	6.90	10.4	7.6	15.80	15.30
105	5.1	4.2	-	-	10.2	9.3	15.1	15.1
110	5.1	4.6	-	-	10.2	9.4	15.0	15.8
115	5.1	4.7	-	-	10.2	10.0	15.0	15.6
120	-	-	{ 8.56 8.01 }	-	-	-	{ 14.99 16.61 }	-
			{ 8.40 8.20 }	-			{ 14.82 16.45 }	
130	-	-	{ 8.00 8.41 }	-	-	-	14.85	16.82
			{ 8.25 8.25 }					



Graph drawn by Vol'f and Kuznetsov, 1953. Other graphical results are shown in this and in the 1955 paper

For data on the system  $\text{Na}_2\text{O} - \text{Al}_2\text{O}_3 - \text{SiO}_2 - \text{H}_2\text{O}$  at high temperatures and pressures, see Friedman, 1951 and Barrer and White, 1952.

At 25°, 3.57 gms. sodium aluminate dissolve in 100 gms. ethylene glycol.

At 25°, 0.36 gms. sodium aluminate dissolve in 100 gms. propylene glycol. (Palit, 1947)

Melting points in the system  $\text{NaAlO}_2 - \text{NaFeO}_2$  are given by Toropov and Shisacov, 1939.

# SODIUM ARSENITES $x\text{Na}_2\text{O} \cdot y\text{As}_2\text{O}_3 \cdot z\text{H}_2\text{O}$

AsO

## THE SYSTEM $\text{Na}_2\text{O} - \text{As}_2\text{O}_3 - \text{H}_2\text{O}$

### Results at 25°

(Schreinemakers and de Baat, 1917)

Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
$\text{As}_2\text{O}_3$	$\text{Na}_2\text{O}$		$\text{As}_2\text{O}_3$	$\text{Na}_2\text{O}$	
2.019	0	$\text{As}_2\text{O}_3$	31.05	21.82	$\text{Na}_4\text{As}_2\text{O}_4 \cdot 9\text{H}_2\text{O}$
14.45	2.45	"	±29	±22.7	" + $\text{Na}_{10}\text{As}_4\text{O}_{11} \cdot 26\text{H}_2\text{O}$
24.42	4.23	"	21.92	24.04	$\text{Na}_{10}\text{As}_4\text{O}_{11} \cdot 26\text{H}_2\text{O}$
37.73	6.46	"	17.50	25.64	"
58.54	9.60	"	14.26	29.16	"
±73	±12	" + $\text{NaAsO}_2$	14.63	30.24	"
63.01	12.73	$\text{NaAsO}_2$	19.32	32.04	" + $\text{Na}_4\text{As}_2\text{O}_5$
57.90	13.24	"	15.53	33.57	$\text{Na}_4\text{As}_2\text{O}_5$
48.05	14.27	"	10.49	36.21	"
36.32	18.74	"	6.59	39.39	" + $\text{NaOH} \cdot \text{H}_2\text{O}$
±34	±21.1	" + $\text{Na}_4\text{As}_2\text{O}_5 \cdot 9\text{H}_2\text{O}$	5.11	39.69	$\text{NaOH} \cdot \text{H}_2\text{O}$
32.24	21.6	$\text{Na}_4\text{As}_2\text{O}_5 \cdot 9\text{H}_2\text{O}$	0	41.2	"

### Results at 35°

(Nelson, 1941)

These results differ from those of Schreinemakers and deBaat at 25°, who found the phases  $\text{Na}_4\text{As}_2\text{O}_5 \cdot 9\text{H}_2\text{O}$  and  $\text{Na}_{10}\text{As}_4\text{O}_{11} \cdot 26\text{H}_2\text{O}$  and did not find  $2\text{Na}_2\text{O} \cdot \text{As}_2\text{O}_3 \cdot 7\text{H}_2\text{O}$  nor  $\text{Na}_2\text{O} \cdot 3\text{As}_2\text{O}_3$ . Nelson points out that Schreinemakers and deBaat's data did not justify assigning the formula  $\text{Na}_4\text{As}_2\text{O}_5 \cdot 9\text{H}_2\text{O}$  and that the  $\text{Na}_{10}\text{As}_4\text{O}_{11} \cdot 26\text{H}_2\text{O}$  is improbable for theoretical reasons.

# Na SODIUM

## THE SYSTEM $\text{Na}_2\text{O} - \text{As}_2\text{O}_3 - \text{H}_2\text{O}$ —Cont.

### Results at 35°—Cont.

Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
$\text{As}_2\text{O}_3$	$\text{Na}_2\text{O}$		$\text{As}_2\text{O}_3$	$\text{Na}_2\text{O}$	
6.3	42.0	$\text{NaOH} \cdot \text{H}_2\text{O}$	39.6	16.9	$\text{Na}_2\text{O} \cdot \text{As}_2\text{O}_3$
6.3	41.5	$2\text{Na}_2\text{O} \cdot \text{As}_2\text{O}_3$	45.8	15.2	"
5.7	41.0	"	48.9	14.7	"
9.2	38.4	"	54.2	13.9	"
9.8	38.4	"	58.0	13.7	"
11.6	36.4	"	58.7	13.5	$\text{Na}_2\text{O} \cdot 3\text{As}_2\text{O}_3$
12.3	35.8	"	55.2	12.8	"
15.4	34.9	"	53.1	12.2	"
16.3	34.4	"	52.1	11.2	"
20.0	33.4	"	50.3	11.0	"
19.5	32.6	$2\text{Na}_2\text{O} \cdot \text{As}_2\text{O}_3 \cdot 7\text{H}_2\text{O}$	48.2	10.2	"
17.9	31.0	"	47.1	9.1	"
18.0	28.9	"	45.3	7.6	$\text{Na}_2\text{O} \cdot 3\text{As}_2\text{O}_3 + \text{As}_2\text{O}_3$
18.8	28.2	"	45.5	7.7	"
20.2	26.1	"	44.6	7.5	$\text{As}_2\text{O}_3$
22.8	24.9	"	40.1	6.8	"
25.5	24.0	"	36.9	6.2	"
26.3	24.1	"	32.5	5.4	"
29.4	23.2	"	31.8	5.4	"
34.5	23.1	$\text{Na}_2\text{O} \cdot \text{As}_2\text{O}_3$	23.3	3.9	"
34.4	22.5	"	19.8	3.3	"
36.2	20.2	"	18.2	3.0	"
37.3	18.5	"	14.9	2.5	"

At 25°, 28.06 gms. sodium metaarsenite dissolve in 100 gms. ethylene glycol.

At 25°, 20.84 gms. sodium metaarsenite dissolve in 100 gms. propylene glycol.

(Palit, 1947)

## AsO SODIUM ARSENATES $x\text{Na}_2\text{O} \cdot y\text{As}_2\text{O}_5 \cdot z\text{H}_2\text{O}$

## THE SYSTEM $\text{Na}_2\text{O} - \text{As}_2\text{O}_5 - \text{H}_2\text{O}$

### Results at 0°

(Rosenhelm and Thon, 1927)

Highly purified  $\text{NaOH}$  and  $\text{As}_2\text{O}_5$  were used for preparing the solutions. Considerable difficulty was experienced in filtering the syrupy arsenic acid solutions which always contained finely divided, almost colloidal particles in suspension. This was accomplished with the aid of porcelain filter discs and suction.

Up to 40 hours was allowed for securing equilibrium.

THE SYSTEM  $\text{Na}_2\text{O} - \text{As}_2\text{O}_3 - \text{H}_2\text{O}$ —Cont.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Na}_2\text{O}$	$\text{As}_2\text{O}_3$		$\text{Na}_2\text{O}$	$\text{As}_2\text{O}_3$	
0.0	66.06	$\text{H}_2\text{AsO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$	9.34	38.01	$\text{NaH}_2\text{AsO}_4 \cdot \text{H}_2\text{O}$
2.18	63.17	"	10.25	38.03	"
3.11	60.14	"	10.98	38.33	"
3.31	58.34	"	12.95	39.34	"
3.77	57.26	"	13.15	39.03	" + $\text{Na}_2\text{HASO}_4 \cdot 12\text{H}_2\text{O}$
3.72	56.19	"	13.04	35.89	$\text{Na}_2\text{HASO}_4 \cdot 12\text{H}_2\text{O}$
5.36	54.15	$\text{NaH}_2\text{AsO}_4 \cdot \text{H}_2\text{O}$	10.35	30.87	"
7.01	52.14	"	6.29	19.15	"
7.91	47.11	"	4.18	11.92	"
8.51	44.48	"	2.62	5.80	"
9.01	40.28	"	1.82	3.37	"

AsO

Results at 20°

(Manzel and Hagen, 1937)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Na}_2\text{O}$	$\text{As}_2\text{O}_3$		$\text{Na}_2\text{O}$	$\text{As}_2\text{O}_3$	
10.70	39.70	$\text{NaH}_2\text{AsO}_4 \cdot \text{H}_2\text{O}$	9.14	13.45	$\text{Na}_3\text{AsO}_4 \cdot 12\text{H}_2\text{O}$
12.22	39.80	"	8.16	11.23	"
13.72	40.59	"	7.73	10.24	"
14.99	41.52	" + $\text{Na}_2\text{HASO}_4 \cdot 12\text{H}_2\text{O}$	5.99	7.31	$\text{Na}_3\text{AsO}_4 \cdot 12\text{H}_2\text{O}$
(17.32)	(50.47)	"	4.78	3.89	"
13.71	36.81	$\text{NaH}_2\text{AsO}_4 \cdot 12\text{H}_2\text{O}$	5.33	2.05	"
13.03	34.07	"	7.74	0.71	"
11.77	29.08	"	11.46	0.29	"
11.29	26.93	"	15.08	0.15	"
10.12	22.32	"	21.10	0.10	"
9.09	18.31	"	25.43	0.15	"
8.70	16.70	"	27.22	0.27 (tr.pt.)	"
8.25	15.35	"	28.51	0.27	"
9.21	16.32	"	30.25	0.31	"
11.25	18.35	" + $\text{Na}_3\text{AsO}_4 \cdot 12\text{H}_2\text{O}$	32.12	0.44	"
			35.21	0.33	lower hydrate

Results at 25°

(Guerin, 1956, 1957)

Sat. Sol. Wt. %			Sat. Sol. Wt. %			Sat. Sol. Wt. %		
dens.	$\text{Na}_2\text{O}$	$\text{As}_2\text{O}_3$	dens.	$\text{Na}_2\text{O}$	$\text{As}_2\text{O}_3$	dens.	$\text{Na}_2\text{O}$	$\text{As}_2\text{O}_3$
$\text{Na}_2\text{O} \cdot 2\text{As}_2\text{O}_3 \cdot 6\text{H}_2\text{O}$								
2.15	0	70.3		0.307	67.5	2	1.4	65
2.12	0	70.2		0.674	66	2	2.35	63.9
2.1	0	69.8	2.02	0.99	65.8	2	3.1	64
	0	69.7	2	1.07	66.2	2	4.06	63.5
	0	68.6	2	1.12	66.1	2	4.21	63.1

(Cont.)



# Na SODIUM

## THE SYSTEM $\text{Na}_2\text{O} - \text{As}_2\text{O}_5 - \text{H}_2\text{O}$ —Cont.

### Results at 25°—Cont.

(Guerin, 1956, 1957)

Sat. Sol. Wt. %			Sat. Sol. Wt. %			Sat. Sol. Wt. %		
dens.	$\text{Na}_2\text{O}$	$\text{As}_2\text{O}_5$	dens.	$\text{Na}_2\text{O}$	$\text{As}_2\text{O}_5$	dens.	$\text{Na}_2\text{O}$	$\text{As}_2\text{O}_5$
$\text{Na}_2\text{O} \cdot 2\text{As}_2\text{O}_5 \cdot 5\text{H}_2\text{O}$								
2.1	3	67.1m	2.03	4.72	63.25	2	8.04	61.3
2.08	3.87	65.5m	2	6.14	61.75			
$\text{AsO} \quad \text{Na}_2\text{O} \cdot 2\text{As}_2\text{O}_5 \cdot 5\text{H}_2\text{O} + \text{Na}_2\text{O} \cdot \text{As}_2\text{O}_5 \cdot 4\text{H}_2\text{O}$								
			2.04	7.9	60.6			
$\text{Na}_2\text{O} \cdot \text{As}_2\text{O}_5 \cdot 4\text{H}_2\text{O}$								
1.95	8.19	52.5	1.77	9.2	48.2	1.69	12.5	40.2
1.95	8.2	57	1.72	9.53	46	1.74	14.55	41.7
1.77	8.55	49.7	1.66	10.2	42.1	1.72	14.78	41.7
1.77	8.73	50.5	1.7	10.8	41.2	1.75	15.4	42.1
$2\text{Na}_2\text{O} \cdot \text{As}_2\text{O}_5 \cdot 4\text{H}_2\text{O}$								
1.298	9.3	17.15	1.62	13.53	34.9	1.73	15	41
1.38	10.3	22.95	1.62	13.65	36.25	1.75	15.4	42.2
1.38	11.48	18.6	1.66	14.5	38.09	1.75	15.8	43.2
1.52	13.5	33.2	1.69	14.6	40.2			
$2\text{Na}_2\text{O} \cdot \text{As}_2\text{O}_5 \cdot 15\text{H}_2\text{O} + 3\text{Na}_2\text{O} \cdot \text{As}_2\text{O}_5 \cdot 24\text{H}_2\text{O}$								
			1.38	12.3	19.8			
$3\text{Na}_2\text{O} \cdot \text{As}_2\text{O}_5 \cdot 24\text{H}_2\text{O}$								
1.35	11.37	18.04	1.26	9.75	13.45	1.23	8.8	11.88
1.35	11.31	17.75	1.27	9.62	14.07	1.2	7.63	10.44
1.34	11.3	17.7	1.27	9.6	13.8	1.19	7.58	9.56
1.32	10.48	16.06	1.26	9.48	12.95	1.18	7.05	8.76
$3.24\text{Na}_2\text{O} \cdot \text{As}_2\text{O}_5 \cdot 24.1\text{H}_2\text{O}$								
1.11	5.17	4.44	1.17	11.94	0.269	1.28	20.86	0.16
1.09	5.48	2.30	1.18	13.15	0.29	1.3	22.47	0.13
1.1	5.94	2.92	1.19	14.63	0.237	1.3	22.72	0.22
1.1	6.42	1.35	1.21	15.47	0.18	1.33	24.5	0.215
1.1	7.38	1.2	1.22	15.69	0.188	1.34	26.38	0.34
1.11	7.4	1.15	1.24	17.8	0.185	1.35	26.54	0.298
1.11	7.91	0.72	1.25	18.59	0.182	1.36	26.71	0.316
1.15	10.68	0.49	1.28	19.96	0.16	1.36	27.16	0.29
1.16	11.74	0.32	1.28	20.30	0.182	1.36	27.38	0.44

(Cont.)

THE SYSTEM  $\text{Na}_2\text{O} - \text{As}_2\text{O}_5 - \text{H}_2\text{O}$ —Cont.

## Results at 25°—Cont.

(Guerin, 1956, 1957)

Sat. Sol. Wt. %			Sat. Sol. Wt. %			Sat. Sol. Wt. %		
dens.	$\text{Na}_2\text{O}$	$\text{As}_2\text{O}_5$	dens.	$\text{Na}_2\text{O}$	$\text{As}_2\text{O}_5$	dens.	$\text{Na}_2\text{O}$	$\text{As}_2\text{O}_5$
$3\text{Na}_2\text{O} \cdot \text{As}_2\text{O}_5 \cdot 16\text{H}_2\text{O}$								
1.37	27.4	0.275	1.4	29.8	0.36	1.41	31.34	0.466
1.37	27.92	0.375	1.4	29.81	0.394	1.41	31.45	0.47
1.37	28.35	0.292	1.4	29.85	0.463	1.42	32	0.6
1.39	29.17	0.33	1.4	30.62	0.41	1.43	32.53	0.6
1.398	29.34	0.452	1.41	30.72	0.406	1.43	32.6	0.58

AsO

 $3\text{Na}_2\text{O} \cdot \text{As}_2\text{O}_5 \cdot 8\text{H}_2\text{O}^*$  or  $3\text{Na}_2\text{O} \cdot \text{As}_2\text{O}_5 \cdot 6\text{H}_2\text{O}$ 

1.41	32.65	0.48*	1.47	36.34	0.177	1.5	38.22	0.194
1.41	32.65	0.48*	1.47	36.42	0.232	1.5	38.24	0.173
1.42	32.9	0.402*	1.48	36.8	0.35*	1.5	38.8	0.419*
1.42	33.1	0.404*	1.48	36.96	0.311*	1.5	38.82	0.460*
1.45	34.9	0.396*	1.48	37	0.19	1.5	39.69	0.172
1.46	35.41	0.391*	1.48	37.1	0.373*	1.5	39.98	0.152
1.47	36.07	0.374*	1.48	37.24	0.426*	1.51	40.31	0.189
1.47	36.3	0.212	1.5	38	0.405*	1.51	40.5	0.19

 $3\text{Na}_2\text{O} \cdot \text{As}_2\text{O}_5 \cdot 6\text{H}_2\text{O} + \text{NaOH}$ 

1.51 40.5 0.18

## Results at 30°

(Serebrennikova, 1939)

A = $3\text{As}_2\text{O}_5 \cdot 5\text{H}_2\text{O}$	E = $\text{Na}_3\text{AsO}_4 \cdot 12\text{H}_2\text{O}$
B = $\text{NaH}_2\text{AsO}_4 \cdot \text{H}_3\text{AsO}_4 \cdot \text{H}_2\text{O}$	F = Solid Solution
C = $\text{NaH}_2\text{AsO}_4 \cdot \text{H}_2\text{O}$	G = $3(\text{Na}_3\text{AsO}_4) \cdot \text{NaOH} \cdot \text{H}_2\text{O} (?)$
D = $\text{Na}_2\text{HASO}_4 \cdot 7\text{H}_2\text{O}$	H = $\text{Na}_3\text{AsO}_4 \cdot \text{NaOH} \cdot 10\text{H}_2\text{O} (?)$

# Na SODIUM

THE SYSTEM  $\text{Na}_2\text{O} - \text{As}_2\text{O}_5 - \text{H}_2\text{O}$  at  $30^\circ$ —Cont.

(Key on previous page)

	Gms. per 100 gms. Sat. Sol.		Density	Solid Phase	Gms. per 100 gms. Sat. Sol.		Density	Solid Phase
	$\text{As}_2\text{O}_5$	$\text{Na}_2\text{O}$			$\text{As}_2\text{O}_5$	$\text{Na}_2\text{O}$		
AsO	72.53	0.0	2.208	A	21.65	12.69	-	D
	68.30	1.97	-	A	22.50	13.74	1.422	D + E
	67.42	2.39	-	A	21.22	13.53	1.415	E
	68.6	3.4	-	A + B	19.81	12.76	1.361	E
	65.85	4.00	2.015	B	18.01	12.01	-	E
	65.61	4.22	2.110	B	15.86	11.12	-	E
	63.34	5.03	2.049	B	10.82	8.85	-	F
	63.42	5.13	2.053	B	8.85	7.44	-	F
	60.66	6.43	2.010	B	7.60	6.87	1.143	F
	59.36	7.45	1.995	B	6.94	6.61	1.138	F
	59.16	7.82	1.988	B	6.66	6.51	1.140	F
	61.20	8.90	2.071	B + C	6.58	6.53	1.142	F
	61.34	8.97	2.066	C	6.40	6.53	-	F
	59.92	9.02	2.048	C	4.96	6.36	-	F
	57.97	9.01	2.030	C	4.59	6.40	1.130	F
	56.08	8.87	1.949	C	4.49	6.11	1.127	F
	53.47	9.22	1.850	C	3.89	6.53	1.120	F
	52.27	9.07	1.858	C	3.22	6.40	-	G
	50.55	9.63	1.840	C	2.79	6.66	1.114	G
	45.26	10.34	1.727	C	2.46	6.68	1.115	G
	43.15	10.72	1.710	C	1.95	8.69	1.118	G
	41.38	11.07	1.674	C	1.61	8.57	1.131	G
	41.40	11.17	1.675	C	1.22	8.69	-	G
	41.10	12.00	1.667	C	1.20	9.35	1.126	G
	41.49	12.36	-	C	0.34	13.33	1.174	G
	41.27	13.29	1.715	C	.44	15.71	-	G
	41.21	13.66	1.738	C	.23	17.47	-	G
	42.77	15.15	1.779	C	.22	20.96	-	G
	43.52	16.36	1.855	C	.41	26.16	-	G
	44.23	17.02	-	C + D	.43	26.70	-	G + H
	33.58	13.96	1.579	D	.49	26.79	-	H
	28.47	12.74	1.505	D	.59	30.97	-	H
	26.03	12.22	1.453	D	.24	37.77	-	H
	20.70	11.04	-					

## AsO DISODIUM HYDROGEN ARSENATE $\text{Na}_2\text{HAsO}_4$

### SOLUBILITY OF DISODIUM ARSENATE IN WATER (Menzel and Hagen, 1937)

The previous results of Rosenheim and Thon, 1927, for this system are considered to be slightly in error due to inaccuracy of the analytical method. Some additional data are given by Rosenheim and Thon, 1927 and by Guerin, 1956.

## SOLUBILITY OF DISODIUM ARSENATE IN WATER--Cont.

t.°	Gms. $\text{Na}_2\text{HAsO}_4$ per 100 gms. sat. sol.	Solid Phase	
- 0.210	0.94	Ice	
- 0.615	2.67	"	
- 0.968	4.32	"	
- 1.138	5.12	" + $\text{Na}_2\text{HAsO}_4 \cdot 12\text{H}_2\text{O}$	
+ 0.1	5.59	$\text{Na}_2\text{HAsO}_4 \cdot 12\text{H}_2\text{O}$	
5.0	7.93	"	
10	11.52	"	
15.0	16.92	"	
20	25.31	"	
20.5 tr.pt.	26.1	" + $\text{Na}_2\text{HAsO}_4 \cdot 7\text{H}_2\text{O}$	
22.2	27.27	$\text{Na}_2\text{HAsO}_4 \cdot 7\text{H}_2\text{O}$	AsO
25	29.33	"	
34.9	36.73	"	
45.1	45.31	"	
50.1	49.83	"	
56.2 tr.pt.	57.1	" + $\text{Na}_2\text{HAsO}_4 \cdot 5\text{H}_2\text{O}$	
60.3	58.99	$\text{Na}_2\text{HAsO}_4 \cdot 5\text{H}_2\text{O}$	
64	61.4	$\text{Na}_2\text{HAsO}_4 \cdot 5\text{H}_2\text{O}$	
67	63.8	"	
68 tr.pt.	67.3	" + $\text{Na}_2\text{HAsO}_4$	
67.4 "	64.8	" + $\text{Na}_2\text{HAsO}_4 \cdot \text{H}_2\text{O}$	
69	64.8	$\text{Na}_2\text{HAsO}_4 \cdot \text{H}_2\text{O}$	
75.1	64.9	"	
80	65.1	"	
85.6	65.1	"	
91.7	65.4	"	
96.0	65.9	"	
99.5	66.5	" + $\text{Na}_2\text{HAsO}_4$	
69.3	67.2*	$\text{Na}_2\text{HAsO}_4$	
81.6	66.5*	"	
98.5	66.5*	"	
103.1	66.7	"	
108.1	66.0	"	
115.9 b.pt.	66.9	"	

\*Metastable

A double salt  $(\text{Na}_2\text{AsO}_4 \cdot 11\text{H}_2\text{O})_4 \cdot \text{NaOCl} \cdot \text{NaCl}$  is precipitated from cooling  $\text{Na}_2\text{HAsO}_4 \cdot 7\text{H}_2\text{O}$  (+NaOH) + NaOCl solutions. The solubility in water is 44.46 gms per 100 ml  $\text{H}_2\text{O}$  at  $30^\circ$ .  
(Braak, Larson, Shiflett and Wilson, 1956)

Results for the solubility of  $\text{Na}_2\text{HAsO}_4$  in NaOH or HCl in the presence of  $\text{Al}^{+++}$ ,  $\text{Fe}^{+++}$  and other soil cations are given by Wiklander and Alvelid, 1951.

100 gms. sat. solution of Disodium Arsenate in 93.5 Wt. % Ethyl Alcohol contain 0.02465 gm.  $\text{Na}_2\text{HAsO}_4$  at about  $18^\circ$ , Wohlk, 1934.

100 gms. glycerol dissolve 50 gms. sodium arsenate at  $15.5^\circ$ . (Ossendowski, 1907.)

# Na SODIUM

## B SODIUM BOROHYDRIDE $\text{NaBH}_4$

### SODIUM TRIMETHOXY BOROHYDRIDE $\text{NaBH}(\text{OCH}_3)_3$

SOLUBILITY OF EACH IN VARIOUS SOLVENTS  
(Schlesinger, Brown and Finholt, 1953)

Solvent	t°	gms per 100 gms solvent	
		$\text{NaBH}_4$	$\text{NaBH}(\text{OCH}_3)_3$
Ammonia (liq)	25	104	5.6
Methylamine	20	28	-
Ethylamine	17	21	-
n-propylamine	28	10	-
i-propylamine	28	6	9.0
n-butylamine	28	5	-
Pyridine	0	3	0.4
	75	3.5	3.0
Morpholine	25	0.3	0.3
	75	0.1	2.3
Dioxane	25	insol.	1.6
	75	insol.	4.5

The solubility  $\text{NaBH}_4$  is less than 1 gm per 100 gms solvent in the following solvents: aniline, ethyl and diethyl cellosolve, acetonitrile diethylamine, triethylamine, ethyl acetate, diethyl ether, methyl borate.

## B SODIUM HYDROXY FLUOBORATE $\text{Na}(\text{OH})\text{BF}_3$

The solubility of  $\text{NaOH} \cdot \text{BF}_3$  in ethanol at room temperature is 0.3% (Ryss and Slutskaya, 1952)

## BO SODIUM BORATES $\text{Na}_2\text{O} \cdot y\text{B}_2\text{O}_3$

### THE SYSTEM SODIUM OXIDE - BORIC OXIDE - WATER

1.5.10 =  $\text{Na}_2\text{O} \cdot 0.5\text{B}_2\text{O}_3 \cdot 10\text{H}_2\text{O}$ ; 1.2.10 =  $\text{Na}_2\text{O} \cdot 0.2\text{B}_2\text{O}_3 \cdot 10\text{H}_2\text{O}$ ; 1.1.8 =  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 8\text{H}_2\text{O}$ ; 1.1.4 =  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O}$ ; 1.1.1 =  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot \text{H}_2\text{O}$ ; 2.1.1 =  $2\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot \text{H}_2\text{O}$ ; 1.2.5 =  $\text{Na}_2\text{O} \cdot 0.2\text{B}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$

#### Results at 0°

(Data of Sborgi and Amelotti, 1930; Sborgi, 1932.)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
Na <sub>2</sub> O	B <sub>2</sub> O <sub>3</sub>		Na <sub>2</sub> O	B <sub>2</sub> O <sub>3</sub>	
<u>Results at 0°</u>					
0.0	1.49	H <sub>3</sub> BO <sub>3</sub>	16.04	1.66	1.1.8
0.88	4.74	" + 1.2.10	20.82	1.15	"
0.34	0.76	1.2.10	24.12	1.67	" + 1.1.4
0.46	0.65	"	22.81	2.00*	1.1.4
3.05	3.33	"	26.66	1.50	"
6.45	7.09	"	29.43	1.21	"
7.22	7.66	" + 1.1.8	32.50	1.69	" + NaOH.4H <sub>2</sub> O
8.32	4.98	1.1.8	28.33	0.45	NaOH.4H <sub>2</sub> O
10.71	3.26	"	22.84	0.0	"

(Cont.)

## THE SYSTEM SODIUM OXIDE - BORIC OXIDE - WATER--Cont.

1.5.10 =  $\text{Na}_2\text{O} \cdot 5\text{B}_2\text{O}_3 \cdot 10\text{H}_2\text{O}$ ; 1.2.10 =  $\text{Na}_2\text{O} \cdot 2\text{B}_2\text{O}_3 \cdot 10\text{H}_2\text{O}$ ; 1.1.8 =  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 8\text{H}_2\text{O}$ ; 1.1.4 =  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O}$ ; 1.1.1 =  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot \text{H}_2\text{O}$ ; 2.1.1 =  $2\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot \text{H}_2\text{O}$ ; 1.2.5 =  $\text{Na}_2\text{O} \cdot 2\text{B}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$

Results at 0°--Cont.

(Data of Rosenheim and Leyser, 1921.)

The mixtures were constantly stirred for 1 to 2 days. The curve plotted from the results is somewhat irregular.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase	80
NaOH	H <sub>2</sub> BO <sub>3</sub>		NaOH	H <sub>2</sub> BO <sub>3</sub>		
0.639	5.84	-	0.416	1.97 <sup>(3)</sup>	1:2:10	
1.27	9.2	-	5.143	8.06	"	
1.62	11.2	-	7.349	11.44	"	
1.65	9.3	} 1:2:10 + 1:5:10	8.921	13.76	"	
1.23	9.20		9.160	14.07	1:2:10	
1.16	8.96 <sup>(1)</sup>		8.794	13.63	+	
1.29	9.55		8.989	13.65	1:1:8	
1.37	9.79		9.265	12.83	1:1:8	
1.09	8.78 <sup>(2)</sup>		9.845	11.45	"	
1.10	8.73		11.130	8.35	"	

<sup>(1)</sup> By analysis the solid phase had the composition,  $\text{Na}_2\text{O} \cdot 0.4.54\text{B}_2\text{O}_3 \cdot 10.1\text{H}_2\text{O}$

<sup>(2)</sup> " " " " " " " " " "  $\text{Na}_2\text{O} \cdot 3.34\text{B}_2\text{O}_3 \cdot 9.71\text{H}_2\text{O}$

<sup>(3)</sup> " " " " " " " " " "  $\text{Na}_2\text{O} \cdot 2.01\text{B}_2\text{O}_3 \cdot 10.1\text{H}_2\text{O}$

Results at 20°

(Sborgi and Amelotti, 1924; Sborgi, 1932)

gms per 100 gms sat sol		Solid Phase	gms per 100 gms sat sol.		Solid Phase
Na <sub>2</sub> O	B <sub>2</sub> O <sub>3</sub>		Na <sub>2</sub> O	B <sub>2</sub> O <sub>3</sub>	
0.0	2.70	H <sub>3</sub> BO <sub>3</sub>	15.78	4.40	1.1.8
1.50	8.70	" + 1.5.10	19.40	2.95	"
2.18	10.37	1.2.10 + "	23.19	3.32	" + 1.1.4
0.78	1.75	"	24.65	2.69	1.1.4
4.60	5.26	"	30.71	2.31	"
7.20	8.35	"	34.30	2.71	"
8.95	10.50	" + 1.1.8	39.56	3.93	NaOH·H <sub>2</sub> O
9.75	8.94	1.1.8	40.00	0.0	"

(Cont.)

## THE SYSTEM SODIUM OXIDE - BORIC OXIDE - WATER--Cont.

1.5.10 =  $\text{Na}_2\text{O} \cdot 5\text{B}_2\text{O}_3 \cdot 10\text{H}_2\text{O}$ ; 1.2.10 =  $\text{Na}_2\text{O} \cdot 2\text{B}_2\text{O}_3 \cdot 10\text{H}_2\text{O}$ ; 1.1.8 =  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 8\text{H}_2\text{O}$ ; 1.1.4 =  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O}$ ; 1.1.1 =  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot \text{H}_2\text{O}$ ; 2.1.1 =  $2\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot \text{H}_2\text{O}$ ; 1.2.5 =  $\text{Na}_2\text{O} \cdot 2\text{B}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$

## Results at 30°

(Dukelski, 1906)

	Gms. per 100 Gms. sat sol		Solid Phase	gms per 100 gms sat sol		Solid Phase
	$\text{Na}_2\text{O}$	$\text{B}_2\text{O}_3$		$\text{Na}_2\text{O}$	$\text{B}_2\text{O}_3$	
BO	42.0	-	NaOH $\text{H}_2\text{O}$	8.85	10.49	1:2:10
	41.37	5.10	"	5.81	6.94	"
	38.85	5.55	1:1:4	1.88	2.41	"
	34.44	3.73	"	1.38	5.16	"
	29.39	2.51	"	2.02	7.79	"
	26.13	2.75	"	4.08	17.20	" + 1:5:10
	23.00	3.82	"	3.79	15.84	1:5:10
	16.61	13.69	"	2.26	12.14	"
	21.58	4.63	" + 1:1:8	1.99	11.84	" + B(OH) <sub>3</sub>
	20.58	4.69	1:1:8	1.86	11.18	B(OH) <sub>3</sub>
	15.32	6.21	"	0.64	6.11	"
	12.39	9.12	"	-	3.54	"

## Results at 35°

(Sborgi and Amelotti, 1930; Sborgi, 1932)

	Gms. per 100 gms. sat. sol.		Solid Phase	gms per 100 gms sat sol		Solid Phase
	$\text{Na}_2\text{O}$	$\text{B}_2\text{O}_3$		$\text{Na}_2\text{O}$	$\text{B}_2\text{O}_3$	
	0.0	4.04	$\text{H}_3\text{BO}_3$	20.64	6.46	1.1.8 + 1.1.4
	2.05	12.86	" + 1.5.10	24.53	3.98	1.1.4
	3.36	16.23	1.5.10	33.79	3.87	"
	4.47	18.74	" + 1.2.10	37.60	5.07	"
	2.60	10.34	1.2.10	40.54	5.82	" + 2.1.1
	1.48	3.32	"	41.83	5.54	2.1.1
	7.43	9.75	"	42.76	4.73	" + NaOH. $\text{H}_2\text{O}$
	13.04	15.40	" + 1.1.8	42.73	3.96	NaOH. $\text{H}_2\text{O}$
	13.59	10.13	1.1.8	42.48	3.09	"
	18.01	6.68	"	43.00	0.0	"

## Results at 45°

(Sborgi and Amelotti, 1930; Sborgi, 1932)

	gms per 100 gms sat sol		Solid Phase	gms per 100 gms sat sol		Solid Phase
	$\text{Na}_2\text{O}$	$\text{B}_2\text{O}_3$		$\text{Na}_2\text{O}$	$\text{B}_2\text{O}_3$	
	2.55	16.43	$\text{H}_3\text{BO}_3$ + 1.5.10	37.0	5.50	1.1.1 + 1.1.4
	7.50	28.85	1.5.10 + 1.2.10	40.46	4.68	" + 2.1.1
	15.32	20.10	1.1.8 + "	44.73	3.51	NaOH. $\text{H}_2\text{O}$ + "
	18.50	14.0	" + 1.1.4			

## THE SYSTEM SODIUM OXIDE - BORIC OXIDE - WATER--Cont.

1.5.10 =  $\text{Na}_2\text{O} \cdot 0.5\text{B}_2\text{O}_3 \cdot 10\text{H}_2\text{O}$ ; 1.2.10 =  $\text{Na}_2\text{O} \cdot 0.2\text{B}_2\text{O}_3 \cdot 10\text{H}_2\text{O}$ ; 1.1.8 =  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 8\text{H}_2\text{O}$ ; 1.1.4 =  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 4\text{H}_2\text{O}$ ; 1.1.1 =  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot \text{H}_2\text{O}$ ; 2.1.1 =  $2\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot \text{H}_2\text{O}$ . 1.2.5 =  $\text{Na}_2\text{O} \cdot 0.2\text{B}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$

Results at 90°

(Sborgi and Amelotti, 1930; Sborgi, 1932)

gms per 100 gms sat sol		Solid Phase	gms per 100 gms sat sol		Solid Phase
$\text{Na}_2\text{O}$	$\text{B}_2\text{O}_3$		$\text{Na}_2\text{O}$	$\text{B}_2\text{O}_3$	
5.86	37.46	$\text{H}_3\text{BO}_3 + 1.5.10$	30.03	16.26	1.1.1 + 1.1.4
13.0	58.0	1.2.3 + "	43.0	7.0	" + 2.1.1
23.74	39.65	" + 1.1.4	57.88	1.26	$\text{NaOH} + "$

80

Results at 60°

(Sborgi and Mecacci, 1915, 1916)

Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
$\text{Na}_2\text{O}$	$\text{B}_2\text{O}_3$		$\text{Na}_2\text{O}$	$\text{B}_2\text{O}_3$	
49.25	0	$\text{NaOH} \cdot \text{H}_2\text{O}$	19.29	22.78	1.1.4
48.44	0.81	"	20.30	25.50	"
49.28	1.53	" + 2.1.1	22.21	32.17	" + 1.2.5
47.38	2.24	2.1.1	19.43	27.09	1.2.5
44.74	3.78	"	16.13	23.05	"
42.94	5.67	" 1.1.1	13.51	19.10	"
40.14	5.41	1.1.1	11.58	16.62	"
38.70	5.56	"	6.95	11.50	"
35.76	6.29	"	5.65	14.89	"
34.93	6.80	"	6.84	20.40	"
31.88	9.85	" (unstable)	8.42	28.05	"
29.56	11.83	" "	11.29	41.47	" + 1.5.10
28.07	14.65	"	8.29	33.57	1.5.10
33.12	7.47	" + 1.1.4	6.29	28.77	"
28.64	6.51	1.1.4	3.22	21.94	"
22.06	10.29	"	3.40	22.59	" + $\text{H}_3\text{BO}_3$
18.72	17.33	"	1.39	13.92	$\text{H}_3\text{BO}_3$
18.32	19.17	"	0	7.39	



# Na SODIUM

## BO SODIUM METABORATE $\text{NaBO}_2$

### SOLUBILITY OF SODIUM METABORATE IN WATER (Blasdale and Slansky, 1939)

t°	Gms. $\text{NaBO}_2$ per 100 gms. Sat. Sol.	Solid Phase	t°	Gms. $\text{NaBO}_2$ per 100 gms. Sat. Sol.	Solid Phase
0	14.10	$\text{NaBO}_2 \cdot 4\text{H}_2\text{O}$	54	37.85	{ $\text{NaBO}_2 \cdot 4\text{H}_2\text{O}$ + $\text{NaBO}_2 \cdot 2\text{H}_2\text{O}$ $\text{NaBO}_2 \cdot 2\text{H}_2\text{O}$
5	15.70	"	55	38.12	
10	17.23	"	60	39.00	
15	18.50	"	65	40.35	"
20	20.22 (20.48) <sup>a</sup>	"	70	41.90	"
25	22.00	"	75	43.80	"
30	23.90	"	80	45.80	"
35	26.22 (26.3) <sup>a</sup>	"	85	48.10	"
40	28.75	"	90	50.35	"
45	31.81	"	95	52.80	"
50	35.02	"	100	55.60	"

<sup>a</sup>Teeple, 1929

### FREEZING POINTS OF SOLUTIONS OF SODIUM METABORATE (Menzel and Schulz, 1948)

t°	Gms. $\text{NaBO}_2$ per 100 gms. $\text{H}_2\text{O}$	Moles $\text{NaBO}_2$ per 1000 gms. $\text{H}_2\text{O}$	t°	Gms. $\text{NaBO}_2$ per 100 gms. $\text{H}_2\text{O}$	Moles $\text{NaBO}_2$ per 1000 gms. $\text{H}_2\text{O}$
-0.511	1.011	0.1551	-4.822	11.15	1.906
-1.286	2.695	.4208	-5.524	12.61	2.192
-2.532	5.732	.9238	-5.768	13.10	2.289*
-4.084	9.511	1.597			

\*Eutectic (Ice +  $\text{NaBO}_2 \cdot 4\text{H}_2\text{O}$ )

### THE SYSTEM $\text{NaBO}_2$ - $\text{Na}_2\text{B}_4\text{O}_7$ - $\text{NaCl}$ - $\text{H}_2\text{O}$ (Teeple, 1929)

Gms. per 100 gms. $\text{H}_2\text{O}$			Solid Phase
$\text{Na}_2\text{B}_2\text{O}_4$	$\text{Na}_2\text{B}_4\text{O}_7$	$\text{NaCl}$	
-	2.5	-	1.2.10
0.5	1.95	-	"
4.9	0.5	-	"
11.3	0.4	-	"
25.75	-	-	1.1.8
25.1	0.5	-	" + 1.2.10
23.0	-	19.2	D.S. + $\text{NaCl}$
8.0	-	33.3	" + "
-	0.9	36.0	1.2.10 + "
0.5	0.5	35.8	" + "
2.3	0.3	34.7	" + "
23.2	0.4	19.3	" + 1.1.8 + D.S.
8.0	0.2	33.2	" + $\text{NaCl}$ + "
-	5.3	-	1.2.10
35.7	-	-	1.1.8

(Cont.)

THE SYSTEM  $\text{NaBO}_2 - \text{Na}_2\text{B}_4\text{O}_7 - \text{NaCl} - \text{H}_2\text{O}$ —Cont.

Gms. per 100 gms. $\text{H}_2\text{O}$			Solid Phase
$\text{Na}_2\text{B}_2\text{O}_4$	$\text{Na}_2\text{B}_4\text{O}_7$	$\text{NaCl}$	
-	2.2	35.5	$\text{NaCl} + 1.2.10$
8.3	-	33.5	" + D.S.
34.8	5.6	-	$1.1.8 + 1.2.10$
32.8	-	13.7	" + D.S.
8.0	2.0	33.1	$\text{NaCl} + " + 1.2.10$
32.7	5.2	12.9	$1.1.8 + " + "$

1.1.8 =  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 8\text{H}_2\text{O}$ .1.2.10 =  $\text{Na}_2\text{O} \cdot 2\text{B}_2\text{O}_3 \cdot 10\text{H}_2\text{O}$ .

80

D.S. =  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 2\text{NaCl} \cdot 4\text{H}_2\text{O}$ .

Results for the systems  $\text{Na}_2\text{B}_2\text{O}_4 - \text{Na}_2\text{B}_4\text{O}_7 - \text{Na}_2\text{HPO}_4 - \text{Na}_3\text{PO}_4 - \text{H}_2\text{O}$   
and  $\text{Na}_2\text{B}_2\text{O}_4 - \text{Na}_2\text{B}_4\text{O}_7 - \text{Na}_2\text{HPO}_4 - \text{Na}_3\text{PO}_4 - \text{NaCl} - \text{H}_2\text{O}$  at  $20^\circ$  are given  
by Teeple, 1929.

THE SYSTEM  $\text{NaBO}_2 - \text{Na}_2\text{CO}_3 - \text{NaCl} - \text{H}_2\text{O}$  AT  $35^\circ$   
(Teeple, 1929)

Gms. per 100 gms. $\text{H}_2\text{O}$			Solid Phase
$\text{Na}_2\text{B}_2\text{O}_4$	$\text{NaCl}$	$\text{Na}_2\text{CO}_3$	
8.3	33.5	-	D.S. + $\text{NaCl}$
24.0	-	33.0	$1.1.8 + \text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
32.8	13.7	-	" + D. S.
6.8	21.2	22.8	D.S. + $\text{NaCl} + \text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
26.9	6.9	26.2	" + $1.1.8 + "$

1.1.8 =  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 8\text{H}_2\text{O}$ ; D.S. =  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 2\text{NaCl} \cdot 4\text{H}_2\text{O}$ .THE SYSTEM  $\text{NaBO}_2 - \text{Na}_3\text{PO}_4 - \text{NaCl} - \text{H}_2\text{O}$  AT  $20^\circ$   
(Teeple, 1929)Gms. per 100 gms.  $\text{H}_2\text{O}$ 

$\text{Na}_2\text{B}_2\text{O}_4$	$\text{Na}_3\text{PO}_4$	$\text{NaCl}$	Solid Phase	
1.17	11.2	-	$\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O} + \text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 2\text{Na}_3\text{PO}_4 \cdot 36\text{H}_2\text{O}$	
0.2	2.9	-	$\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 2\text{Na}_3\text{PO}_4 \cdot 36\text{H}_2\text{O}$	
25.5	0.03	-	" + 1.1.8	
23.0	-	19.2	$\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 2\text{NaCl} \cdot 4\text{H}_2\text{O} + "$	
8.0	-	33.0	" + $\text{NaCl}$	
-	1.9	35.0	$\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O} + "$	
23.0	0.2	19.2	$1.1.8 + \text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 2\text{NaCl} \cdot 4\text{H}_2\text{O} + \text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 2\text{Na}_3\text{PO}_4 \cdot 36\text{H}_2\text{O}$	
8.0	0.15	33.0	" + "	
0.6	1.5	35.0	$\text{NaCl} + "$	
0.4	2.0	35.0	$\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O} + \text{NaCl} + "$	

A 3 dimensional diagram of the system  $\text{NaBO}_2 - \text{NaF} - \text{H}_2\text{O}$  from  $70^\circ$  to  $200^\circ \text{ F.}$  is draw by King, 1954

## Na SODIUM

BO SODIUM TETRABORATE  $\text{Na}_2\text{B}_4\text{O}_7$ SOLUBILITY OF SODIUM TETRABORATE IN WATER  
(Blasdale and Slansky, 1939)

(Menzel and Schulz, 1940 - interpolated values given in parentheses)  
(Benrath, 1942 - above  $100^\circ$ )  
(Earlier solution compositions found by Horn and Van Wagener, 1903;  
Sborgi, 1924; Sborgi, Bovalini and Cappellini, 1924. and Menzel, 1927  
agree with these results)

The pentahydrate is metastable over the entire temperature range.  
The stable phase above  $58.5^\circ$  is  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$  (Kernite) rather than  
 $\text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$  as had been previously supposed. The pentahydrate is  
remarkably stable even at the boiling point, but solutions containing  
the salt which were kept at  $95^\circ$  for five days gradually became less  
concentrated as the tetra hydrate was formed.

$t^\circ$	Gms. $\text{Na}_2\text{B}_4\text{O}_7$ per 100 gms. Sat. Sol.	Solid Phase
0	1.18	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
5	1.44	"
10	1.76	"
15	2.12	"
20	2.58 (2.47)	"
25	3.13 (3.06)	"
30	3.85 (3.84)	"
35	4.76 (4.80)	"
40	6.00 (5.93)	"
45	7.58 (7.40)	"
50	9.55 (9.31)	"
55	12.25 (12.1)	"
58.5 (58.2)	14.52 (17.4)	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O} + \text{Na}_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$
60	14.82 (14.80)	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$
65	15.88 (15.90)	"
70	17.12 (17.22)	"
75	18.41 -	"
80	19.88 (19.99)	"
85	21.48 -	"
90	23.31 (23.41)	"
95	25.55 -	"
100	28.22 -	"
m60.8 (60.6)	16.65 (16.55)	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O} + \text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$
m35	- (11.99)	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$
m45	- (12.88)	"
m55	- (15.05)	"
m65	17.88 -	"
m70	19.49 (19.37)	"
m75	21.30 -	"
m80	23.38 (23.4)	"
m85	25.73 -	"
m90	28.37 (27.7)	"
m95	31.28	"
m100	34.63	"
*102.8	36.73	"

\*boiling point

(Cont.)

m = Metastable

## SOLUBILITY OF SODIUM TETRABORATE IN WATER--Cont.

t°	Gms. $\text{Na}_2\text{B}_4\text{O}_7$ per 100 gms. Sat. Sol.	Solid Phase
108	38	
116	43	
121	48	
125	52.8	
126	53.9	
130	57	
132	60	
135	63.1	
137	66.	
140	69.1	

80

For a study of the species present in  $\text{Na}_2\text{B}_4\text{O}_7$  solutions see  
Lourijssen-Teyssedre, 1955

THE SYSTEM SODIUM TETRABORATE - SODIUM CARBONATE - WATER  
(Umeda, 1945; Antonova and Polyntseva, 1957; Hill, 1945)

Gms. per 100 gms. Sat. Sol.

$\text{Na}_2\text{CO}_3$	$\text{Na}_2\text{B}_4\text{O}_7$	Solid Phase
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Results at 25° (A. + P.)

0	3.11	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
2.20	2.24	"
3.37	2.15	"
4.99	2.22	"
7.92	2.31	"
8.62	2.32	"
10.41	2.33	"
12.46	2.41	"
15.72	2.51	"
18.93	2.47	"
21.69	2.50	"
23.60	2.45	" + $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$
22.84	0.94	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$
22.80	0	"

Results at 30° (U.)

28.81	1.22	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$
29.95	2.65	"
28.75	2.73	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O} + \text{Na}_2\text{CO}_3 \cdot 6\text{H}_2\text{O}$
28.89	2.73	"
29.03	2.59	$\text{Na}_2\text{CO}_3 \cdot 6\text{H}_2\text{O}$
29.67	3.28	"
29.62	3.38	$\text{Na}_2\text{CO}_3 \cdot 6\text{H}_2\text{O} + \text{Na}_2\text{CO}_3 \cdot 4\text{H}_2\text{O}$
29.33	3.27	$\text{Na}_2\text{CO}_3 \cdot 4\text{H}_2\text{O}$
28.89	4.36	"

(Cont.)

# Na SODIUM

## THE SYSTEM SODIUM TETRABORATE - SODIUM CARBONATE - WATER--Cont.

Gms. per 100 gms. Sat. Sol.

	$\text{Na}_2\text{CO}_3$	$\text{Na}_2\text{B}_4\text{O}_7$	Solid Phase
	<u>Results at 35° (U.)</u>		
	32.65	0.77	$\text{Na}_2\text{CO}_3 \cdot 6\text{H}_2\text{O}$
	32.48	1.65	"
	32.77	1.79	"
	32.52	1.81	$\text{Na}_2\text{CO}_3 \cdot 4\text{H}_2\text{O}$
	32.50	2.22	"
	32.16	2.59	"
	31.27	3.12	$\text{Na}_2\text{CO}_3 \cdot 2\text{H}_2\text{O}$
	31.02	4.28	"
	30.53	4.57	"
	29.61	5.31	"
	28.73	5.51 (d.)	"
	20.46	3.28 (1.243) (H)	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
	17.32	3.30 (1.210) (H)	"
	14.02	3.19 (1.172) (H)	"
	10.47	3.40 (1.134) (H)	"
	6.41	3.41 (1.090) (H)	"
	3.27	3.33 (1.058) (H)	"
	0.0	4.83 (1.036) (H)	"

BO

	<u>Results at 50° (A. + P.)</u>		
	0.0	9.80	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
	4.59	7.46	"
	7.71	6.98	"
	11.37	6.96	"
	14.84	6.98	"
	16.53	6.90	"
	20.11	6.99	"
	23.68	7.06	"

	<u>Results at 55° (U.)</u>		
	3.31	10.01	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
	4.64	9.50	"
	8.09	9.15	"
	17.38	9.36	"
	18.18	9.26	"
	18.34	9.51	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O} + \text{Na}_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$
	20.65	9.16	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$
	20.40	6.35	"
	24.09	7.69	"
	26.76		$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$

	<u>Results at 60° (U.)</u>		
	2.22	14.29	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$
	7.57	12.88	"
	11.22	12.19	"
	14.25	10.89	"
	24.24	7.80	"
	27.44	10.11	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$

THE SYSTEM SODIUM TETRABORATE - SODIUM BICARBONATE - WATER  
(Antonova and Polyntseva, 1957)

at 25°			at 50°		
Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	NaHCO <sub>3</sub>		Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	NaHCO <sub>3</sub>	
3.13	0.0	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O	9.80	0.0	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O
2.67	1.66	"	8.70	1.60	"
2.47	3.32	"	8.55	4.48	"
2.35	5.48	"	8.80	5.89	"
2.31	6.91	"	9.07	11.26	"
2.26	9.54	" + NaHCO <sub>3</sub>	6.73	11.64	" + NaHCO <sub>3</sub>
1.68	9.43	NaHCO <sub>3</sub>	5.90	11.83	NaHCO <sub>3</sub>
1.33	9.49	"	4.26	12.03	"
0.0	9.61	"	2.66	12.18	"
			0.0	12.70	"

THE SYSTEM Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub> - NaHCO<sub>3</sub> - Na<sub>2</sub>CO<sub>3</sub> - H<sub>2</sub>O  
(Antonova and Polyntseva, 1957)

Sat. Sol. Wt. %				Wat Residue Wt. %			Solid Phase
Na <sub>2</sub> O	B <sub>2</sub> O <sub>3</sub>	CO <sub>2</sub>	H <sub>2</sub> O	Na <sub>2</sub> O	B <sub>2</sub> O <sub>3</sub>	CO <sub>2</sub>	
Results at 25°							
13.72		10.28	76.00				NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O + Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O
13.92	0.62	10.06	75.40				
14.64	1.63	10.04	73.69	21.74	12.42	14.04	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O + NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O + Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O
11.96		9.59	78.45				NaHCO <sub>3</sub> + NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O
12.21	0.76	9.30	77.73	24.78	0.43	22.78	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O + NaHCO <sub>3</sub> + NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O
12.79	1.38	9.35	76.48	29.45	3.80	26.75	
4.21	1.57	4.98	89.24	20.78	14.86	20.14	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O + NaHCO <sub>3</sub>
6.20	1.27	5.76	86.77	17.66	18.25	14.35	
7.72	1.29	6.58	84.41	18.78	21.31	13.37	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O + NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O + NaHCO <sub>3</sub>
12.79	1.38	9.35	76.48	29.45	3.80	26.75	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O + NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O + Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O
14.64	1.63	10.04	73.69	21.74	12.42	14.04	
Results at 35° (Nall, 1945)							
16.14	2.52	10.46	70.88	-	-	-	NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O
17.94	3.27	11.15	67.64	-	-	-	
18.95	2.88	11.90	66.27	-	-	-	NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O
16.13	2.49	10.55	70.83	-	-	-	
17.78	3.27	11.01	67.94	-	-	-	NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
19.25	4.35	11.31	65.09	-	-	-	NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + NaHCO <sub>3</sub>
12.41	1.99	9.26	76.33	-	-	-	
Results at 50°							
18.91	13.53	67.56					Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O + NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O
16.72	1.77	11.37	70.14	33.02	1.02	30.20	
16.55	2.86	10.86	69.73	33.54	0.71	30.28	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O + NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
16.47	3.85	10.31	69.37	32.22	1.70	28.88	
17.09	5.46	10.02	67.43				NaHCO <sub>3</sub> + NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O
17.72	6.43	10.08	65.77	29.20	7.06	23.31	
12.21		10.32	77.47				Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O + NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O
12.64	1.70	10.01	75.62	31.84	0.66	35.44	NaHCO <sub>3</sub> + NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O
12.84	3.01	9.67	74.48	30.60	1.38	33.00	
13.10	3.96	9.33	73.61	27.40	6.20	27.49	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O + NaHCO <sub>3</sub> + NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O
6.95	6.38	5.90	80.87	22.39	13.25	23.47	
11.22	4.07	8.25	76.46	21.88	17.71	19.29	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O + NaHCO <sub>3</sub>
13.10	3.96	9.33	73.61	27.40	6.20	27.49	
13.69	3.99	9.34	72.98	24.87	12.19	18.22	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O + NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O
14.47	4.32	9.61	71.60	23.58	15.75	14.83	
16.27	5.07	9.93	68.73	23.98	13.97	16.00	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O + NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O
16.52	5.27	9.83	68.38	24.40	16.46	14.86	
16.80	5.70	9.86	67.64	30.77	3.75	25.97	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O + NaHCO <sub>3</sub> ·Na <sub>2</sub> CO <sub>3</sub> ·2H <sub>2</sub> O + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
17.72	6.43	10.08	65.77	29.20	7.06	23.29	

# Na SODIUM

## THE QUATERNARY SYSTEM $\text{Na}_2\text{O} - \text{B}_2\text{O}_3 - \text{CO}_2 - \text{H}_2\text{O}$ AT $35^\circ$ (Hill, 1945)

Gms. per 100 gms. Sat. Sol.

$\text{Na}_2\text{O}$	$\text{B}_2\text{O}_3$	$\text{CO}_2$	Density	Solid Phase
19.2	-	13.8	-	7 + S*
11.9	-	9.6	-	S + H*
16.14	2.52	10.46	1.304	S
17.94	3.27	11.15	1.348	S
18.95	2.88	11.90	1.360	S
16.13	2.49	10.55	1.306	S + B
17.78	3.27	11.01	1.343	S + B
19.25	4.35	11.31	1.379	M + B + S
12.41	1.99	9.26	1.232	H + B + S

80

7 =  $\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$       S =  $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$       H =  $\text{NaHCO}_3$

B =  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$       M =  $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$

\*Freeth; Phil. Trans. 1922, A, 223 65.

## THE SYSTEM $\text{Na}_2\text{B}_4\text{O}_7 - \text{NaHCO}_3 - \text{NaCl} - \text{H}_2\text{O}$ AT $35^\circ$ (Teeple, 1929)

gms per 100 gms $\text{H}_2\text{O}$			Solid Phase
$\text{Na}_2\text{B}_4\text{O}_7$	$\text{NaCl}$	$\text{NaHCO}_3$	
2.2	35.2	-	$\text{NaCl} + \text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
4.6	-	12.6	$\text{NaHCO}_3 +$
2.5	34.8	2.1	" + " + $\text{NaCl}$

## SOLUBILITY OF MIXTURES OF SODIUM TETRABORATE + SODIUM CHLORIDE IN MAGNESIUM SULFATE SOLUTIONS (Schlesinger, Feigelson, and Spiriagina, 1938)

Each solution was saturated with both  $\text{Na}_2\text{B}_4\text{O}_7$  and  $\text{NaCl}$ .

Results at  $35^\circ$

Gms. per 100 gms. Sat. Sol.

$\text{MgSO}_4$	$\text{NaCl}$	$\text{Na}_2\text{B}_4\text{O}_7$	Density
0.0	25.93	1.42	1.2034
1.34	25.05	2.14	1.2199
2.64	24.10	3.10	1.2373
3.82	23.17	3.76	1.2512
5.03	22.14	4.68	1.2670
6.00	20.92	5.83	1.2834

Results at  $50^\circ$

Gms. per 100 gms. Sat. Sol.

$\text{MgSO}_4$	$\text{NaCl}$	$\text{Na}_2\text{B}_4\text{O}_7$
1.51	24.38	3.75
4.15	22.27	4.32
7.02	20.65	4.69

THE SYSTEM  $\text{Na}_2\text{B}_4\text{O}_7 - \text{NaF} - \text{H}_2\text{O}$  AT  $25^\circ$   
(Ryas, Slutskaya and Vitukhnovskaya, 1951)

sat sol wt %		density	solid phase	sat sol wt %		density	solid phase
$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$	NaF			$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$	NaF		
0.0	3.79	-	A	3.02	2.84	1.046	B
0.98	3.48	1.046	A	3.12	2.56	-	B
2.00	3.37	-	A	3.35	1.87	-	B
2.08	3.43	1.050	A	3.39	1.91	1.040	B
2.79	3.46	1.054	A + B	4.27	0.90	-	B
				5.82	0.0	-	B

A = NaF      B =  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$

A three dimensional diagram of the system  $\text{Na}_4\text{B}_2\text{O}_7 - \text{NaF} - \text{H}_2\text{O}$  from  $70^\circ$  to  $200^\circ\text{F}$  is drawn by King, 1954

THE SYSTEM  $\text{Na}_2\text{B}_4\text{O}_7 - \text{Na}_2\text{HPO}_4 - \text{NaCl} - \text{H}_2\text{O}$  AT  $20^\circ$   
(Teeple, 1929)

Gms. per 100 gms. $\text{H}_2\text{O}$			Solid Phase
$\text{Na}_2\text{B}_4\text{O}_7$	$\text{Na}_2\text{HPO}_4$	NaCl	
2.0	2.6	-	1.2.10
1.5	6.7	-	" + $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$
-	7.0	33.8	NaCl + "
0.85	-	36.5	" + 1.2.10
0.8	0.7	35.7	" + "
0.8	2.7	34.8	" + "
1.0	7.2	33.3	" + "
1.0	7.8	32.5	" + " + $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$ .

1.2.10 =  $\text{Na}_2\text{O} \cdot 2\text{B}_2\text{O}_3 \cdot 10\text{H}_2\text{O}$ .

THE SYSTEM SODIUM TETRABORATE - SODIUM SULFATE - WATER  
(Sborgi, Bovalini and Cappellini, 1924)

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Na}_2\text{B}_4\text{O}_7$	$\text{Na}_2\text{SO}_4$	
		at $-0.45^\circ$
1.086	0.0	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ + Ice
		at $-1.38^\circ$
0.631	3.82	" + $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ + Ice
		at $-1.20^\circ$
0.0	3.85	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ + Ice

(Cont.)



## Na SODIUM

## THE SYSTEM SODIUM TETRABORATE - SODIUM SULFATE - WATER--Cont.

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Na}_2\text{B}_4\text{O}_7$	$\text{Na}_2\text{SO}_4$	
		<u>at +10°</u>
1.603	0.0	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
1.086	1.843	"
0.806	4.383	"
0.704	8.36	" + $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
0.0	8.43	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
		<u>at 20°</u>
2.52	0.0	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
1.108	9.238	"
1.00	16.11	" $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
0.0	16.23	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
		<u>at 25°</u>
3.087	0.0	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
2.626	1.187	"
2.057	3.22	"
1.442	9.645	"
1.300	12.66	"
1.248	15.57	"
1.229	16.76	"
1.200	17.38	"
1.131	21.926	" + $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
0.326	21.91	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
0.0	21.90	"
		<u>at 30°</u>
3.75	0.0	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
1.27	28.78	" + $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
0.0	28.6	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
		<u>at 31.9°</u>
1.41	32.38	" + $\text{Na}_2\text{SO}_4$ + $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
		<u>at 35°</u>
4.829	0.0	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
3.405	3.665	"
1.798	24.18	"
1.73	26.95	"
1.603	31.64	"
1.579	32.25	" + $\text{Na}_2\text{SO}_4$
1.263	32.60	$\text{Na}_2\text{SO}_4$
0.554	32.91	"
0.00	33.07	"

(Cont.)

## THE SYSTEM SODIUM TETRABORATE - SODIUM SULFATE - WATER--Cont.

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Na}_2\text{B}_4\text{O}_7$	$\text{Na}_2\text{SO}_4$	
<u>at 45°</u>		
7.49	0.00	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
6.361	4.258	"
4.112	13.992	"
3.124	30.15	" + $\text{Na}_2\text{SO}_4$
1.145	31.273	$\text{Na}_2\text{SO}_4$
0.600	41.649	"
<u>at 49.3°</u>		
4.584	29.245	$\text{Na}_2\text{SO}_4$ + $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ + $\text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$
<u>at 50°</u>		
9.52	0.0	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
6.936	7.978	"
5.116	21.171	"
4.760	25.482	"
4.61	29.00	" + $\text{Na}_2\text{SO}_4$
1.872	30.62	$\text{Na}_2\text{SO}_4$
0.92	31.09	"
0.0	31.9	"
<u>at 55°</u>		
12.37	0.0	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
8.473	13.05	"
8.06	16.97	" + $\text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$
7.884	17.646	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$
7.58	18.31	"
7.68	20.97	"
7.44	21.21	"
6.49	26.23	"
5.99	28.08	" + $\text{Na}_2\text{SO}_4$
0.0	31.575	$\text{Na}_2\text{SO}_4$
<u>at 65°</u>		
17.953	0.0	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$
16.10	3.71	"
15.98	3.94	"
10.46	17.08	"
7.90	26.47	" + $\text{Na}_2\text{SO}_4$
2.86	29.37	$\text{Na}_2\text{SO}_4$
<u>at 80°</u>		
23.9	0.0	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$
14.57	22.38	" + $\text{Na}_2\text{SO}_4$

(Cont.)

# Na SODIUM

## THE SYSTEM SODIUM TETRABORATE - SODIUM SULFATE - WATER--Cont.

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Na}_2\text{B}_4\text{O}_7$	$\text{Na}_2\text{SO}_4$	
<u>at 102.9° (b.pt.)</u>		
37.07	0.0	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$
<u>at 104°</u>		
28.15	15.89	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O} + \text{Na}_2\text{SO}_4$

80

Results for the system  $\text{Na}_2\text{B}_4\text{O}_7 + (\text{NH}_4)_2\text{SO}_4 \rightleftharpoons (\text{NH}_4)_2\text{B}_4\text{O}_7 + \text{Na}_2\text{SO}_4$  (+H<sub>2</sub>O) at 25° are given by Sborgi, Bovalini and Cappellini, 1924.

A diagram of the system  $\text{Na}_2\text{B}_4\text{O}_7 - \text{Na}_2\text{SO}_4 - \text{H}_3\text{BO}_3 - \text{H}_2\text{O}$  at 0°, 35° and 90° is drawn by Zdanovskii (1949). The system had been studied earlier by other Russian workers.

## SOLUBILITY OF SODIUM BORATES IN SEVERAL SOLVENTS

Borate	Solvent	t°	Gms. Salt per 100 Gms. Solvent
"Sodium borate"	Alcohol (d = 0.941)	15.5	2.48 (U.S.P. VIII.)
" "	Glycerol	15.5	60.3 (U.S.P. VIII.)
" "	"	80	100 (U.S.P. VIII.)
"Sodium Biborate"	Trichlorethylene	15	0.011 (Wester and Bruins, 1914.)
Sodium Metaborate	Ethylene Glycol	25	6.98 (Palit, 1947)
" "	Propylene Glycol	25	3.36 (Palit, 1947)
$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$	86.5% glycerol	20	89.0 (Holm, 1921, 1921a, 1922)
"	98.5% "	20	111.0 (Holm, 1921, 1921a, 1922)

Fusion-point data for mixtures of  $\text{NaBO}_2 + \text{NaPO}_3$  and  $\text{NaBO}_2 + \text{Na}_2\text{SiO}_3$  are given by Van Klooster (1910(11)). Results for  $\text{NaBO}_2 + \text{Na}_2\text{CrO}_4$  are given by Bergman and Bartbaronov, 1957b.

Melting points in the systems  $\text{Na}_2\text{B}_4\text{O}_7 + \text{NaCl}$  and  $\text{Na}_2\text{B}_4\text{O}_7 + \text{NaF}$  were determined by Bergman and Nikonova, 1942. King, 1954 also gives data for the  $\text{Na}_2\text{B}_4\text{O}_7 + \text{NaF}$  system. Results for  $\text{Na}_2\text{B}_4\text{O}_7 + \text{Na}_4\text{P}_2\text{O}_7$  are given by Le Chatelier (1894).

## SOLUBILITY OF SODIUM PENTABORATE IN WATER

## Results of Rollet and Peng, 1935

t°	Gms. Na <sub>2</sub> B <sub>10</sub> O <sub>16</sub> per 100 gms. sat. sol.	Solid Phase
- 0.53	1.36	Ice
- 0.91	2.68	"
- 1.24	3.94	"
- 1.70E	5.8	" + Na <sub>2</sub> B <sub>10</sub> O <sub>16</sub> ·10H <sub>2</sub> O
0	6.0	Na <sub>2</sub> B <sub>10</sub> O <sub>16</sub> ·10H <sub>2</sub> O
13.5	8.6	"
20	10.7	"
35	15.9	"
50	22.7	"
59.6	27.45	"
70.8	33.7	"
80	38.8	"
85	41.9	"
90	45.5	"
93	47.3	"
96	49.0	"
99	50.9	" + Na <sub>2</sub> B <sub>10</sub> O <sub>16</sub> ·2H <sub>2</sub> O
100	51.8	"
102	53.5*	"
104.5	55.5*	Na <sub>2</sub> B <sub>10</sub> O <sub>16</sub> ·2H <sub>2</sub> O
103	52.7	"
107	54.3	"
108.3	54.8	"
109.6BP	55.3	"

Results of Blasdale  
and Slansky, 1939Solid Phase  
Na<sub>2</sub>B<sub>10</sub>O<sub>16</sub>·10H<sub>2</sub>OGms. Na<sub>2</sub>B<sub>10</sub>O<sub>16</sub>  
100 gms.  
Sat. Sol.

t°	Sat. Sol.
0	6.28
5	7.10
10	8.10
15	9.30
20	10.55
25	12.20
30	13.75
35	15.60
40	17.40
45	19.63
50	21.80
55	24.30
60	26.90
65	29.35
70	32.25
75	34.98
80	37.84
85	40.77
90	43.80
95	47.95
100	50.30

80

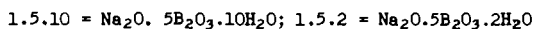
E = Eutec. BP = b.pt.  
\* = metastableTHE SYSTEM SODIUM PENTABORATE - SODIUM CHLORIDE - WATER  
(Peng, Chung-Ming, 1936)1.5.10 = Na<sub>2</sub>O. 5B<sub>2</sub>O<sub>3</sub>.10H<sub>2</sub>O; 1.5.2 = Na<sub>2</sub>O.5B<sub>2</sub>O<sub>3</sub>.2H<sub>2</sub>O.

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
t°	Na <sub>2</sub> O.5B <sub>2</sub> O <sub>3</sub>	NaCl		t°	Na <sub>2</sub> O.5B <sub>2</sub> O <sub>3</sub>	NaCl	
0	1.1	25.6	1.5.10 + NaCl	20	3.85	21.75	1.5.10
20	10.31	0.97	1.5.10	"	3.52	24.92	" + NaCl
"	8.34	2.84	"	"	1.52	25.7	NaCl
"	6.77	6.17	"	"	0.85	26.04	"
"	6.12	7.09	"	35	10.48	5.95	1.5.10
"	4.5	14.8	"	"	9.60	7.35	"

(Cont.)

# Na SODIUM

## THE SYSTEM SODIUM PENTABORATE - SODIUM CHLORIDE - WATER--Cont.



Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
t°	Na <sub>2</sub> O.5B <sub>2</sub> O <sub>3</sub>	NaCl		t°	Na <sub>2</sub> O.5B <sub>2</sub> O <sub>3</sub>	NaCl	
35	7.26	13.84	1.5.10	80	22.6	13.8	1.5.2
"	6.68	16.80	"	"	17.1	18.9	"
"	5.50	24.29	" + NaCl	"	15.2	20.5	" + NaCl
"	4.07	25.02	NaCl	"	10.44	22.8	NaCl
"	1.65	25.89	"	"	4.2	25.6	"
"	0.98	26.18	"	93	44.2	2.1	1.5.10 + 1.5.2
70	25.7	6.2	1.5.10	"	42.1	3.1	1.5.2
"	24.3	7.25	"	"	34.0	7.3	"
"	22.7	9.3	"	"	25.5	13.4	"
"	21.6	11.1	"	"	19.0	19.1	" + NaCl
"	20.2	12.7	"	"	13.7	21.6	NaCl
"	19.2	14.8	" + 1.5.2	"	5.6	25.6	"
"	15.6	17.5	1.5.2	100	43.3	3.5	1.5.2
"	14.8	18.2	"	"	42.1	4.2	"
"	13.3	20.4	"	"	35.1	8.26	"
"	11.6	21.9	" + NaCl	"	30.1	11.50	"
"	4.6	25.1	NaCl	"	28.4	13.1	"
"	7.8	23.8	"	"	25.8	15.1	"
80	35.3	2.8	1.5.10	"	24.9	16.35	"
"	33.2	4.8	"	"	24.2	17.2	" + NaCl
"	29.1	8.6	" + 1.5.2	"	16.4	20.6	NaCl
"	26.5	10.5	1.5.2	"	7.1	25.0	"

## BO SODIUM PERBORATE NaBO<sub>3</sub>

The transition temperature for the equilibrium  $\text{NaBO}_3 \cdot 4\text{H}_2\text{O} \rightleftharpoons \text{NaBO}_3 \cdot 3\text{H}_2\text{O} + \text{H}_2\text{O}$  is  $15 \pm 2^\circ$  (van Gelder, 1956)

## BO SODIUM TETRAALKOXY BOROHYDRIDES NaB(OR)<sub>4</sub>

### SOLUBILITIES IN VARIOUS SOLVENTS (Brown and Mead, 1956)

Solvent	t°	gms per liter sat. sol.		
		Methyl	Ethyl	isopropyl
Benzene	70	0	0	0
Ethyl ether	25	0	0	0
Acetonitrile	70	0	0	0
Methyl alcohol	0	272	-	-
	25	334	-	-
Ethyl alcohol	0	-	96	-
	25	-	113	-

(Cont.)

## SODIUM Na

## SOLUBILITIES IN VARIOUS SOLVENTS--Cont.

Solvent	t°	gms per liter sat. sol.		
		Methyl	Ethyl	isopropyl
isopropyl alcohol	0	-	-	24
	25	-	-	29
Triglyme	25	-	-	5.4
Tetrahydrofuran	0	v.sol. <sup>a</sup>	v.sol. <sup>a</sup>	7
	25	467	v.sol. <sup>a</sup>	10

<sup>a</sup>very soluble; solutions very viscousSODIUM DIFLUORO-ORTHOBORATE Na<sub>3</sub>B<sub>3</sub>O<sub>3</sub>F<sub>6</sub>

B0

At 15° a saturated solution contains 19.5% of Na<sub>3</sub>B<sub>3</sub>O<sub>3</sub>F<sub>6</sub>. Some results in NaI solutions are also given (Ryss, 1954)

## SODIUM BROMIDE NaBr

Br

## SOLUBILITY OF SODIUM BROMIDE IN WATER

The results of Rudorff, 1862; Guthrie, 1875; de Coppet, 1883; Richards and Churchill, 1899; Etard, 1894; Cocheret, 1911; Greenish, 1900; Scott and Frazier, 1927; Scott and Durham, 1930; Nikolaew and Rawitch, 1931; Keevil, 1942 and Ricci, 1934, were plotted and the following values taken from the average curve.

The figures in parentheses are densities of the sat. solutions.

The lower of the two values given for the temperatures above 100° are taken from a curve plotted from the results of Distanow, 1937.

t°	Gms. NaBr per 100 gms. sat. sol.		Solid Phase	t°	Gms. NaBr per 100 gms. sat. sol.		Solid Phase
-5	12.5		Ice	30	49.6		NaBr.2H <sub>2</sub> O
-10	21.0		"	35	50.48(1.5655)		"
-15	27.5		"	45.21	52.66(1.5950)		"
-20	33.0		"	50.21	53.80(1.6108)		"
-25	37.7		"	51.0	53.9		" + NaBr
-28	40.3		" + NaBr.2H <sub>2</sub> O	60.17	54.10(1.6073)		NaBr
-20	41.8		NaBr.2H <sub>2</sub> O	75.44	54.41(1.5986)		"
-10	42.9		"	91.95	54.83(1.5915)		"
0	44.47(1.4954)		"	100	53.8-54.8		"
+10	46.0		"	140	55.5-56.5		"
16.4	47.0 (1.523)		"	180	57.4-59.5		"
20	47.6		"	210	58.8-60.9		"
25	48.61(1.5418)		"	230	59.8-62.0		"
				250	61.0-63.0		"
				300	- 66.1		"
				350	- 69.8		"

# Na SODIUM

## SOLUBILITY OF SODIUM BROMIDE IN DEUTERIUM OXIDE (Eddy and Menzies, 1940)

Solid Phase NaBr·2D <sub>2</sub> O			Solid Phase NaBr					
t°	Gms. NaBr per 100 gms. D <sub>2</sub> O		t°	Gms. NaBr per 100 gms. D <sub>2</sub> O		t°	Gms. NaBr per 100 gms. D <sub>2</sub> O	
0	78.3		40	11.26(m)		110	12.03	
10	83.6		50	11.31		120	12.20	
20	89.8		60	11.39		130	12.40	
30	97.1		70	11.48		140	12.61	
40	105.6		80	11.59		150	12.84	
47.4	113.0*		90	11.72		160	13.11	
			100	11.88		170	13.39	

Br

\*Solid Phases: NaBr·2D<sub>2</sub>O + NaBr

(m) = Metastable

## SOLUBILITY OF SODIUM BROMIDE IN AQUEOUS SOLUTIONS OF HYDROBROMIC ACID AT SEVERAL TEMPERATURES (Nikolaew and Rawitch, 1931)

Results in parentheses are by Scott and Durham, 1930

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	HBr	NaBr			HBr	NaBr	
<u>Results at 25°</u>				<u>Results at 44.5°</u>			
1.5426	0.0	48.56	NaBr.2H <sub>2</sub> O	1.5912	0.0	52.56	NaBr.2H <sub>2</sub> O
1.5245	3.03	44.97	"	1.5782	3.94	47.87	"
--	(4.61)	(42.55)	"	1.5560	10.21	40.76	"
1.4989	8.84	38.20	"	1.5455	11.49	39.51	NaBr
--	(9.04)	(37.19)	"	1.5361	12.76	37.62	"
--	(12.98)	(32.62)	"	1.5121	17.89	31.36	"
1.4789	14.22	31.68	"	1.4961	21.91	26.74	"
--	(17.65)	(27.31)	"				
1.4642	18.69	27.24	"				
1.4534	23.10	22.21	"				
1.4468	28.77	16.38	"				
1.4484	33.16	12.84	"	1.5850	4.04	47.67	NaBr
--	37.21	9.81	"	1.5596	13.30	33.80	"
--	41.38	6.33	NaBr	1.5689	18.29	27.50	"
1.4825	43.31	4.62	"	1.5689	23.51	22.37	"
1.5260	49.25	1.59	"				
1.6171	55.78	0.40	"				
<u>Results at 65°</u>				<u>Results at 65°</u>			

## SOLUBILITY OF SODIUM BROMIDE IN AQUEOUS SOLUTIONS OF SODIUM HYDROXIDE

(17° - Ditte, 1897)

(25°, 44.5°, 65° - Nikolaew and Rawitch, 1931)

N. and R. also give f. pt. determinations of mixtures of NaBr + HBr and of NaBr + NaOH in water. The existence of NaBr·5H<sub>2</sub>O is shown.

Results at 17°			Results at 25°			Results at 44.5°		
Gms. per 100 Gms. H <sub>2</sub> O		d. of sat. sol.	Gms. per 100 gms. sat. sol.		d. of sat. sol.	Gms. per 100 gms. sat. sol.		Br
NaOH	NaBr		Na <sub>2</sub> O	NaBr		Na <sub>2</sub> O	NaBr	
0.0	91.38	Solid phase NaBr·2H <sub>2</sub> O			Solid phase NaBr·2H <sub>2</sub> O			
3.26	79.86							
9.24	68.85	1.5421	0.87	47.22	1.5955	1.71	50.21	
13.43	64.90	1.5404	2.50	44.51	1.5958	3.98	47.20*	
17.17	63.06	1.5402	4.41	41.94				
19.12	62.51	1.5502	8.96	36.73				
22.35	59.60	1.5634	11.37	34.61				
24.74	55.03				1.5835	6.40	43.22	
28.43	48.00	Solid Phase NaBr			1.5615	12.35	33.94	
36.61	38.41				--	16.68	28.32	
49.96	29.37	--	12.32	33.47				
54.52	24.76	--	14.56	29.89				
		1.5535	19.78	23.42				
		1.5611	24.66	18.71				
		1.5770	27.87	16.10				
		1.6112	32.31	13.35				
					1.5850	4.04	47.67	
					1.5596	13.30	33.80	
					1.5589	18.29	27.50	
					1.5689	23.51	22.37	

\*NaBr·2H<sub>2</sub>O + NaBr present

The solubility of NaBr and the system NaBr - NH<sub>3</sub> - H<sub>2</sub>O from -80° to +215° have been studied by Distanov 1953. The solubility first increases, then goes through a minimum and then increases again as NH<sub>3</sub> is added.

THE SYSTEM SODIUM BROMIDE - SODIUM BROMATE - WATER  
(Ricci, 1934; Klebanov and Banova, 1935 (at 35°))

d. of sat. sol.	Gms. per 100 gms. sat. sol.			d. of sat. sol.	Gms. per 100 gms. sat. sol.		
	NaBr	NaBrO <sub>3</sub>			NaBr	NaBrO <sub>3</sub>	
			Solid Phase				
Results at 10°							
1.492	45.80	0.0	NaBr·2H <sub>2</sub> O	1.240	11.10	14.46	NaBrO <sub>3</sub>
1.517	44.51	2.58	" + NaBrO <sub>3</sub>	1.220	5.33	18.73	"
1.498	43.09	2.83	NaBrO <sub>3</sub>	1.211	0.0	23.24	"
1.452	39.40	3.55	"				

(Cont.)



# Na SODIUM

## THE SYSTEM SODIUM BROMIDE - SODIUM BROMATE - WATER--Cont.

d. of sat. sol.	Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
	NaBr	NaBrO <sub>3</sub>			NaBr	NaBrO <sub>3</sub>		
Br	<u>Results at 25°</u>				<u>Results at 35°</u>			
	1.530	48.41	0.0	NaBr.2H <sub>2</sub> O	50.57	0.0	NaBr.2H <sub>2</sub> O	
	1.546	47.37	1.90	"	47.92	3.31	NaBr.2H <sub>2</sub> O + NaBrO <sub>3</sub>	
	1.555	46.82	2.94	" + NaBrO <sub>3</sub>	39.69	4.94	NaBrO <sub>3</sub>	
	1.542	45.62	3.15	NaBrO <sub>3</sub>	27.94	9.69	"	
	1.462	39.24	4.61	"	18.18	15.30	"	
	1.457	38.66	4.78	"	8.73	22.59	"	
	1.377	29.83	7.86	"	0.0	31.95	"	
	1.320	21.27	12.04	"	<u>Results at 45°</u>			
	1.282	13.82	16.72	"	52.55	0.0	NaBr.2H <sub>2</sub> O	
	1.270	6.46	22.38	"	50.68	3.51	" + NaBrO <sub>3</sub>	
	1.257	0.0	28.29	"	44.39	3.72	NaBrO <sub>3</sub>	
					28.69	11.17	"	
					7.91	26.65	"	

## THE SYSTEM SODIUM BROMIDE - SODIUM BROMATE - SODIUM BICARBONATE - WATER (Klebanov and Basova, 1939)

Results at 25°					Results at 35°				
Gms. per 100 gms. Sat. Sol.			Solid Phases		Gms. per 100 gms. Sat. Sol.			Solid Phases	
NaBr	NaBrO <sub>3</sub>	NaHCO <sub>3</sub>			NaBr	NaBrO <sub>3</sub>	NaHCO <sub>3</sub>		
47.91	0.0	0.44	A, B		49.20	0.0	0.48	A, B	
46.92	1.92	.38	A, B		49.60	0.90	.46	A, B	
46.20	3.06	.42	A, B, C		48.82	1.78	.46	A, B	
46.82	2.94	0.00	A, C		47.94	2.98	.52	A, B	
39.07	4.44	0.62	B, C		47.79	3.20	.50	A, B, C	
31.25	6.95	.70	B, C		47.92	3.31	0.00	A, C	
27.96	8.09	.98	B, C		41.05	4.66	0.60	B, C	
18.97	12.18	1.50	B, C		33.85	6.92	.78	B, C	
10.08	17.44	3.04	B, C		28.85	8.76	1.04	B, C	
4.34	21.52	3.94	B, C		17.48	15.12	1.60	B, C	
0.0	24.34	4.76	B, C		9.68	19.72	2.94	B, C	
26.85	7.68	1.17	B		0.0	28.02	4.88	B, C	
25.83	7.29	±.33	B						
22.14	6.50	1.50	B						
10.28	2.97	4.52	B						
4.91	1.42	6.52	B						
0.0	0.0	9.34	B						

A = NaBr·2H<sub>2</sub>O  
B = NaHCO<sub>3</sub>  
C = NaBrO<sub>3</sub>

THE SYSTEM SODIUM BROMIDE - SODIUM BROMATE - SODIUM CARBONATE -  
WATER AT 80°  
(Klebanov and Basova, 1939)

Gms. per 100 gms. Sat. Sol.

NaBr	NaBrO <sub>3</sub>	Na <sub>2</sub> CO <sub>3</sub>	Solid Phase
52.67	0.0	1.05	NaBr + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
48.20	6.60	1.18	NaBr + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O + NaBrO <sub>3</sub>
52.20	6.25	0.0	NaBr + NaBrO <sub>3</sub>
29.82	12.26	4.66	NaBrO <sub>3</sub> + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
17.05	17.09	9.34	"
10.81	19.18	11.80	"
0.0	21.88	18.84	"

Br

THE SYSTEM SODIUM BROMIDE - SODIUM BICARBONATE - WATER  
(Klebanov and Basova, 1939)

Results at 25°

Results at 35°

Gms. per 100  
gms. Sat. Sol.Gms. per 100  
gms. Sat. Sol.

NaBr	NaHCO <sub>3</sub>	Solid Phase	NaBr	NaHCO <sub>3</sub>	Solid Phase
48.43	0.0	NaBr·2H <sub>2</sub> O	50.57	0.0	NaBr·2H <sub>2</sub> O
47.91	0.44	NaBr·2H <sub>2</sub> O + NaHCO <sub>3</sub>	49.20	0.48	NaBr·2H <sub>2</sub> O + NaHCO <sub>3</sub>
44.94	.48	NaHCO <sub>3</sub>	47.55	.48	NaHCO <sub>3</sub>
33.80	1.03	"	40.60	.73	"
27.05	2.16	"	31.17	1.45	"
13.60	3.38	"	18.32	3.67	"
7.44	6.49	"	11.19	5.04	"
0.0	9.34	"	0.0	10.55	"

THE SYSTEM SODIUM BROMIDE - SODIUM CARBONATE - WATER AT 80°  
(Klebanov and Basova, 1939)

Gms. per 100  
gms. Sat. Sol.Gms. per 100  
gms. Sat. Sol.

NaBr	Na <sub>2</sub> CO <sub>3</sub>	Solid Phase	NaBr	Na <sub>2</sub> CO <sub>3</sub>	Solid Phase
54.35	0.0	NaBr	29.58	8.64	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
52.67	1.05	NaBr + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O	16.25	17.26	"
47.74	1.90	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O	10.47	21.86	"
42.35	3.28	"	0.0	30.95	"
35.05	5.91	"			

# Na SODIUM

## THE SYSTEM SODIUM BROMIDE - SODIUM CHLORIDE - WATER (Vlassov and Bergman, 1943; Bergman and Vlassov, 1949)

The salts form continuous dihydrated solid solutions below 0.15° and continuous anhydrous solid solutions above 50.2°. Between these temperatures both series are found. More detailed results at 8-10° are reported by Bakowkij and Polanskij, 1927.

	Gms. per 100 gms. Sat. Sol.		Solid Phase		Gms. per 100 gms. Sat. Sol.		Solid Phase	
	NaBr	NaCl			NaBr	NaCl		
	<u>Results at -20°</u>				<u>Results at -10°</u>			
Br	32.8	0.0	Ice		21.6	0.0	Ice	
	32.1	0.8	"		19.6	1.6	"	
	29.2	2.6	"		9.2	7.8	"	
	17.8	10.2	"		0.0	13.4	"	
	8.3	16.8	"		0.0	24.8	NaCl·2H <sub>2</sub> O	
	0.0	22.3	"		7.9	20.3	S.S.·2H <sub>2</sub> O	
	0.0	23.7	NaCl·2H <sub>2</sub> O		16.8	15.1	"	
	8.0	19.1	S.S.·2H <sub>2</sub> O		26.9	9.8	"	
	17.0	13.8	"		30.4	8.3	"	
	27.0	9.0	"		33.2	6.4	"	
	30.8	7.0	"		36.2	4.6	"	
	33.7	5.3	"		41.4	1.2	"	
	36.8	3.4	"		42.0	0.9	"	
	40.5	0.9	"		43.2	0.0	NaBr·2H <sub>2</sub> O	
	41.7	0.0	NaBr·2H <sub>2</sub> O					
	<u>Results at 0°</u>				<u>Results at 10°</u>			
	44.3	0.0	NaBr·2H <sub>2</sub> O		45.9	0.0	NaBr·2H <sub>2</sub> O	
	43.7	0.9	S.S.·2H <sub>2</sub> O		44.6	1.0	S.S.·2H <sub>2</sub> O	
	40.8	2.8	"		39.9	4.8	"	
	35.8	5.7	"		37.2	6.2	S.S.·2H <sub>2</sub> O + S.S.	
	32.8	7.5	"		35.3	7.1	S.S.	
	30.0	9.3	"		32.6	8.6	"	
	26.6	11.0	"		29.7	10.0	"	
	21.4	14.0	S.S.·2H <sub>2</sub> O + S.S.		26.5	11.45	"	
	0.0	26.2	NaCl·2H <sub>2</sub> O		16.6	16.8	"	
					7.8	21.6	"	
					0.0	26.33	NaCl	
	<u>Results at 20°</u>				<u>Results at 25°</u>			
	47.6	0.0	NaBr·2H <sub>2</sub> O		48.6	0.0	NaBr·2H <sub>2</sub> O	
	46.8	0.8	S.S.·2H <sub>2</sub> O		47.6	1.0	S.S.·2H <sub>2</sub> O	
	46.6	1.0	"		46.3	1.8	"	
	43.8	2.8	"		44.6	3.4	S.S.·2H <sub>2</sub> O + S.S.	
	42.4	4.3	S.S.·2H <sub>2</sub> O + S.S.		43.2	4.1	S.S.	
	39.8	5.2	S.S.		39.8	5.2	"	
	35.2	7.3	"		35.2	7.35	"	
	32.55	8.65	"		32.5	8.65	"	
	29.7	10.1	"		29.7	10.10	"	
	26.5	11.5	"		26.5	11.5	"	
	16.5	16.9	"		16.6	17.0	"	
	7.8	21.9	"		7.8	21.9	"	
	0.0	26.37	NaCl		0.0	26.48	NaCl	

(Cont.)

## THE SYSTEM SODIUM BROMIDE - SODIUM CHLORIDE - WATER--Cont.

Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.		
NaBr	NaCl	Solid Phase	NaBr	NaCl	Solid Phase
Results at 30°			Results at 50°		
49.4	0.0	NaBr·2H <sub>2</sub> O	1.75	51.62	S.S.
48.2	1.0	S.S.·2H <sub>2</sub> O	2.06	49.77	"
45.6	3.2	S.S.·2H <sub>2</sub> O + S.S.	3.2	46.38	"
43.1	4.1	S.S.	6.14	38.33	"
39.8	5.2	"	6.84	36.80	"
35.2	7.40	"	19.15	13.21	"
32.5	8.65	"	19.26	13.30	"
29.7	10.2	"	26.93	0.0	NaCl
26.50	11.6	"			
16.6	17.0	"			
7.7	22.0	"			
0.0	26.52	NaCl			

Br

## Additional Data

t°	Gms. per 100 gms. Sat. Sol.		Solid Phase	t°	Gms. per 100 gms. Sat. Sol.		Solid Phase
	NaBr	NaCl			NaBr	NaCl	
-23.8	41.2	0.0	B <sub>5</sub> + B <sub>2</sub>	-21.3	0.0	23.5	C <sub>2</sub> + I
-28.2	40.3	0.0	B <sub>5</sub> + I	+50.2	53.4	0.0	B <sub>2</sub> + B
-23.2	40.0	1.1	B <sub>5</sub> + S <sub>2</sub>	+32.5	45.6	3.2	S <sub>2</sub> + S
-23.5	37.0	2.6	"	+13.4	39.8	5.0	"
-24.0	33.9	4.9	"	+ 8.0	35.2	7.0	"
-27.2	37.7	0.7	B <sub>5</sub> + I	+ 6.0	32.6	8.5	"
-27.0	37.2	0.9	"	+ 4.0	30.0	10.0	"
-28.0	34.6	2.7	"	+ 2.0	26.4	11.4	"
-29.0	31.1	6.2	S <sub>2</sub> + I	- 2.0	16.5	16.7	"
-28.8	27.4	8.2	"	- 3.0	7.9	21.3	"
-27.6	17.2	13.2	"	+ 0.15	0.0	26.3	C <sub>2</sub> + C
-22.5	8.0	18.8	"	+22.0	43.2	4.1	S <sub>2</sub> + S
-29.2	31.6	6.0	S <sub>2</sub> + S <sub>5</sub> + I				

B = NaBr

C = NaCl

S<sub>2</sub> = Dehydrated Solid SolutionB<sub>2</sub> = NaBr·2H<sub>2</sub>OC<sub>2</sub> = NaCl·2H<sub>2</sub>O

S = Anhydrous Solid Solution

B<sub>5</sub> = NaBr·5H<sub>2</sub>O

I = Ice

S<sub>5</sub> = Pentahydrated Solid Solution

# Na SODIUM

## THE SYSTEM NaBr - NaCl - 6.611 M NaOH AT 35° (Simons, Orlick and Vaughan, 1952)

In 6.6 M NaOH both phases are anhydrous at 35°. Contrary to theoretical calculations, no miscibility gap in the anhydrous solid solutions was observed.

	Sat. Sol. Wt. %			Sat. Sol. Wt. %			Sat. Sol. Wt. %		
	NaBr	NaCl	% NaBr in S.S.	NaBr	NaCl	% NaBr in S.S.	NaBr	NaCl	% NaBr in S.S.
Br	37.03	0.0	100.0	33.39	1.60	48.9	25.30	3.23	8.2
	35.86	0.70	93.2	32.85	1.75	40.6	21.43	4.27	3.9
	34.72	1.16	88.0	30.82	2.06	22.9	18.23	5.21	3.5
	34.75	1.23	84.9	30.68	2.13	22.0	13.94	6.49	0.88
	34.15	1.46	78.7	29.00	2.46	15.9	8.40	8.58	0
	33.73	1.61	74.5	29.04	2.41	13.9	3.60	10.49	0
	33.68	1.68	66.2	27.11	2.86	10.4	0.0	12.07	0

## THE SYSTEM SODIUM BROMIDE - SODIUM CHLORATE - WATER AT 25° (Ricci, 1944)

Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.		
NaClO <sub>3</sub>	NaBr	Solid Phase	NaClO <sub>3</sub>	NaBr	Solid Phase
50.10	0.0	NaClO <sub>3</sub>	13.89	40.28	NaClO <sub>3</sub> + NaBr·2H <sub>2</sub> O
37.93	11.86	"	12.38	41.16	NaBr·2H <sub>2</sub> O
29.54	20.72	"	8.07	43.74	"
20.87	30.75	"	7.22	44.28	"
16.29	36.77	"	0.0	48.49	"
15.37	38.10	"			

At 50° a solution containing 43.0% NaClO<sub>3</sub> and 16.2% NaBr is saturated with NaClO<sub>3</sub> and anhydrous NaBr. (Ricci, 1944).

## THE SYSTEM SODIUM BROMIDE - SODIUM IODIDE - WATER AT 25° (Scholle, Uhlir and Benes, 1958)

Sat Sol Wt %			Wet Residue Wt %		Solid Phase	Sat Sol Wt %			Wet Residue Wt %		Solid Phase
NaI	NaBr		NaI	NaBr		NaI	NaBr		NaI	NaBr	
51.1	-		-	-	A	54.9	10.3		57.1	16.45	B + C
63.2	2.1		71.0	1.6	A				52.8	17.9	B + C
62.2	3.0		71.5	1.65	A				50.4	21.5	B + C
60.2	5.0		70.1	2.8	A	54.0	10.9		28.0	43.1	C
59.2	5.8		72.1	1.8	A	51.7	12.1		-	-	C
58.8	6.55		69.0	3.8	A	49.2	13.6		23.6	45.7	C
57.6	8.15		68.3	5.85	A + B	48.2	14.45		-	-	C
			64.0	10.0	A + B	45.5	16.3		-	-	C
			62.6	11.9	A + B	43.4	17.4		14.3	57.6	C
			59.3	13.1	A + B	40.2	19.7		18.6	50.1	C
56.65	8.4		59.3	15.0	B	38.1	21.3		-	-	C
55.75	9.5		57.7	14.25	B	33.7	24.2		10.3	60.2	C

(Cont.)

## THE SYSTEM SODIUM BROMIDE - SODIUM IODIDE - WATER AT 25°--Cont.

Sat. Sol. Wt. %		Wet Residue Wt. %		Solid Phase
NaI	NaBr	NaI	NaBr	
31.5	25.2	12.0	55.9	C
30.5	26.4	13.15	54.1	C
24.75	30.6	9.8	57.3	C
19.3	34.8	6.12	63.3	C
15.4	37.5	8.14	57.6	C
12.7	39.4	5.63	60.0	C
9.6	41.8	4.51	61.4	C
7.7	43.1	2.47	66.1	C
5.1	45.1	2.31	62.6	C
-	48.6	-	-	C

Br

A = NaI·2H<sub>2</sub>O    B = Na(I,Br)·2H<sub>2</sub>O (solid solution)    C = NaBr·2H<sub>2</sub>O

The distribution of iodide ions at 25° between solid and liquid phases in the system NaBr - NaI - H<sub>2</sub>O in solutions containing small amounts of iodide was studied by Cirkov and Schnee, 1939a. See also Cirkov, 1944.

THE SYSTEM SODIUM BROMIDE - SODIUM IODATE - WATER  
(Ricci, 1934)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	NaBr	NaIO <sub>3</sub>		NaBr	NaIO <sub>3</sub>	
<u>Results at 5°</u>				<u>Results at 40°</u>		
1.489	45.08	0.0	NaBr·2H <sub>2</sub> O	51.55	0.0	NaBr·2H <sub>2</sub> O
1.492	45.04	0.075	" + D.S.15	50.84	1.37	" + D.S.10
1.473	43.99	0.084	D.S.15	49.38	1.53	D.S.10
1.415	39.98	0.124	"	47.95	1.77	" + D.S.15
1.287	29.50	0.584	"	46.82	1.89	D.S.15
1.238	24.56	1.09	"	44.86	2.13	"
1.230	23.51	1.28	" + NaIO <sub>3</sub> ·5H <sub>2</sub> O	43.77	2.48	"
1.225	22.95	1.25	NaIO <sub>3</sub> ·5H <sub>2</sub> O	41.96	2.69	" + NaIO <sub>3</sub>
1.132	14.13	1.09	"	42.44	2.52*	NaIO <sub>3</sub>
1.052	4.97	1144	"	40.05	2.63	"
1.027	0.0	3.297	"	39.5	2.65	" + NaIO <sub>3</sub> ·H <sub>2</sub> O
1.227	23.30	1.34*	D.S.15	37.29	2.80*	NaIO <sub>3</sub>
1.215	21.71	1.78*	" + NaIO <sub>3</sub> ·5H <sub>2</sub> O	39.06	2.68	NaIO <sub>3</sub> ·H <sub>2</sub> O
1.204	20.78	1.74*	NaIO <sub>3</sub> ·5H <sub>2</sub> O	32.08	2.77	"
1.123	12.26	2.03*	"	20.65	3.65	"
1.079	6.97	2.52*	"	0.0	11.70	"
1.050	0.0	5.479*	"			

(Cont.)

(Cont.)

\* = Metastable

D.S. 15 = 3NaBr·2NaIO<sub>3</sub>·15H<sub>2</sub>O; D.S.10 = 3NaBr·2NaIO<sub>3</sub>·10H<sub>2</sub>O.

Similar results are also given for the 15°, 35°, and 45° isotherms.

# Na SODIUM

## THE SYSTEM SODIUM BROMIDE - SODIUM IODATE - WATER--Cont.

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	NaBr	NaIO <sub>3</sub>		NaBr	NaIO <sub>3</sub>	
	Results at 25°			Results at 50°		
1.530	48.41	0.00	NaBr.2H <sub>2</sub> O	53.63	0.0	NaBr.2H <sub>2</sub> O
1.537	48.21	0.42	" + D.S.15	53.0	1.57	" + NaBr
1.509	46.73	0.45	D.S.15	52.57	2.37	" + D.S.10
1.417	39.55	0.86	"	51.40	2.49	D.S.10
1.367	35.23	1.51	"	50.93	2.63	" + NaIO <sub>3</sub>
1.343	32.68	2.16	" + NaIO <sub>3</sub> .H <sub>2</sub> O	44.74	2.50	NaIO <sub>3</sub>
1.266	26.39	2.35	NaIO <sub>3</sub> .H <sub>2</sub> O	32.41	3.41	"
1.172	16.40	3.00	"	2.46	5.15	" + NaIO <sub>3</sub> .H <sub>2</sub> O
1.104	7.78	4.46	"	13.28	6.28	NaIO <sub>3</sub> .H <sub>2</sub> O
1.075	0.0	8.569	"	6.63	9.03	"
				0.0	13.49	"

D.S. 15 = 3NaBr.2NaIO<sub>3</sub>.15H<sub>2</sub>O; D.S.10 = 3BaBr.2NaIO<sub>3</sub>.10H<sub>2</sub>O.

Similar results are also given for the 15°, 35°, and 45° isotherms.

## THE SYSTEM SODIUM BROMIDE - SODIUM NITRATE - WATER AT 25° (Ricci, Budish and Borodulis, 1937)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
NaNO <sub>3</sub>	NaBr		NaNO <sub>3</sub>	NaBr	
0.0	48.41	NaBr.2H <sub>2</sub> O	15.72	37.11	NaNO <sub>3</sub>
8.41	44.08	"	19.80	31.54	"
11.36	42.26	"	25.14	24.63	"
13.62	41.05	" + NaNO <sub>3</sub>	31.67	17.02	"
14.42	39.74	NaNO <sub>3</sub>	47.87	0.0	"

## THE SYSTEM SODIUM BROMIDE - LEAD BROMIDE - WATER AT 25° (Roger, 1944)

The index of refraction of many solutions were also determined.

Gms. per 100 gms. Sat. Sol.		Density	Solid Phase	Gms. per 100 gms. Sat. Sol.		Density	Solid Phase
PbBr <sub>2</sub>	NaBr			PbBr <sub>2</sub>	NaBr		
0.975	0.0	1.0049	A	0.364	6.85	-	A
.733	0.221	-	A	.543	9.10	-	A
.502	0.650	-	A	.715	11.23	-	A
.310	1.45	-	A	4.80	22.94	1.264	A
.249	3.12	-	A	17.18	27.77	1.525	A
.332	4.95	-	A	27.15	29.38	1.778	A

A = PbBr<sub>2</sub>

(Cont.)

## THE SYSTEM SODIUM BROMIDE - LEAD BROMIDE - WATER AT 25°--Cont.

Gms. per 100 gms. Sat. Sol.			Solid Phase	Gms. per 100 gms. Sat. Sol.			Solid Phase
PbBr <sub>2</sub>	NaBr	Density		PbBr <sub>2</sub>	NaBr	Density	
30.78	20.34	1.891	A	38.04	34.28	2.299	C, B
36.23	30.76	2.107	A	37.37	34.68	2.275	B
38.34	31.09	2.179	A	35.40	35.98	2.234	B
38.70	31.13	2.206	A, C	29.82	38.33	-	B
36.43	31.25	-	C	19.46	42.13	1.861	B
35.43	31.90	2.136	C	0.0	48.81	1.543	B
36.76	33.35	2.196	C				

A = PbBr<sub>2</sub>B = NaBr·H<sub>2</sub>OC = 4PbBr<sub>2</sub>·3NaBr·12H<sub>2</sub>O

Br

SOLUBILITY OF SODIUM BROMIDE IN AQUEOUS METHANOL SOLUTIONS  
(Baron and Mishenko, 1948)

Solvent Wt. % CH <sub>3</sub> OH	Gms. NaBr per 100 gms. Sat. Sol.		Gms. NaBr per 100 gms. Solvent	
	25°	40°	25°	40°
25.11	41.4	45.0	70.7	81.9
42.105	37.5	39.3	60.0	64.6
80.48	22.4	23.0	28.9	29.8
100	14.8	13.95	17.36	16.2

## SOLUBILITY OF SODIUM BROMIDE IN AQUEOUS ETHANOL SOLUTIONS

## Results at 25°

(Flatt and Jordan, 1933)

Wt. % C <sub>2</sub> H <sub>5</sub> OH in solvent	Gms. NaBr per 100:			Solid Phase
	gms. solvent	gms. sat. sol.	cc. sat. sol.	
0.0	93.55	48.32	93.45	NaBr·2H <sub>2</sub> O
20.4	77.26	43.59	75.21	"
42.5	57.43	36.48	54.18	"
67.9	33.75	25.24	29.95	"

## Results at 30°

(Cocheret, 1911)

Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
C <sub>2</sub> H <sub>5</sub> OH	NaBr		C <sub>2</sub> H <sub>5</sub> OH	NaBr	
0	49.4	NaBr·2H <sub>2</sub> O	65.51	16.08	NaBr·2H <sub>2</sub> O
11.79	42.9	"	72.36	13.41	"
31.78	32.12	"	76.92	12.03	" + NaBr
43.22	26.79	"	87.35	7.44	NaBr
54.59	20.83	"	97.08	3.01	"



# Na SODIUM

## SOLUBILITY OF SODIUM BROMIDE IN 95% ETHYL ALCOHOL SOLUTIONS OF HYDROBROMIC ACID AT 25° (Yagoda, 1930)

Normality of HBr in 95% C <sub>2</sub> H <sub>5</sub> OH	d. of solvent	Gms. NaBr per 100 gms. solvent	Normality of HBr in 95% C <sub>2</sub> H <sub>5</sub> OH	d. of solvent	Gms. NaBr per 100 gms. solvent
0.0	0.7997	3.97	0.337	0.833	4.48
0.100	0.810	4.04	0.629	0.862	4.50
0.162	0.815	4.25	0.800	0.878	4.35
0.204	0.820	4.25	0.954	0.893	4.55

## Br THE SYSTEM SODIUM BROMIDE - ISOPROPYL ALCOHOL - WATER AT 25° (Ginnings and Chen, 1931)

Points on the binodal curve of the system were determined by the titration method and a tie line, \*, located by estimation of the NaBr in layers in contact with each other. The plait point, PP, was found by plotting.

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
iso C <sub>3</sub> H <sub>7</sub> OH	NaBr	iso C <sub>3</sub> H <sub>7</sub> OH	NaBr
62.10	11.30*	20.40	27.20
53.10	13.70	8.70	35.0
41.50	18.00	4.10	42.60*
29.5	23.6 PP.		

## THE SYSTEM SODIUM BROMIDE - t-BUTYL ALCOHOL - WATER AT 25° (Ginnings, Herring and Webb, 1933)

The composition of the homogeneous mixture (plait point) at 25° of the system NaBr + Tertiary Butyl Alcohol + H<sub>2</sub>O was found to 11.0 percent NaBr + 36.3 percent ter. (CH<sub>3</sub>)<sub>3</sub>COH + 52.7 percent H<sub>2</sub>O.

The original results for the remaining points on the binodal curve are not given but only the values corresponding to derived empirical equations for the curve.

The effect of the addition of 0.04 - 0.10 molar sodium bromide on the mutual solubility of n-butyl alcohol and water is reported by Reber, McNabb, and Lucasse, 1942.

100 gms. 86.5% glycerol (d = 1.2326) dissolve 44.7 gms. NaBr at 20°. 100 gms. 98.5% glycerol (d = 1.2645) dissolve 38.7 gms. NaBr at 20°. (Holm, 1921, 1922.)

100 gms. 95% formic acid dissolve 22.3 gms. NaBr at 18.5°. (Aschan, 1913.)

SOLUBILITY OF SODIUM BROMIDE IN PURE METHYL ALCOHOL  
(Brown, Glynwyn, Bonnel and Jones, 1928)

t°	Gms. NaBr per 100 gms. CH <sub>3</sub> OH	t°	Gms. NaBr per 100 gms. CH <sub>3</sub> OH	t°	Gms. NaBr per 100 gms. CH <sub>3</sub> OH
0	17.3	20	16.8	40	16.1
10	17.0	25	(17.36) <sup>a</sup>	50	15.8
15	16.9		(17.4) <sup>b</sup>	60	15.3
18	(16.3) <sup>d</sup>	30	16.5	240	(0.9) <sup>c</sup>
19.5	(17.35) <sup>b</sup>				

<sup>a</sup>Larson and Hunt, 1939

<sup>b</sup>deBruyn, 1892

<sup>c</sup>Result at critical temperature (Centnerszwer, 1910.)

<sup>d</sup>Pavlopoulos and Strehlow, 1954

Br

SOLUBILITY OF SODIUM BROMIDE IN ABSOLUTE ETHYL ALCOHOL  
(Bonnell and Jones, 1926)

The materials were carefully purified and especial attention paid to removal of traces of water from the alcohol. The mixtures were kept in a thermostat and shaken by hand at intervals during a long period. In some cases saturation was approached from above.

t°	Gms. NaBr per 100 gms. C <sub>2</sub> H <sub>5</sub> OH	t°	Gms. NaBr per 100 gms. C <sub>2</sub> H <sub>5</sub> OH	t°	Gms. NaBr per 100 gms. C <sub>2</sub> H <sub>5</sub> OH
0.0	2.445	25.0	2.314	50.0	2.259
10.0	2.379		(2.406) <sup>a</sup>	60.0	2.312
15.0	2.343	30.0	2.292	70.0	2.345
20.0	2.322	40.0	2.276		

<sup>a</sup>Larson and Hunt, 1939

SOLUBILITY OF SODIUM BROMIDE IN VARIOUS ALCOHOLS AT 25°  
(Larson and Hunt, 1939)

Solvent	Formula	d. of sat. solution	Gms. NaBr per 100 gms. solvent
Water	H <sub>2</sub> O	-	93.50
Methanol	CH <sub>3</sub> OH	0.9073	17.36
Ethanol	C <sub>2</sub> H <sub>5</sub> OH	0.8019	2.406
1-Propanol	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> OH	0.8026	0.4562
1-Butanol (n)	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>2</sub> CH <sub>2</sub> OH	0.8075	0.246
2-Propanol (iso)	CH <sub>3</sub> CHOHCH <sub>3</sub>	0.7818	0.1313
2-Methyl-1-Propanol	(CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>2</sub> OH	0.7986	0.0951
1-Pentanol	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>3</sub> CH <sub>2</sub> OH	0.8106	0.1103
2 Butanol (sec.)	CH <sub>3</sub> CH <sub>2</sub> CHOHCH <sub>3</sub>	0.8025	0.0341

# Na SODIUM

## SOLUBILITY OF SODIUM BROMIDE IN MIXTURES OF ALCOHOLS AT 25° (Herz and Kuhn, 1908)

In $\text{CH}_3\text{OH} + \text{C}_2\text{H}_5\text{OH}$			In $\text{CH}_3\text{OH} + \text{C}_3\text{H}_7\text{OH}$		
% $\text{CH}_3\text{OH}$ in Mixture	$d_{25}$ of Sat. Sol.	Gms. NaBr per 100 cc. Sat. Sol.	% $\text{C}_3\text{H}_7\text{OH}$ in Mixture	$d_{25}$ of Sat. Sol.	Gms. NaBr per 100 cc. Sat. Sol.
0	0.8189	2.93	0	0.9238	14.40
4.37	0.8265	3.65	11.11	0.9048	12.43
10.4	0.8273	4.04	23.8	0.8887	10.53
41.02	0.8593	7.24	65.2	0.8390	4.42
80.69	0.9079	12.51	91.8	0.8153	1.47
84.77	0.9104	12.86	93.75	0.8144	1.26
91.25	0.9235	14.32	100	0.8093	0.74
100	0.9238	14.40			

In $\text{C}_2\text{H}_5\text{OH} + \text{C}_3\text{H}_7\text{OH}$					
0	0.8189	2.93	88.6	0.8116	1.11
8.1	0.8147	2.49	91.2	0.8083	0.83
17.85	0.8145	2.47	95.2	0.8090	0.82
56.6	0.8107	1.90	100	0.8093	0.74

Data for the effect of small quantities of NaBr on the miscibility temperature of methyl alcohol and cyclohexane are reported by Eckfeldt and Lucasse, 1943.

## SOLUBILITY OF SODIUM BROMIDE IN ISO AMYL ALCOHOL SOLUTIONS OF HYDROBROMIC ACID AT 25° (Yagoda, 1930)

Normality of HBr in iso $\text{C}_5\text{H}_{11}\text{OH}$	d. of solvent	Gms. NaBr per 100 cc. solvent	Normality of HBr in iso $\text{C}_5\text{H}_{11}\text{OH}$	d. of solvent	Gms. NaBr per 100 cc. solvent
0.0	0.805	0.085	0.463	0.850	0.274
0.066	0.8166	0.124	0.764	0.8754	0.390
0.181	0.8262	0.174			

## SOLUBILITY OF SODIUM BROMIDE IN ACETONE

t°	Gms. NaBr per liter sat. solution	Authority
18	0.095	(Lannung, 1932.)
25	0.079	(Kraus and Seward, 1927.)
25	0.122	(Swearingen and Florence, 1935.)
25	0.63(?)	(Koch, 1930a.)
37	0.075	(Lannung, 1932.)

SOLUBILITY OF SODIUM BROMIDE IN ACETONE SOLUTIONS OF LITHIUM  
PERCHLORATE AND OF CALCIUM PERCHLORATE AT 25°  
(Swearingen and Florence, 1935)

Results for acetone solutions of:

Lithium Perchlorate				Calcium Perchlorate	
Gm. Mols. per liter sat. sol.		Gm. Mols. per liter sat. sol.		Gm. Mols. per liter sat. sol.	
LiClO <sub>4</sub>	NaBr	LiClO <sub>4</sub>	NaBr	CaClO <sub>4</sub>	NaBr
0.0000	0.00190	0.003591	0.002246	0.000306	0.001612
0.000310	0.001379	0.019239	0.003575	0.000554	0.001907
0.000547	0.001452	0.038147	0.005207	0.000772	0.002225
0.000785	0.001582	0.078221	0.008243	0.001968	0.003643
0.001974	0.001926	0.392690	0.021575	0.004129	0.005997
				0.008421	0.009477

SOLUBILITY OF SODIUM BROMIDE IN ACETONE SOLUTIONS OF SODIUM  
NITRATE AT 25°  
(Kraus and Seward, 1927, 1928)

Gm. Mols. per liter sat. solution

0.0000	0.000768
0.000137	0.000760
0.000229	0.000746
0.000660	0.000713

SOLUBILITY OF SODIUM BROMIDE IN VARIOUS ORGANIC SOLVENTS

Solvent	t°	Solubility	
Ethylene diamine	25	54.4	gms per 100 gms solvent Isbin and Kobe, 1945
Monoethanolamine	25	33.6	" " " "
Ethylene glycol	25	35.4	" " " "
Ethyl urethan	60	5.081	gms per 100 cc. sat. sol. Stuckgold, 1917
Ethyl ether	15	0.08	gms NaB <sub>2</sub> ·2H <sub>2</sub> O per 100 gms solvent (Schlamp, 1894)
Acetonitrile	18	0.04	gms/100 gms solvent (d.=0.786) (Pavlopoulos and Strehlow, 1954)
	25	0.04	gms/100 gms solvent (d.=0.777) (Pavlopoulos and Strehlow, 1954)
Formic acid	18	19.3	gms/100 gms solvent (d.=1.375) (Pavlopoulos and Strehlow, 1954)

# Na SODIUM

## SOLUBILITY OF SODIUM BROMIDE IN ACETAMIDE AT VARIOUS TEMPERATURES (Menschutkin, 1908)

	Gms. per 100 Gms. Sat. Sol.		
t°	NaBr·2CH <sub>3</sub> CONH <sub>2</sub> = NaBr		Solid Phase
82*	-	-	CH <sub>3</sub> CONH <sub>2</sub>
80	6	2.8	"
78	11.5	5.36	"
76	16.3	7.6	"
74	20.2	9.4	"
72	23	10.7	"
70 <sup>e</sup>	25	11.6	" + NaBr·2CH <sub>3</sub> CONH <sub>2</sub>
80	27	12.6	NaBr·2CH <sub>3</sub> CONH <sub>2</sub>
90	29.4	13.7	"
100	32.2	15	"
110	35.3	16.4	"
120	38.7	18	"
130	42.6	19.8	"
135 <sup>t</sup>	45.3	21.1	" + NaBr
155	46.4	21.6	NaBr
175	47.5	22.1	"

\*M. pt.

<sup>e</sup>Eutec.

<sup>t</sup>Tr. pt.

## SOLUBILITY OF SODIUM BROMIDE IN LIQUID AMMONIA

The results of Scherer, 1931; Hunt, 1932; Johnson and Krumboltz, 1933; Linhard and Stephan, 1933; 1934; Distanow, 1937 and Portnow and Rawdine, 1937, were calculated to a common basis, plotted, and the following values read from the average curve.

t°	Gms. NaBr per 100 gms. sat. sol.	Solid Phase	t°	Gms. NaBr per 100 gms. sat. sol.	Solid Phase
-45	9.1	NaBr·5NH <sub>3</sub>	25	58	NaBr·5NH <sub>3</sub>
-40	12.0	"	35	57.5	NaBr
-34*	16.0	"	50	57	"
-30	19.0	"	75	54.5	"
-20	26.5	"	100	52.5	"
-10	34.0	"	120	52	"
0	41.5	"	140	50	"
+10	49.0	"	160	41	"

\*(d = 7906)

## THE SYSTEM SODIUM BROMIDE - SODIUM CHLORIDE - LIQUID AMMONIA AT 0° (Portnow and Rawdine, 1937)

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
NaCl	NaBr	NH <sub>3</sub>		NaCl	NaBr	NH <sub>3</sub>	
0.0	39.0	61.0	NaBr	5.39	28.32	66.29	NaCl
1.74	37.85	60.31	"	6.61	21.26	72.13	"
3.61	35.96	60.43	" + NaCl	8.19	16.07	75.74	"
4.12	35.42	63.55	NaCl	10.20	5.94	83.86	"
4.54	31.91	65.55	"	11.60	0.0	88.40	"

100 cc. anhydrous hydrazine dissolve 37 gms. NaBr at room temp.  
(Welsh and Broderson, 1913.)

## SOLUBILITY OF NaBr IN LIQUID SULFUR DIOXIDE

0°	0.016 gms NaBr per 100 gms SO <sub>2</sub>	(Jander and Ruppolt, 1937.)
25°	0.0038 " "	(Shatenstein and Viktorov, 1937)

Melting-point data are given for:

NaBr + NaCl	(Amadori, 1912(a); Ruff and Plate, 1903.)	
NaBr + NaI	(Amadori, 1912a)	
NaBr + NaF	(Ruff and Plate, 1903.)	
NaBr + NaOH	(Scarpa, 1915.)	Br
NaBr + NaNO <sub>2</sub>	(Meneghini, 1912.)	
NaBr + Na <sub>2</sub> SO <sub>4</sub>	(Ruff and Plate, 1903.) (Flood, Forland and Nesland, 1951)	
NaBr + SrBr <sub>2</sub>	(Kellner, 1917.)	
NaBr + Na <sub>2</sub> CO <sub>3</sub>	(Nyankovskaya, 1952.)	
NaBr + PbBr <sub>2</sub>	(Gromakov, 1950)	
NaBr + RbBr	(Gromakov and Gromakova, 1953)	
2NaBr + PbCl <sub>2</sub> ⇌ 2NaCl + PbBr <sub>2</sub>	(Il'yasov, Shchemeleva and Bergman, 1957)	
NaBr + AgNO <sub>3</sub> ⇌ NaNO <sub>3</sub> + AgBr	(Zakharchenko and Bergman, 1956)	
NaBr + TlCl ⇌ NaCl + TlBr	(Il'yasov, Fonardzhyan and Bergman, 1957)	

Reactions of the salts below the melting points were studied with X-rays by Link and Wood (1940) for the following pairs:

SODIUM BROMATE NaBrO<sub>3</sub>

BrO

SOLUBILITY OF SODIUM BROMATE IN WATER  
(Ricci, 1934)

The solid phase is NaBrO<sub>3</sub> in all cases.

t°	d. of sat. sol.	Gms. NaBrO <sub>3</sub> per 100 gms. sat. sol.	t°	d. of sat. sol.	Gms. NaBrO <sub>3</sub> per 100 gms. sat. sol.
5	1.194	21.42	40	1.310	32.80
10	1.211	23.24	45	-	34.22 <sup>a</sup>
15	1.232	24.94	50	-	35.55
20	1.248	26.69	60	-	38.5 <sup>b</sup>
25	1.257	28.29	80	-	43.1 <sup>b</sup>
30	1.284	29.85	-	-	(42.51) <sup>c</sup>
35	1.288	31.35	100	-	47.6

<sup>a</sup>Ricci, 1935

<sup>b</sup>Kremers, 1855-56a

<sup>c</sup>Klebanov and Basova, 1939

# Na SODIUM

## SOLUBILITY OF SODIUM BROMATE IN DEUTERIUM OXIDE AT 5° (Noonan, 1948)

% D <sub>2</sub> O	Moles NaBrO <sub>3</sub> per 100 moles Solvent
91.6	2.899
100	2.867

## THE SYSTEM SODIUM BROMATE - SODIUM BICARBONATE - WATER (Klebanov and Basova, 1939)

BrO	Results at 25°			Results at 35°		
	Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
	NaBrO <sub>3</sub>	NaHCO <sub>3</sub>		NaBrO <sub>3</sub>	NaHCO <sub>3</sub>	
	28.14	0.0	NaBrO <sub>3</sub>	31.95	0.0	NaBrO <sub>3</sub>
	25.94	1.80	"	29.00	2.13	"
	24.34	4.76	NaBrO <sub>3</sub> + NaHCO <sub>3</sub>	28.02	4.88	NaBrO <sub>3</sub> + NaHCO <sub>3</sub>
	18.47	4.90	NaHCO <sub>3</sub>	23.25	5.02	NaHCO <sub>3</sub>
	12.24	6.18	"	17.88	5.98	"
	6.98	7.55	"	11.90	7.40	"
	0.0	9.34	"	7.86	8.20	"
				6.26	8.96	"
				0.0	10.55	"

## THE SYSTEM SODIUM BROMATE - SODIUM CARBONATE - WATER AT 80° (Klebanov and Basova, 1939)

Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
			NaBrO <sub>3</sub>	Na <sub>2</sub> CO <sub>3</sub>	
42.51	0.0	NaBrO <sub>3</sub>	15.51	22.60	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
36.58	5.36	"	8.65	25.75	"
28.10	12.50	"	0.0	30.95	"
21.88	18.84	NaBrO <sub>3</sub> + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O			

## THE SYSTEM SODIUM BROMATE - SODIUM CHLORIDE - WATER. (Ricci, 1934)

<u>Results at 10°</u>				<u>Results at 25°</u>			
d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	NaCl	NaBrO <sub>3</sub>			NaCl	NaBrO <sub>3</sub>	
1.211	0.00	23.24	NaBrO <sub>3</sub>	1.241	3.76	23.73	NaBrO <sub>3</sub>
1.193	4.85	17.28	"	1.229	6.17	20.27	"
1.192	9.84	12.75	"	1.225	9.98	16.31	"
1.199	16.15	8.58	"	1.228	12.95	13.67	"
1.213	20.75	6.41	"	1.234	17.55	10.34	"
1.229	23.61	5.32	"	1.234	20.99	8.32	"
1.235	24.52	5.02	" + NaCl	1.247	23.94	6.92	" + NaCl
-	26.32	0.0	NaCl	1.236	24.35	6.62	NaCl
				1.215	25.55	2.48	"

THE SYSTEM SODIUM BROMATE - SODIUM CHLORATE - WATER AT 25°  
(Swenson and Ricci, 1939)

S.S.I and S.S.II indicate solid solutions and the figures which follow show the percentage of  $\text{NaClO}_3$  found in these by analysis. Less complete results than the above are given for the 50° isotherms.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{NaBrO}_3$	$\text{NaClO}_3$	Solid Phase	$\text{NaBrO}_3$	$\text{NaClO}_3$	Solid Phase
28.29	0.0	$\text{NaBrO}_3$	5.33	44.64	SSII, 40.4
16.46	18.91	"	5.07	44.98	" 64.2
12.20	28.03	"	4.49	45.66	" 71.0
8.68	36.75	"	3.79	46.46	" 83.2
7.14	40.28	"	3.69	46.56	" 85.0
7.00	41.47	S.S.I 2.02	2.84	47.42	" 89.4
6.54	42.62	" 1.70	1.89	48.36	" 91.0
5.99	43.66	" 6.84	0.96	49.16	" 98.0
6.05	43.55	" 24.3 + S.S.II(?)	0.79	49.36	" 98.5
			0.0	50.07	$\text{NaClO}_3$

THE SYSTEM SODIUM BROMATE - SODIUM IODIDE - WATER AT 25°  
(Ricci, 1934)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{NaI}$	$\text{NaBrO}_3$			$\text{NaI}$	$\text{NaBrO}_3$	
1.257	0.0	28.29	$\text{NaBrO}_3$	1.727	54.89	2.23	$\text{NaBrO}_3$
1.332	17.32	16.57	"	1.836	60.65	1.44	"
1.438	32.21	8.92	"	1.874	62.13	1.30	"
1.521	40.76	5.78	"	1.914	64.00	1.17	$\text{NaBrO}_3 + \text{NaI}$
1.619	48.11	3.62	"	1.904	64.71	0.0	$\text{NaI}$

THE SYSTEM SODIUM BROMATE - SODIUM NITRATE - WATER AT 25°  
(Ricci, 1934)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{NaNO}_3$	$\text{NaBrO}_3$			$\text{NaNO}_3$	$\text{NaBrO}_3$	
1.270	5.00	24.92	$\text{NaBrO}_3$	1.441	39.57	10.23	$\text{NaBrO}_3$
1.288	11.33	21.25	"	1.455	42.59	9.38	" + $\text{NaNO}_3$
1.314	18.48	17.79	"	1.432	44.46	6.04	$\text{NaNO}_3$
1.353	25.54	14.94	"	1.405	46.50	2.43	"
1.387	32.54	12.41	"	1.384	47.87	0.0	"



# Na SODIUM

## THE SYSTEM SODIUM BROMATE - SODIUM SULFATE - WATER (Ricci, 1934, 1935)

Na.10 =  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ .

m = Metastable. S.S. = Solid Solutions containing the indicated percentages of  $\text{NaBrO}_3$ .

Similar results are also given for the isotherms 30°, 37.5° and 52°.

This system provides a sixth type of solid solution in addition to the five possible types described by Roozeboom.

Results at 10°				Results at 25°			
d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{Na}_2\text{SO}_4$	$\text{NaBrO}_3$			$\text{Na}_2\text{SO}_4$	$\text{NaBrO}_3$	
1.217	1.83	21.96	$\text{NaBrO}_3$	1.284	4.09	24.96	$\text{NaBrO}_3$
1.226	3.61	20.67	"	1.288	8.28	21.72	"
1.227	4.40	20.11	" + Na.10	1.303	12.35	18.71	"
1.230	4.41	19.93	Na.10	1.317	16.45	15.85	"
1.175	5.20	14.21	"	1.254	19.17	7.06	" + Na.10
1.112	6.96	5.40	"	1.225	20.48	3.34	Na.10
1.079	8.26	0.0	"	1.205	21.90	0.0	"

### Results at 45°

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
$\text{Na}_2\text{SO}_4$	$\text{NaBrO}_3$			$\text{Na}_2\text{SO}_4$	$\text{NaBrO}_3$		
0.0	34.22		$\text{NaBrO}_3$	22.92	14.38	S.S.	9.66
8.10	27.14		"	24.18	12.56	"	6.72
16.54	20.38		"	25.85	10.12	"	6.66
19.81	17.93		"	26.56	9.23	"	4.13
21.09	17.03m		"	27.76	7.53	"	3.62
21.59	16.62m		"	29.21	5.85m	"	4.21
22.47	16.00m		"	29.52	5.45m	"	2.48
20.86	17.17		" + S.S. 19.89	29.95	5.01m	"	2.53
20.94	17.0	S.S.	17.17	30.44	4.50m	"	2.64
21.58	15.96	"	14.40	28.78	6.32	" + $\text{Na}_2\text{SO}_4$	
22.77	14.65	"	13.80	29.18	5.64	$\text{Na}_2\text{SO}_4$	
				30.35	3.12	"	

100 cc. anhydrous Hydrazine dissolve 1.0 gms.  $\text{NaBrO}_3$  with decomposition. (Welsh and Broderick, 1915.)

SODIUM METHIONATE  $\text{Na}_2[\text{CH}_2(\text{SO}_3)_2]$   
 SODIUM CHLORO METHIONATE  $\text{Na}_2[\text{CHCl}(\text{SO}_3)_2]$

CH

SOLUBILITY OF EACH SEPARATELY IN WATER  
 (Backer and Terpstra, 1929; Backer, 1930)

t°	Gms. anhydrous compound per 100 gms. $\text{H}_2\text{O}$	Solid Phase
25	38.4	$\text{Na}_2[\text{CH}_2(\text{SO}_3)_2] \cdot 2\frac{1}{2}\text{H}_2\text{O}$
	41.4	"(a)
25	127.0	$\text{Na}_2[\text{CHCl}(\text{SO}_3)_2] \cdot \text{H}_2\text{O}$

(a) Valeri and Saumrucker, 1949

SODIUM FORMATE  $\text{HCOONa}$

CH

THE SYSTEM SODIUM FORMATE - WATER

(Groschuff, 1903 and Elöd and Termmel, 1927; ice curve by Sidgwick and Gentle, 1922)

t°	Gms. $\text{NaHCOO}$ per 100 gms.		Solid Phase
	sat.	sol.	
	E. and T. Groschuff		
- 4.29	-	( 7.24)	Ice
- 7.02	-	(11.42)	"
-11.02	-	(16.95)	"
-18.04	-	(24.86)	"
-20	-	22.80	$\text{NaHCOO} \cdot 3\text{H}_2\text{O}$
0	-	30.47	"
10	38.5	38.5	"
12.0	39.5	39.5	"
14	41.0	41.0	"
15	41.8	41.8	"
15.3 t. p.	42.4	-	" + $\text{NaHCOO} \cdot 2\text{H}_2\text{O}$
15.9 "	-	44.0	" "
18	43.5	45.0sg	$\text{NaHCOO} \cdot 2\text{H}_2\text{O}$
20	44.8	46.2	"
22	46.0	47.5	"
24	47.4	49.0	"
24.5 t. p.	-	49.8	" + $\text{NaHCOO}$
27.9 "	50.3	-	"
30	50.6	50.6	$\text{NaHCOO}$
40	52.0	52.0	"
50	53.4	53.4	"
60	55.0	55.0	"

sg = specific gravity 1.317

# Na SODIUM

## THE SYSTEM SODIUM FORMATE - FORMIC ACID - WATER (Results of Elbd and Trammel, 1927)

For a complete diagram of the system see Schwab, Glatzner and Kovos, 1955. The existence of the compounds  $\text{NaHCOO} \cdot 2\text{HCOOH}$  ( $7^\circ$  to  $31^\circ$ ) and  $3\text{NaHCOO} \cdot 8\text{HCOOH}$  ( $-21^\circ$  to  $7^\circ$ ) is indicated.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.			
HCOOH	HCOONa	Solid Phase	HCOOH	HCOONa	Solid Phase	
Results at 13°			Results at 23.4°			
CH	0.0	39.8	NaHCOO.3H <sub>2</sub> O	0.0	46.7	NaHCOO.2H <sub>2</sub> O
	10.6	43.7	"	5.7	48.5	"
	11.7	43.3	3NaHCOO.HCOOH	6.55	49.15	" + 3NaHCOO.HCOOH
	12.7	43.1	"	40.8	41.3	NaHCOO.HCOO + "
	14.1	42.4	"	71.1	28.9	NaHCOO.HCOOH
	24.8	40.8	"			
	35.4	37.8	"			
	39.2	37.2	NaHCOO.HCOOH			Results at 45°
	54.8	31.2	"	0.0	47.3	NaHCOO
	74.0	26.0	"	2.4	45.1	"
				9.25	38.25	" + 3NaHCOO.HCOOH
				49.58	9.59	NaHCOO.HCOOH + "
				65.1	0.0	NaHCOO.HCOOH

(Results of Groschuff, 1902)

t°	Gms. HCOONa per 100 Gms. Solution	Mols. HCOONa per 100 Mols. $\text{H}_2\text{O}$	Solid Phase
0	22.35	19.5	$\text{HCOONa} \cdot \text{HCOOH}$
25.5	29.62	28.45	"
66.5	41.08	47.1	"
45.5	38.85	43.1	$\text{HCOONa}$
70	41.27	47.5	"
85	43.09	51.2	

Data for the system sodium formate - phenol - water are given by Schryver, 1910

100 gms. Methyl Alcohol ( $\text{CH}_3\text{OH}$ ) dissolve 3.52 gms. anhydrous  $\text{NaHCOO}$  at  $15^\circ$  and 3.68 gms. at the b. pt. ( $66.6^\circ$ ). (Henstock, 1934.)

THE SYSTEM SODIUM FORMATE - ACETIC ACID  
(Davidson and Ramskill, 1941)

t°	Mole % NaCHO <sub>2</sub>	Solid Phase	t°	Mole % NaCHO <sub>2</sub>	Solid Phase
16.60	0.0	H	63.1	22.36	N·2H
16.15	0.54	H	66.5	26.34	"
15.60	1.33	H	68.2	28.32	"
14.25	2.96	H	69.0	30.42	"
13.50	3.74	H	69.2	32.17	"
12.75	4.78	H	69.2	32.80	"
11.80	5.79	H	80.0	33.00	N·H
10.60	7.27	H	83.0	33.51	"
9.70	8.14	H	87.0	33.98	"
14.55	8.75	N·2H	109	35.24	" CH
17.70	9.24	"	114	35.73	"
27.10	11.08	"	171	46.46	"
32.25	12.22	"	173	49.81	"
40.10	14.61	"	179	50.17	N
44.35	15.73	"	215	60.48	N
53.0	18.18	"	227	68.93	N
56.2	19.76	"	253	100.0	N

H = HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub> N = NaCHO<sub>2</sub>

Melting points are given for the systems:

Sodium formate + formic acid	(Kendall and James, 1921)
" + sodium acetate	(Sokolov, 1954)
" + sodium propionate	"
" + sodium iso-propionate	"
" + sodium iso-butyrate	"
" + sodium pentanoate	"
" + sodium stearate	"
" + sodium benzoate	"
" + sodium thiocyanate	(Sokolov and Pochtakova, 1958)
NaHCOO + LiNO <sub>3</sub> = NaNO <sub>3</sub> + LiHCOO	(Tsmirik, 1958)

SODIUM METHOXIDE NaOCH<sub>3</sub>

CH

SOLUBILITY IN VARIOUS LIQUIDS  
(Schlesinger, Brown and Finholt, 1953)

Solvent	t°	Solubility	NaOCH <sub>3</sub> per 100 gms solvent
liquid ammonia	25	0.4 gms	"
isopropyl amine	28	0.1	"
m-butylamine	28	0.1	"
pyridine	0 - 75	0.2 - 0.3	"
morpholine	25	0.3	"
	75	0.1	"
dioxane	25, 75°	insol.	"

# Na SODIUM

## CH SODIUM FORMALDEHYDE SULFOXALATE $\text{NaHSO}_2 \cdot \text{CH}_2\text{O} \cdot 2\text{H}_2\text{O}$

100 cc. sat. solution of sodium formaldehyde sulfoxalate in glycerol of  $d = 1.262$  contain 50.66 gms. sulfoxalate at  $18^\circ$  and the density of the saturated solution is 1.375.

100 cc. sat. solution of sodium formaldehyde sulfoxalate in methyl alcohol of  $d = 0.8$  contain 8.39 gms. sulfoxalate at  $18^\circ$  and the density of the saturated solution is 0.845. (Heyl and Greer, 1922.)

## CH SODIUM ACETATE $\text{CH}_3\text{COONa}$

### SOLUBILITY IN WATER (Green, 1908)

Additional results for the ice curve are given below

Gms.			Gms.		
t°	CH <sub>3</sub> COONa per 100 Gms. H <sub>2</sub> O	Solid Phase	t°	CH <sub>3</sub> COONa per 100 Gms. H <sub>2</sub> O	Solid Phase
-10	19	Ice	20	123.5	CH <sub>3</sub> COONa *
-18	30.4	"	30	126	" *
-10	33	CH <sub>3</sub> COONa.3H <sub>2</sub> O	40	129.5	" *
0	36.3	"	50	134	"
+10	40.8	"	60	139.5	"
20	46.5	"	70	146	"
30	54.5	"	80	153	"
40	65.5	"	90	161	"
50	83	"	100	170	"
58	138	"	110	180	"
0	119	CH <sub>3</sub> COONa *	120	191	"
10	121	" *	123 b. pt.	193	"

\*unstable

### FREEZING-POINTS OF AQUEOUS SOLUTIONS OF SODIUM ACETATE

Results by Klein and Svanberg, 1920      Results by Sidgwick and Gentle, 1922

t° of f. pt.	Gms. CH <sub>3</sub> COONa per 100 cc. sat. sol.	Solid Phase	t° of f. pt.	Gms. CH <sub>3</sub> COONa per 100 gms. sat. sol.	Solid Phase
-0.36	0.82	Ice	- 2.96	6.107	Ice
-0.91	2.05	"	- 6.42	11.27	"
-1.85	4.10	"	-11.12	16.62	"
			-15.17	20.57	"

SOLUBILITY OF SODIUM ACETATE IN AQUEOUS SOLUTIONS OF ACETIC ACID AT  
VARIOUS TEMPERATURES  
(Dunningham, 1912)

Additional data for 5°, 20°, 45° and 60° are also given.

Similar data for 30° are given by Dukelski (1909), and for 20° by Abe (1911-12). One determination at 25°, expressed in terms of volume of solution, is given by Herz (1911-12). Two determinations at 10° similarly expressed, are given by Enklaar (1901).

Results at 0°		Results at 15°		Solid Phase in Each Case	CH
Gms. per 100 Gms. Sat. Sol.		Gms. per 100 Gms. Sat. Sol.			
Na <sub>2</sub> O	(CH <sub>3</sub> CO) <sub>2</sub> O	Na <sub>2</sub> O	(CH <sub>3</sub> CO) <sub>2</sub> O		
-	-	29.34	0.15	CH <sub>3</sub> COONa	
24.12	2.04	25.94	4.19	CH <sub>3</sub> COONa.3H <sub>2</sub> O	
14.46	8.55	15.49	12.01	"	
9.72	31	11.45	23.54	"	
9.77	41.23	11.25	34.56	" + 1.1	
9.04	43.94	10.33	39.08	1.1	
-	-	10.22	39.73	"	
-	-	9.16	49.32	"	
8.96	44.80	8.56	54.34	" + 1.2	
8.72	45.10	7.06	61.63	1.2	
7.83	50.03	5.95	70.55	"	
6.19	62.44	4.84	77.60	"	
4.02	79.29	2.87	86.61	"	
1.05	92.29	1.02	95.87	"	
0.42	97.51	0.79	98.09	"	
Results at 30°		Results at 75°			
35.31	0.77	44.45	0.76	CH <sub>3</sub> COONa	
26.25	8.92	32.47	5.03	"	
-	-	22.30	36.69	"	
25.98	9.06	-	-	CH <sub>3</sub> COONa.3H <sub>2</sub> O	
18.09	13.62	-	-	"	
13.53	21.88	-	-	"	
13.24	33.05	-	-	" + 1.1	
13.14	32.90	17.85	43.06	1.1	
7.64	65.07	11.05	65.71	"	
-	-	7.63	81.49	"	
-	-	0.44	98.35	"	
7.67	66.42	-	-	" + 1.2	
7.33	69.68	-	-	1.2	
6.61	72.85	-	-	"	
5.52	77.76	-	-	"	
3.78	83.92	-	-	"	
2.94	86.73	-	-	"	
1.27	94.78	-	-	"	

1.1 = CH<sub>3</sub>COONa.CH<sub>3</sub>COOH

1.2 = CH<sub>3</sub>COONa.2CH<sub>3</sub>COOH

# Na SODIUM

## THE SYSTEM SODIUM ACETATE - SODIUM HYDROXIDE - WATER (Morgan and Walker, 1945)

Results at 0.5°			Results at 10°			Results at 20°		
Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
NaOH	NaC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>		NaOH	NaC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>		NaOH	NaC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>	
0.0	26.6	A·3	0.0	28.9	A·3	0.0	31.6	A·3
0.22	26.4	"	2.4	26.6	"	7.8	24.6	"
1.4	24.7	"	6.5	21.7	"	14.0	16.6	"
3.0	22.8	"	11.1	17.5	"	21.6	11.3	"
5.8	20.2	"	15.3	12.8	"	26.2	9.9	"
CH 12.3	13.9	"	21.6	8.2	"	28.8	9.8	"
17.3	9.1	"	23.6	7.1	"	31.4	9.3	A·3 + A
20.6	6.9	"	32.1	6.5	"	32.1	8.5	A
21.9	6.2	"	33.4	6.1	A·3 + A	36.0	5.6	A
23.8	5.3	"	35.6	5.1	A	38.4	4.2	A
29.5	3.6	"	38.9	3.2	A	43.7	2.3	A
37.0	2.9	A·3+0·3	42.5	2.0	A	46.5	1.8	A
37.4	1.7	0·3	48.0	1.2	A + 0·1	49.5	1.4	A + 0·1
37.0	3.1	"	47.9	1.2	0·1	50.0	1.0	0·1
38.2	0.0	"	50.0	0.0	"	51.8	0.0	"

A = NaC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>    A·3 = NaC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>·3H<sub>2</sub>O    0·1 = NaOH·H<sub>2</sub>O    0·3 = NaOH·3.1H<sub>2</sub>O

## SOLUBILITY OF SODIUM ACETATE IN THE PRESENCE OF SUGAR (Köhler, 1897)

100 gms. H<sub>2</sub>O dissolve 237.6 gms. sugar + 57.3 gms. CH<sub>3</sub>COONa, or 100 gms. of the saturated solution contain 58.93 gms. sugar + 14.44 gms. CH<sub>3</sub>COONa at 31.25°.

## SOLUBILITY OF SODIUM ACETATE IN AQUEOUS ETHANOL SOLUTIONS

### Results at 18°

(Gerardin, 1865)

Wt. Percent Alcohol	Gms. CH <sub>3</sub> COONa per 100 Gms. Aq. Alcohol	Wt. Percent Alcohol	Gms. CH <sub>3</sub> COONa per 100 Gms. Aq. Alcohol
5.2	38	45	20.4
9.8	35.9	59	14.6
23	29.8	86	3.9
29	27.5	91	2.1
38	23.5		

## SOLUBILITY OF SODIUM ACETATE IN AQUEOUS ETHANOL SOLUTIONS--Cont.

Results at 25°

(Seidell, 1910)

The solid phase in contact with the solution was  $\text{CH}_3\text{COONa} \cdot 3\text{H}_2\text{O}$  in all cases.

Wt. % $\text{C}_2\text{H}_5\text{OH}$ in Solvent	$d_{25}$ of Sat. Sol.	Gms. $\text{CH}_3\text{COO}-$ $\text{Na} \cdot 3\text{H}_2\text{O}$ per 100 Gms. Sat. Sol.	Wt. % $\text{C}_2\text{H}_5\text{OH}$ in Solvent	$d_{25}$ of Sat. Sol.	Gms. $\text{CH}_3\text{COO}-$ $\text{Na} \cdot 3\text{H}_2\text{O}$ per 100 Gms. Sat. Sol.	CH
0	1.209	55.7	60	0.990	30.4	
10	1.160	53	70	0.942	22.8	
20	1.135	49.8	80	0.882	13	
30	1.108	46.5	90	0.838	6.7	
40	1.072	42	95	0.838	6.1	
50	1.038	37	100	0.823	7.3	

Results At Different Temperatures

(Schiavor, 1902)

$t^\circ$	Degree of Alcohol	Gms. per 100 Gms. Alcohol	
		$\text{CH}_3\text{COONa}$	$\text{CH}_3\text{COONa} \cdot 3\text{H}_2\text{O}$
8	98.4	2.08	3.45
12	98.4	2.12	3.51
19	98.4	2.33	3.86
11	90	2.07	3.42
13	90	2.13	3.52
15	63	13.46	22.32
18	63	13.88	23.03
21	63	14.65	24.30
23	40	28.50	47.27

The composition of the homogeneous mixture (plait point) of the system Sodium Acetate - Tertiary Butyl Alcohol - Water at 25° was found by Ginnings, Herring and Webb, 1933, to be 4.7 percent  $\text{CH}_3\text{COONa}$  + 38.0 percent  $\frac{1}{2} (\text{CH}_3)_3\text{COH}$  + 57.3 percent  $\text{H}_2\text{O}$ .

The original results for other points on the binodal curve are not given but only the values corresponding, to derived empirical equations for the curve.

The triangular diagram but no numerical values are given by Jencie, 1934, for the system Sodium Acetate + Phenol + Water at 25°.



# Na SODIUM

## SOLUBILITY OF SODIUM ACETATE IN ANHYDROUS SOLVENTS

Solvent	t°	Solubility
Methanol	15	16.0 gms $\text{CH}_3\text{COONa}$ per 100 gms solvent (Henstock, 1934)
Ethanol	25	7.4 gms $\text{CH}_3\text{COONa} \cdot 3\text{H}_2\text{O}$ per 100 gms solvent (Seidell, 1910; Bodtker, 1897)
Propanol	?	0.97 gms $\text{CH}_3\text{COONa}$ per 100 gms solvent (Schlamp, 1894)
Acetone	15	0.05 gms $\text{CH}_3\text{COONa}$ per 100 gms solvent (Henstock, 1934)
Hydrazine	"ROOM"	6 gms $\text{CH}_3\text{COONa}$ per 100 gms solvent (Welsh and Brodersen, 1915)
CH	Sulfur Dioxide	0 0.073 gms $\text{CH}_3\text{COONa}$ per 100 gms solvent (Jander and Ruppolt, 1937)
	Ethylene glycol	25 29.03 gms $\text{CH}_3\text{COONa}$ per 100 gms solvent (Palit, 1947)
	Furfural	25 0.04 gms $\text{CH}_3\text{COONa} \cdot 3\text{H}_2\text{O}$ per 100 gms solvent (Trimble, 1941)

## THE SYSTEM SODIUM ACETATE - FORMIC ACID (Davidson and Ramskill, 1941)

t°	Mole % $\text{NaC}_2\text{H}_3\text{O}_2$	Solid Phase	t°	Mole % $\text{NaC}_2\text{H}_3\text{O}_2$	Solid Phase
8.4	0.0	$\text{HCHO}_2$	- 6.0	7.01	$\text{HCHO}_2$
7.3	0.76	"	- 8.3	8.56	"
6.0	1.43	"	-12.0	9.73	"
4.5	2.39	"	-14.5	10.71	"
3.1	3.20	"	-18.2	11.85	"
0.9	4.17	"	-20.3	12.42	"
-1.5	5.19	"	-22.5	13.11	"
-3.7	6.06	"	-24.0	13.61	"

## SOLUBILITY OF SODIUM ACETATE IN MIXED SOLVENTS AT 25° (Palit, 1947)

Wt. Ratio <u>Ethylene Glycol: n-Amyl Alcohol:</u>	100:0	80:20	0:100
Gms. $\text{CH}_3\text{COONa}$ per 100 gms. Solvent	29.5	22.57	0.31

SOLUBILITY OF SODIUM ACETATE IN PURE ACETIC ACID, DETERMINED  
BY THE FREEZING-POINT METHOD  
(Kendall and Adler, 1921)

The results in parentheses, differing somewhat from those of Kendall and Adler, are by Bakunin and Vitale, 1935.

Results for this system are also given by Vasilev, 1909.

Mol. % CH <sub>3</sub> COONa in			Mol. % CH <sub>3</sub> COONa in		
t°	sat. sol.	Solid Phase	t°	sat. sol.	Solid Phase
16.5	0.0	CH <sub>3</sub> COOH	96.1	30.72	CH <sub>3</sub> COONa.2CH <sub>3</sub> COOH
16.1	0.83	"	96.25	33.03	" CH
14.3	3.59	"	96.3	33.16	"
13.1	5.40	"	112.0	34.03	CH <sub>3</sub> COONa.CH <sub>3</sub> COOH
25.3	7.11	CH <sub>3</sub> COONa.2CH <sub>3</sub> COOH	(128.5)	41.1	"
(9.0)	(7.51)	"	132.0	36.87	"
36.7	8.92	"	145.2	39.06	"
54.3	12.17	"	157.0	42.54	"
(55.0)	(14.99)	"	160.6	44.25	"
66.9	15.27	"	162.3	46.28	"
71.9	16.58	"	174.0	48.76	CH <sub>3</sub> COONa
(81.0)	(23.46)	"	195.5	49.49	"
85.7	21.55	"			
(92.0)	(33.01)	"			
93.2	26.86	"			

Data for equilibrium in the system Sodium Acetate + Lead Acetate + Acetic Acid at 30° are given by Griswold and Olson, 1934.

Data for equilibrium in the system Sodium Acetate + Zinc Acetate + Acetic Acid, Determined by the Freezing-point method, are given by Davidson and McAllister, 1930.

Melting points are given for the systems

Sodium acetate - Zinc Acetate	(Lehrman and Skell, 1939)
Sodium acetate - Sodium propionate	(Sokolov, 1954)
Sodium acetate - sodium iso butyrate	(Sokolov, 1954)
Sodium acetate - sodium iso pentanoate	(Sokolov, 1954)
Sodium acetate - sodium benzoate	(Sokolov, 1954)
Sodium acetate - sodium stearate	(Sokolov, 1954)
NaCH <sub>3</sub> COO + KC <sub>2</sub> H <sub>3</sub> COO = NaC <sub>2</sub> H <sub>3</sub> COO + KCH <sub>3</sub> COO (Sokolov and Pochtakova, 1958)	

### SODIUM TRICHLOROACETATE Cl<sub>3</sub>CCOONa

Data for the system sodium trichloroacetate - phenol - water are reported by Schryver, 1910.

## Na SODIUM

### C<sub>6</sub>H SODIUM PHENYLACETATE C<sub>6</sub>H<sub>5</sub>CH<sub>2</sub>COONa

A diagram for the system sodium phenylacetate - phenylacetic acid - water at 25° is given by SMITH, 1953. The solubility of sodium phenyl acetate in water at 25° is 3.9 moles per 1000 gms saturated solution

Melting points are given for the systems:

		(Crawford, 1941)
Sodium phenylacetate + phenylacetic acid	(Bakunin and Vitale, 1935)	
+ phenylacetic anhydride	(Bakunin and Vitale, 1935)	
+ ethyl phenylacetate	(Bakunin and Vitale, 1935)	

### C<sub>3</sub>H SODIUM PROPIONATE C<sub>2</sub>H<sub>5</sub>COONa

The triangular diagram but no numerical values are given by Jencic, 1934, for the system Sodium Propionate + Phenol + Water at 25°.

#### SOLUBILITY IN ORGANIC SOLVENTS

Methanol	15°	13.28 gms C <sub>2</sub> H <sub>5</sub> COONa per 100 gms. solvent	
			(Henstock, 1934)
	68°	13.77 gms C <sub>2</sub> H <sub>5</sub> COONa per 100 gms. solvent	
			(Henstock, 1934)
Ethylene glycol	25	3.221 moles C <sub>2</sub> H <sub>5</sub> COONa per 1000 gms solvent	
			(Palit, 1947)
Propylene glycol	25	2.072 moles C <sub>2</sub> H <sub>5</sub> COONa per 1000 gms solvent	
			(Palit, 1947)

Melting points are given for:

Sodium propionate - Sodium isopropionate	(Sokolov, 1954)
" " - Sodium isobutyrate	( " " )
" " - Sodium pentanoate	( " " )
" " - Sodium benzoate	( " " )
" " - Sodium stearate	( " " )
NaC <sub>2</sub> H <sub>3</sub> COO + LiNO <sub>3</sub> = NaNO <sub>3</sub> + LiC <sub>2</sub> H <sub>3</sub> COO	(Tsindrik and Sokolov, 1958)

### SODIUM ISOPROPIONATE (CH<sub>3</sub>)<sub>2</sub>CHCOONa

Melting points are given for the systems

Na isopropionate - Na isobutyrate	(Sokolov, 1954)
Na " - Na pentanoate	( " " )
Na " - Na stearate	( " " )
Na " - Na Benzoate	( " " )

**SODIUM Na**

**SODIUM PROPYLNITRONATE**  $C_3H_7NO_2Na$

$C_3H$

**SODIUM ISOPROPYLNITRONATE**  $i-(C_3H_7NO_2Na)$

**SOLUBILITY IN GLYCOLS AT 25°**  
(Palit, 1947)

**Sodium Propylnitronate**

Solvent	Gms. per 100 gms. Solvent
Ethylene Glycol	39.51
80 Wt. % Ethylene Glycol + 20 Wt. % n-Amyl Alcohol	34.89

**Sodium Isopropylnitronate**

Propylene Glycol	21.84
80 Wt. % Propylene Glycol + 20 Wt. % n-Amyl Alcohol	18.82
n-Amyl Alcohol	0.24

**SODIUM LACTATE**  $CH_3CHONCOONa$

$C_3H$

**FREEZING POINTS OF SODIUM LACTATE SOLUTIONS**  
(Dietz, Degering, and Schapmeyer, 1941)

t°	Gms. Sodium Lactate per 100 gms. Sat. Sol.	t°	Gms. Sodium Lactate per 100 gms. Sat. Sol.
-2.2	5	-18.2	30
-4.1	10	-32.5	40
-9.7	20		

The density, refractive index, viscosity, boiling points, and surface tension of various sodium lactate solutions are also reported.

**SODIUM MALONATE**  $CH_2(COO)_2Na_2$

**FREEZING POINTS OF DILUTE AQUEOUS SOLUTIONS**  
(Taft and Welch, 1951)

Molality of solution	0.01	0.05	0.1	0.2	0.5	1.0
Freezing Point °C	-0.051	-0.254	-0.481	-0.926	-2.358	-4.433

# Na SODIUM

## C<sub>4</sub>H SODIUM BUTYRATE n-C<sub>3</sub>H<sub>7</sub>COONa

EQUILIBRIUM IN THE SYSTEM SODIUM HYDROXIDE, BUTYRIC ACID AND WATER AT 25°  
(Bury and Owens, 1935)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
Na <sub>2</sub> O	(C <sub>4</sub> H <sub>7</sub> O) <sub>2</sub> O	Solid Phase	Na <sub>2</sub> O	(C <sub>4</sub> H <sub>7</sub> O) <sub>2</sub> O	Solid Phase
40.56	0.0	NaOH.H <sub>2</sub> O	15.00	27.22	C <sub>3</sub> H <sub>7</sub> CO <sub>2</sub> Na.H <sub>2</sub> O
40.62	0.77	" + C <sub>3</sub> H <sub>7</sub> CO <sub>2</sub> Na	15.10	32.97	"
39.01	0.50	C <sub>3</sub> H <sub>7</sub> CO <sub>2</sub> Na	14.31	37.77	"
33.88	0.76	"	14.27	41.34	"
29.05	0.58	"	14.19	43.55	"
23.81	1.00	"	13.92	46.44	"
20.38	3.09	"	13.82	49.76	"
19.29	6.50	"	13.47	52.07	2C <sub>3</sub> H <sub>7</sub> CO <sub>2</sub> NaC <sub>3</sub> H <sub>7</sub> CO <sub>2</sub> H
18.86	11.66	C <sub>3</sub> H <sub>7</sub> CO <sub>2</sub> Na.H <sub>2</sub> O	12.40	60.72	"
17.24	17.93	"	11.03	74.63	"
16.89	20.70	"	10.59	79.92	"
16.53	24.01	"	10.35	82.28	"

EQUILIBRIUM IN THE SYSTEM SODIUM BUTYRATE AND BUTYRIC ACID,  
DETERMINED BY THE FREEZING-POINT METHOD  
(Bakunin and Vitale, 1935)

t°	Mol. % C <sub>3</sub> H <sub>7</sub> CO <sub>2</sub> Na in sat. sol.	Solid Phase	t°	Mol. % C <sub>3</sub> H <sub>7</sub> CO <sub>2</sub> Na in sat. sol.	Solid Phase
- 6	7.11	C <sub>3</sub> H <sub>7</sub> COOH	155	53.14	X.1
- 13	14.56	"	196	67.80	"
- 22	22.12	"	206	72.63	"
- 27 Eutec.	-	" + 1.1	225	84.12	"
+ 20	29.76	1.1	238	92.90	C <sub>3</sub> H <sub>7</sub> CO <sub>2</sub> Na
83.1	39.51	X.1	286 m.pt.	100.00	"
127.0	47.22	"			

1.1 = C<sub>3</sub>H<sub>7</sub>COONa.C<sub>3</sub>H<sub>7</sub>COOH; X.1 = XC<sub>3</sub>H<sub>7</sub>COONa.C<sub>3</sub>H<sub>7</sub>COOH

100 gms. Methyl Alcohol (CH<sub>3</sub>OH) dissolve 15.31 gms. n C<sub>3</sub>H<sub>7</sub>COONa at 15° and 20.70 gms. at 68.2° (b.pt.).

100 gms. Acetone ((CH<sub>3</sub>)<sub>2</sub>CO) dissolve 0.14 gm. n C<sub>3</sub>H<sub>7</sub>COONa at 15°. (Henstock, 1934.)

Melting points are given for the systems:

NaC<sub>3</sub>H<sub>7</sub>COO + NaSCN (Solokov and Pochtakova, 1958)

NaC<sub>3</sub>H<sub>7</sub>COO + LiNO<sub>3</sub> = NaNO<sub>3</sub> + LiC<sub>3</sub>H<sub>7</sub>COO (Tsindrik and Sokolov, 1958)

SODIUM ISO BUTYRATE  $i\text{-C}_4\text{H}_7\text{COONa}$  $\text{C}_4\text{H}$ 

Melting points are given for the systems Na isobutyrate - Na pentanoate, Na isobutyrate - Na stearate and Na isobutyrate - Na benzoate by Sokolov, 1954.

SODIUM HYDROGEN DIGLYCOLATE  $\text{NaOOCCH}_2\text{OCH}_2\text{COOH}$  $\text{C}_4\text{H}$ 

SOLUBILITY IN WATER  
(E. I. Dupont Co.)

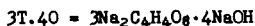
0° 2.6 gms  $\text{NaOOCCH}_2\text{OCH}_2\text{COOH}$  per 100 gms  $\text{H}_2\text{O}$   
25° 5.1 " " " " " "

SODIUM TARTRATE  $\text{Na}_2\text{C}_4\text{H}_4\text{O}_6$  d. and meso. $\text{C}_4\text{H}$ 

THE SYSTEM dextro-SODIUM TARTRATE - SODIUM HYDROXIDE - WATER AT 17°  
(Peyronel, 1949)

## Selected Data

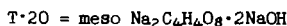
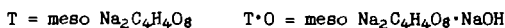
Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.		
$\text{Na}_2\text{C}_4\text{H}_4\text{O}_6$	NaOH	Solid Phase	$\text{Na}_2\text{C}_4\text{H}_4\text{O}_6$	NaOH	Solid Phase
30.90	0.0	T·2	12.47	31.90	T·O·3
24.52	5.82	"	15.65	32.20	T·O·3 + 3T·40
19.36	11.43	"	12.97	33.68	3T·40
17.96	17.53	"	10.00	37.00	"
18.37	17.18	"	9.50	40.40	"
20.32	18.16	T·2 + T·O·3	7.63	44.50	"
17.60	19.70	T·O·3	3.40	49.75	"
18.20	21.02	"	3.55	49.40	3T·40 + O·1
10.87	26.43	"	0.0	50.00	O·1
10.13	30.50	"			



Results for the system d-sodium tartrate - sodium hydroxide - ethanol - water at 18° are given by Peyronel and Venosta, 1952.

# Na SODIUM

## THE SYSTEM meso SODIUM TARTRATE - SODIUM HYDROXIDE - WATER AT 17° (Peyronel, 1951)



	Sat. Sol. Wt. %			Sat. Sol. Wt. %			Sat. Sol. Wt. %		
	T	NaOH	Solid Phase	T	NaOH	Solid Phase	T	NaOH	Solid Phase
C <sub>4</sub> H	9.07	0.0	T	1.04	41.63	T·O	1.21	47.70	T·2O
	6.51	13.09	T	0.97	42.30	T·O	1.65	49.20	T·2O
	3.77	22.37	T	1.14	46.43	T·O	3.30	49.90	T·2O
	2.72	29.30	T	1.35	47.50	T·O	6.46	49.00	T·2O
	2.65	33.50	T	0.82	47.85	T·O	8.86	48.20	T·2O
	4.74	37.10	T	0.94	48.10	T·O	11.95	47.20	T·2O
	12.03	38.10*	T	1.72	44.45*	T·2O	16.00	46.10	T·2O
	19.75	38.00*	T	1.26	45.35*	T·2O	18.22	45.20	T·2O
	19.60	38.00*	T	1.98	45.50*	T·2O	22.23	43.80	T·2O
	2.94	34.90	T+T·O	1.67	47.60	T·2O			

\*metastable

## THE SYSTEM SODIUM TARTRATE - SODIUM CARBONATE - WATER AT 17° (Peyronel, 1949)

Gms. per 100 gms. Sat. Sol.

Na <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>8</sub>	Na <sub>2</sub> CO <sub>3</sub>	Solid Phase
30.90	0.0	Na <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>8</sub> ·2H <sub>2</sub> O
25.83	5.10	"
24.41	6.87	"
20.72	10.46	Na <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>8</sub> ·2H <sub>2</sub> O + Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O
20.30	10.68	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O
16.25	11.00	"
9.74	13.14	"
0.0	15.85	"

The composition of the homogeneous mixture (plait point) of the system, Sodium Tartrate - Tertiary Butyl Alcohol - Water at 25° was found by Ginnings, Herring and Webb, 1933, to be 3.8 percent Na<sub>2</sub>C<sub>4</sub>H<sub>4</sub>O<sub>8</sub> + 31.4 percent t(CH<sub>3</sub>)<sub>3</sub>COH + 66.8 percent H<sub>2</sub>O.

## SODIUM POTASSIUM TARTRATE NaKC<sub>4</sub>H<sub>4</sub>O<sub>8</sub>

Results for the plait point in the system Sodium Potassium Tartrate - Tertiary Butyl Alcohol - water at 25° are: 4.0 percent NaKC<sub>4</sub>H<sub>4</sub>O<sub>8</sub> + 31.1 percent t(CH<sub>3</sub>)<sub>3</sub>COH + 64.9 percent H<sub>2</sub>O.

The original results for other points on these binodal curves are not given but only the values corresponding to derived empirical equations for the curves. (Ginnings, Herring and Webb, 1933.)

100 gms. Acetone ((CH<sub>3</sub>)<sub>2</sub>CO) dissolve 6.7 gms. NaKC<sub>4</sub>H<sub>4</sub>O<sub>8</sub> at 15°.  
(Henstock, 1934.)

## SODIUM HYDROXY and PYRO TARTRATES

## SOLUBILITY IN WATER

Salt	Formula	t°	Gms. Salt per 100 Gms. H <sub>2</sub> O
Sodium Neutral Inactive Pyrotartrate	$C_5H_6O_8 \cdot Na_2 \cdot 6H_2O$	20	39.73
" Dextro "	" "	20	41.10
			(Schlossberg, 1900.)
Sodium Dihydroxy Tartrate	$C_4H_4O_8Na_2 \cdot 3H_2O$	0	0.039
			(Fenton, 1898.)

SODIUM FUMARATES; Neutral,  $Na_2C_4H_2O_4$ ; Acid,  $NaC_4H_3O_4$  $C_4H$ 100 gms. H<sub>2</sub>O dissolve 22.83 gms. neutral sodium fumarate at 25°.

100 gms. H<sub>2</sub>O dissolve 6.87 gms. acid sodium fumarate at 25°, 10.74 gms. at 40° 18.15 gms. at 60° and 30.2 gms. at 100°.

(Weiss and Downs, 1923.)

SODIUM MALEATE  $Na_2C_4H_2C_4 \cdot 1/2H_2O$ 

100 gms. H<sub>2</sub>O dissolve 96.06 gms.  $Na_2C_4H_2O_4$  at 25°.

(Weiss and Downs, 1923.)

SODIUM ACID MALEATE  $NaC_4H_3O_4 \cdot 3H_2O$ 

100 gms. H<sub>2</sub>O dissolve 6.73 gms.  $NaC_4H_3O_4$  at 25°, 12.81 gms. at 40°, 31.3 gms. at 60° and 288.0 gms. at 100°.

(Weiss and Downs, 1923.)

SODIUM CACOOYLATE  $(CH_2)_2AsO \cdot ONa$ 

100 gms. H<sub>2</sub>O dissolve about 200 gms. of the salt at 15°-20°.

(Squire and Caines, 1905.)

100 cc. 90% alcohol dissolve about 100 gms. of the salt at 15°-20°.

(Squire and Caines, 1905.)



# Na SODIUM

## C<sub>4</sub>H SODIUM SUCCINATE (CH<sub>2</sub>)<sub>2</sub>(COONa)<sub>2</sub>

### SOLUBILITY IN WATER (Marshall and Bain, 1910)

t°	Gms. (CH <sub>2</sub> ) <sub>2</sub> (COONa) <sub>2</sub> per 100 Gms. H <sub>2</sub> O	Solid Phase
0	21.45	(CH <sub>2</sub> ) <sub>2</sub> (COONa) <sub>2</sub> ·6H <sub>2</sub> O
12.5	27.38	"
25	34.90	"
37.5	43.64	"
50	56.3	(CH <sub>2</sub> ) <sub>2</sub> (COONa) <sub>2</sub> ·6H <sub>2</sub> O
62.5	78.49	"
64.9	83.38	" + (CH <sub>2</sub> ) <sub>2</sub> (COONa) <sub>2</sub>
75	86.63	(CH <sub>2</sub> ) <sub>2</sub> (COONa) <sub>2</sub>

### FREEZING POINTS OF DILUTE SOLUTIONS (Taft and Welch, 1951)

Molality of solution	0.01	0.05	0.1	0.2	0.5	1.0
Freezing pt. °C	-0.050	-0.260	-0.489	-0.971	-2.491	-4.583

### EQUILIBRIUM IN THE SYSTEM SODIUM SUCCINATE, SUCCINIC ACID AND WATER (Marshall and Bain, 1910)

Results at 0°			Results at 25°		
Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
Na <sub>2</sub> Su	H <sub>2</sub> Su		Na <sub>2</sub> Su	H <sub>2</sub> Su	
0	2.68	H <sub>2</sub> Su*	0	7.71	H <sub>2</sub> Su
3.23	4.76	"	3.68	10.26	"
5.38	5.83	"	8.99	13.35	"
8.27	7.12	" + NaHSu.3H <sub>2</sub> O	12.64	15.53	"
8.67	6.27	NaHSu.3H <sub>2</sub> O	15.26	16.90	" + NaHSu.3H <sub>2</sub> O
9.68	4.74	"	15.07	13.83	NaHSu.3H <sub>2</sub> O
11.74	3.49	"	18.89	8.41	"
15.62	2.34	"	22.71	5.65	"
18.36	1.90	" + Na <sub>2</sub> Su.6H <sub>2</sub> O	26.88	4.08	" + Na <sub>2</sub> Su.6H <sub>2</sub> O
18.07	1.67	Na <sub>2</sub> Su.6H <sub>2</sub> O	26.50	2.38	Na <sub>2</sub> Su.6H <sub>2</sub> O
17.87	0.94	"	26.11	0.85	"
17.64	-		25.87	0	"

(Cont.)

\*Su = (CH<sub>2</sub>)<sub>2</sub>(COO)<sub>2</sub>

## EQUILIBRIUM IN THE SYSTEM SODIUM SUCCINATE, SUCCINIC ACID AND WATER--Cont.

Results at 50°			Results at 75°		
Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
Na <sub>2</sub> Su	H <sub>2</sub> Su		Na <sub>2</sub> Su	H <sub>2</sub> Su	
0	19.27	H <sub>2</sub> Su*	0	37.64	H <sub>2</sub> Su
5.95	22.90	"	8.22	40.38	"
10.25	25.33	"	13.14	42.50	"
15.40	28.73	"	16.93	44.38	"
19.65	31.73	" + NaHSu	19.56	45.98	" + NaHSu
20.72	26.51	NaHSu	21.88	35.60	NaHSu
22.53	18.44	"	24.30	26.82	"
25.53	13.09	"	29.45	15.28	"
28.28	9.46	"	36.11	7.79	"
30.48	7.38	"	41.26	4.93	"
37.33	4.20	" + Na <sub>2</sub> Su.6H <sub>2</sub> O	45.27	4	" + Na <sub>2</sub> Su.H <sub>2</sub> O
36.85	3.88	Na <sub>2</sub> Su.6H <sub>2</sub> O	45.36	3.17	Na <sub>2</sub> Su.H <sub>2</sub> O
36.67	2.66	"	45.93	1.23	"
36.43	0	"	46.42	0	"

The following double and triple points were located:

t°	Gms. per 100 Gms. Sat. Sol.		Solid Phase
	Na <sub>2</sub> Su	N <sub>2</sub> Su	
34.9	30.8	5.6	NaHSu.3H <sub>2</sub> O + NaHSu + Na <sub>2</sub> Su.6H <sub>2</sub> O
37.8	19.6	25.46	NaHSu.3H <sub>2</sub> O + NaHSu + H <sub>2</sub> Su
38.7	22.47	16.44	NaHSu.3H <sub>2</sub> O + NaHSu
63.4	42.92	3.64	Na <sub>2</sub> Su.6H <sub>2</sub> O + Na <sub>2</sub> Su.H <sub>2</sub> O + NaHSu
64.9	45.43	-	Na <sub>2</sub> Su.6H <sub>2</sub> O + Na <sub>2</sub> Su.H <sub>2</sub> O

\*In the above tables the abbreviation Su is used for (CH<sub>2</sub>)<sub>2</sub>(COO)<sub>2</sub>.

## SODIUM HYDROGEN SUCCINATE

C<sub>4</sub>HSOLUBILITY OF SODIUM HYDROGEN SUCCINATE IN WATER  
(Marshall and Bain, 1910)

t°	Gms. (CH <sub>2</sub> ) <sub>2</sub> (COOH)(COONa) per 100 Gms. H <sub>2</sub> O	Solid Phase
0	17.55	NaH(CH <sub>2</sub> ) <sub>2</sub> (COO) <sub>2</sub> ·3H <sub>2</sub> O
2.5	27.93	"
25	39.82	"
37.5	60.01	"
38.7	63.99	NaH(CH <sub>2</sub> ) <sub>2</sub> (COO) <sub>2</sub> ·3H <sub>2</sub> O + NaH(CH <sub>3</sub> ) <sub>2</sub> (COO) <sub>2</sub>
50	67.37	NaH(CH <sub>3</sub> ) <sub>2</sub> (COO) <sub>2</sub>
62.5	76.15	"
75	86	"

100 gms. Methyl Alcohol (CH<sub>3</sub>OH) dissolve 0.72 gms. anhydrous (CH<sub>2</sub>)<sub>2</sub>(COONa)<sub>2</sub> at 15° and 1.80 gms. at 66.6° (b.pt.). (Henstock, 1934.)

## Na SODIUM

### $C_4H_7N_2O_5Na$ SODIUM DILITURATE $C_4H_7N_2O_5Na$

#### SOLUBILITY IN WATER

18°	0.049 moles per liter Sat. Sol.	(Fredholm, 1936)
30°	$\left\{ \begin{array}{l} 0.0531 \text{ moles per 1000 gms. H}_2\text{O} \\ 10.34 \text{ gms. per 1000 gms. H}_2\text{O} \end{array} \right.$	(Dermer and Dermer, 1939) " " " "

### SODIUM $\beta$ -METHYL ADIPATE (Racemic)

100 gms. sat. solution in water contain 36.8 gms. of the salt at 20°. (Maurisse)

### $C_5H_7N_4O_3Na$ SODIUM URATE $C_5H_7N_4O_3Na$

#### SOLUBILITY IN AQUEOUS SODIUM CHLORIDE AT 37° (d'Agostino, 1910)

Gms. Mols. per Liter		Gms. Mols. per Liter		Gms. Mols. per Liter	
NaCl	$C_5H_7N_4O_3 \cdot Na$	NaCl	$C_5H_7N_4O_3 \cdot Na$	NaCl	$C_5H_7N_4O_3 \cdot Na$
0	0.00536	0.01084	0.00211	0.05116	0.00050
0.00486	0.00340	0.01398	0.00172	0.06667	0.00034
0.00532	0.00321	0.02564	0.00102	0.07363	0.00032
0.00865	0.00256	0.04012	0.00054	0.08595	0.00026

One liter of  $H_2O$  dissolves 1.5 gms. sodium urate at 37°.

(Bechhold and Ziegler, 1910.)

One liter of serum dissolves 0.025 gm. sodium urate at 37°.

(Bechhold and Ziegler, 1910.)

#### SOLUBILITY OF SODIUM URATE IN AQUEOUS SOLUTIONS OF $KH_2PO_4 + K_2HPO_4$ AT 37° (Jung, 1923)

$p_H$ of aq. phosphate solution	5.0	5.6	6.4	6.6	7.0
Gms. $C_5H_7N_4O_3Na$ per liter of solvent	0.25	0.675	0.93	1.15	1.13

### SODIUM DIETHYL THIOCARBAMATE $(C_2H_5)_2NC:SSNa$

Data for the distribution between  $H_2O$  and  $CCl_4$  at varying pH are given by Bode, 1954

SODIUM CITRATE  $(\text{CH}_3)_2\text{COH}(\text{COONa})_3 \cdot 5\frac{1}{2}\text{H}_2\text{O}$ SOLUBILITY IN AQUEOUS ETHYL ALCOHOL AT 25°  
(Seidell, 1910)

Wt. % $\text{C}_2\text{H}_5\text{OH}$ in Solvent	$d_{25}$ of Sat. Sol.	Gms. $\text{C}_6\text{H}_5\text{O}_7\text{Na}_3 \cdot 5\frac{1}{2}\text{H}_2\text{O}$ per 100 Gms. Sat. Sol.	Wt. % $\text{C}_2\text{H}_5\text{OH}$ in Solvent	$d_{25}$ of Sat. Sol.	Gms. $\text{C}_6\text{H}_5\text{O}_7\text{Na}_3 \cdot 5\frac{1}{2}\text{H}_2\text{O}$ per 100 Gms. Sat. Sol.
0	1.276	48.1	40	0.953	4.5
10	1.190	37.4	50	0.918	1.4
20	1.100	25	60	0.892	0.3
30	1.006	11.8	100	0.789	0

Data for equilibrium in the system sodium hydroxide, citric acid, phosphoric acid and water at 20° are given by Pratolongo (1913). The author fails to describe clearly the terms in which the results are expressed, consequently their exact meaning is not clear.

SODIUM PENTANOATE (VALERATE)  $\text{CH}_3(\text{CH}_2)_3\text{COONa}$  $\text{C}_5\text{H}$ 

Melting points in the systems sodium pentanoate - sodium stearate and sodium pentanoate - sodium benzoate are given by Sokolov, 1954.

SODIUM VALERATE (ISO)  $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{COONa}$ SOLUBILITY OF SODIUM ISO-VALERATE IN GLYCOLS AT 25°  
(Palit, 1947)

	Moles $\text{C}_4\text{H}_9\text{COONa}$ per 1000 gms. Glycol
Ethylene Glycol	2.511
Propylene Glycol	1.742

MONO SODIUM L-GLUTAMATE  $\text{C}_3\text{H}_5(\text{NH}_2)(\text{COOH})\text{COONa}$ 

The "hydration temperature" is -8.5°. The transition from pentahydrate to monohydrate occurs at +0.8° and the solution contains 30.5% of the salt. The solubility of the mono sodium salts in gms per 100 gms  $\text{H}_2\text{O}$  at temperature t° is:

$$\begin{aligned} \log S &= 1.711 + 0.00345 t^\circ && \text{for the l-monohydrate} \\ \text{and } \log S &= 1.199 + 0.00743 t^\circ && \text{for the dl-dihydrate} \end{aligned}$$

(Ogawa and Fujii, 1949)

## Na SODIUM

### $C_6H$ SODIUM CAPROATE $CH_3(CH_2)_4COONa$

The triangular diagram, but no numerical results, for the system Sodium Caproate - Phenol - Water at  $25^\circ$  are given by Jencic, 1934.

### SOLUBILITY OF SODIUM CAPROATE IN GLYCOLS AT $25^\circ$ (Palit, 1947)

	Moles $C_6H_{11}OONa$ per 1000 gms. Glycol
Ethylene Glycol	2.641
Propylene Glycol	1.988

### SODIUM STYPHMATE $C_6HO(OH)_2(NO_2)_3Na$

8.43 gms. (0.035 moles) dissolve in 100 gms. of water at  $30^\circ$ .  
(Dermer and Dermer, 1939).

### SODIUM NITRAMILATE $(C_6H_5N_2O_2)Na$

0.724 gms. (0.00264 moles) dissolve in 100 gms. of water at  $30^\circ$ .  
(Dermer and Dermer, 1939).

### SODIUM GLUCONATE $NaC_6H_{11}O_7$

100 gms. sat. solution of Sodium Gluconate in Water contain 46.1 gms.  $NaC_6H_{11}O_7$  at  $25^\circ$ . (May, Weissberg and Herrick, 1929.)

### SODIUM (LANTHANON) ETHYLENEDIAMINE TETRACETATES $(NCH_2CH_2N)(COO)_4Na \cdot L$

#### SOLUBILITIES IN WATER (Marsh, 1955)

(Results in gms of hydrated salt per liter sat. sol)

$t^\circ$	"L" =	La	Ce	Pr	Nd	Sm	Gd	Dy	Y	Er	Yd
2		120	28	18	11.8	10.6	11.7 <sup>a</sup>	46	97	196 <sup>c</sup>	$\infty$
25		139	70	42	31	29	39	133	260	450	$\infty$
35		-	-	-	42	43	56 <sup>b</sup>	199	342	589 <sup>d</sup>	$\infty$

a = 1.18 gms/100 gms  $H_2O$

b = 5.7 gms/100 gms  $H_2O$

c = 21.8 gms/100 gms  $H_2O$

d = 84.3 gms/100 gms  $H_2O$

SODIUM PHENOLATES  $C_6H_5ONa \cdot 3H_2O$  and  $C_6H_5ONa \cdot 2C_6H_5OH$  $C_6H$ 

THE SYSTEM SODIUM HYDROXIDE - PHENOL - WATER AT 25°  
(von Meurs, 1916)

Mols. per 100 mols. sat. sol.		Solid Phase	Mols. per 100 mols. sat. sol.		Solid Phase
NaOH	$C_6H_5OH$		NaOH	$C_6H_5OH$	
33.92	0.0	$NaOH \cdot H_2O$	16.56	28.99	$C_6H_5ONa \cdot 3H_2O$
26.56	0.08	$C_6H_5ONa \cdot 3H_2O$	16.62	31.75	"
23.69	0.61	"	16.47	36.54	$C_6H_5ONa \cdot 2C_6H_5OH$
19.47	2.06	"	14.25	44.81	"
18.19	5.18	"	13.17	48.31	"
17.61	6.91	"	10.74	57.47	"
16.52	10.08	"	7.88	67.03	"
15.27	13.44	"	5.68	73.37	$C_6H_5OH$
15.21	14.61	"	3.32	73.98	"
15.89	19.67	"	0.0	74.27	"
15.98	23.24	"			

SODIUM p-NITROPHENOLATES  $p-C_6H_4NO_2ONa$  $C_6H$ 

SOLUBILITY IN WATER AND IN AQUEOUS NORMAL SOLUTIONS OF  
NON-ELECTROLYTES  
(Goldschmidt, 1895)

Solid phase  $p-C_6H_4(NO_2)ONa \cdot 4H_2O$  below 36°,  $p-C_6H_4(NO_2)ONa \cdot 2H_2O$   
above 36°.

t°	Gms. p-C <sub>6</sub> H <sub>4</sub> (NO <sub>2</sub> )ONa per 100 gms. sat. sol. in:							
	Water	Alco- hol	Urea	Glyc- erine	Acetone	Propio- nitrile	Aceto- nitrile	Ure- thane
23.7	5.597	5.615	5.244	6.188	6.225	6.257	6.065	6.520
28.6	6.721	6.874	7.489	7.440	7.498	7.571	7.328	7.889
30.6	7.256	-	-	-	-	-	-	-
33.6	8.125	8.318	9.000	9.025	9.025	9.066	8.886	9.507
35.9	8.851	-	-	-	-	-	-	-
36.1	8.883	-	9.683	9.688	9.665	9.911	9.667	10.248
40.2	9.881	10.147	10.666	10.777	10.695	10.905	10.667	11.379
45.2	11.235	11.513	12.068	12.229	-	-	-	12.869
50.1	12.730	13.133	13.555	13.785	-	-	-	-

SOLUBILITY OF SODIUM - NITRO PHENOLATE IN AQUEOUS ALCOHOL AT 25°  
(Fischer, 1914, 1918)

Saturation was secured by means of constant agitation in a thermo-  
stat. The compound also crystallized with 4  $H_2O$  but in all concentrations  
of alcohol above 15 percent the solid phase was  $C_6H_4(NO_2)ONa \cdot 2H_2O$ .

# Na SODIUM

## SOLUBILITY OF SODIUM NITRO PHENOLATE IN AQUEOUS ALCOHOL AT 25°—Cont.

Vol. % C <sub>2</sub> H <sub>5</sub> OH	Gms. p C <sub>6</sub> H <sub>4</sub> NO <sub>2</sub> -ONa per 100 cc. sat. sol.	Vol. % C <sub>2</sub> H <sub>5</sub> OH	Gms. p C <sub>6</sub> H <sub>4</sub> NO <sub>2</sub> -ONa per 100 cc. sat. sol.
0	5.640	55	5.039
10	5.168	60	4.749
15	5.019	65	4.378
20	5.007	70	3.895
25	5.088	75	3.284
30	5.156	80	2.753
35	5.281	85	2.045
40	5.344	90	1.495
45	5.313	95	1.256
50	5.200	100	4.412

## C<sub>6</sub>H SODIUM CHLORO NITRO PHENOLATE C<sub>6</sub>H<sub>3</sub>(4)Cl(2)NO<sub>2</sub>(1)ONa·H<sub>2</sub>O

### SOLUBILITY OF CHLORO NITRO PHENOLATE IN AQUEOUS ALCOHOL AT 25° (Fischer, 1914, 1918)

Vol. % C <sub>2</sub> H <sub>5</sub> OH	Gms. C <sub>6</sub> H <sub>3</sub> Cl(NO <sub>2</sub> )ONa per 100 cc. sat. sol.	Solid Phase
0	2.702	C <sub>6</sub> H <sub>3</sub> ClNO <sub>2</sub> ·ONa·H <sub>2</sub> O
10	2.374	"
15	2.346	"
20	2.314	"
25	2.404	"
30	2.576	"
35	2.708	"
40	2.990	"
45	3.190	"
50	3.068	" + C <sub>6</sub> H <sub>3</sub> ClNO <sub>2</sub> ONa
55	2.908-2.564*	
60	3.146	
65	3.110	C <sub>6</sub> H <sub>3</sub> ClNO <sub>2</sub> ·ONa
70	2.604	"
75	2.307	"
80	1.860	"
85	1.293	"
90	0.870	"
95	0.616	"
100	0.680	"

\*Gradual dehydration by the alcohol occurs here.

SODIUM DINITRO PHENOLATE  $C_6H_3(2,4)(NO_2)_2(OH)ONa \cdot H_2O$  $C_8H$ 

SOLUBILITY OF SODIUM DINITRO PHENOLATE AT 25° IN:  
(Fischer, 1914, 1918)

Aqueous Ethyl Alcohol

Gms. $C_6H_3(NO_2)_2 \cdot ONa \cdot H_2O$ per 100 cc. sat. sol.		Gms. $C_6H_3(NO_2)_2 \cdot ONa \cdot H_2O$ per 100 cc. sat. sol.	
Vol. % $C_2H_5OH$		Vol. % $C_2H_5OH$	
0	4.461	55	3.392
10	3.516	60	3.214
15	3.246	65	2.976
20	3.188	70	2.630
25	3.090	75	2.174
30	3.148	80	1.798
35	3.260	85	1.258
40	3.386	90	0.818
45	3.440	95	0.566
50	3.470	100	2.671

Aqueous Methyl Alcohol

	Gms. $C_6H_3(NO_2)_2 \cdot ONa \cdot H_2O$ per 100 cc. sat. sol.
Vol. % $CH_3OH$	
0	4.461
10	3.686
20	3.196
30	2.950
40	2.854
50	2.824
60	2.792
70	2.672
80	2.518
90	2.475
100	4.651

Aqueous Acetone

Vol. % $CH_3CO \cdot CH_3$	Gms. $C_6H_5(NO_2)_2 \cdot ONa \cdot H_2O$ per 100 cc. sat. sol.
0	4.461
10	4.859
20	5.470
30	6.086
40	6.850
50	7.442
60	7.784
70	7.568
80	6.536
90	4.356
100	1.085

SODIUM PICRATE  $C_6H_2(NO_2)_3 \cdot ONa$  $C_8H$ 

## SOLUBILITY IN WATER

25° - 100 cc.  $H_2O$  dissolve 4.247 gms.  $C_6H_2(NO_2)_3 \cdot ONa \cdot H_2O$  (Fisher and  
Miloszewski, 1910)  
30° - 100 gms.  $H_2O$  dissolve 5.58 gms.  $C_6H_2(NO_2)_3ONa$  (Dermer and Dermer,  
1939)



# Na SODIUM

## SOLUBILITY OF HYDRATED SODIUM PICRATE IN AQUEOUS SALT SOLUTIONS AT 25° (Fisher and Miloszewski, 1910)

		Gms. $C_6H_2(NO_2)_3 \cdot ONa \cdot H_2O$ per 100 cc. Aq. Solution of Normality:							
C <sub>6</sub> H	Solubility in Aq. Solution of:	0.01	0.02	0.04	0.066	0.10	0.25	0.5	1
	Na <sub>2</sub> CO <sub>3</sub>	4.159	4.044	3.807	3.434	3.187	2.017	1.120	0.611
	NaCl	4.189	3.956	3.677	3.335	3.021	1.678	0.846	0.410
	Na <sub>2</sub> SO <sub>4</sub>	4.246	4.102	3.879	3.651	3.195	2.053	1.156	0.552
	Na <sub>3</sub> PO <sub>4</sub>	4.235	4.051	3.814	3.562	3.225	2.219	1.329	0.705
	NaOH	4.192	4.048	3.715	3.339	2.941	1.781	0.921	0.371
	NaNO <sub>3</sub>	4.154	4.029	3.710	3.363	3.041	1.932	0.943	0.684
	NaBr	4.190	4.117	3.770	3.384	3.024	1.777	0.912	0.499

## SOLUBILITY OF SODIUM PICRATE IN AQUEOUS SOLUTIONS OF ETHYL ALCOHOL (Fischer, 1914, 1918)

At 0° the mixtures were stirred in a vessel which was cooled by melting ice. At 25° the mixtures were constantly agitated in a thermostat. The dissolved picrate was determined either by evaporating and weighing the residue or by a method of titration. The concentration of the aqueous alcohol mixtures was controlled by density determinations.

The solid phase in contact with the saturated solutions was  $C_6H_2(NO_2)_3 \cdot ONa \cdot H_2O$  in all cases.

### Results at 0°

Vol. % C <sub>2</sub> H <sub>5</sub> OH	Gms. $C_6H_2(NO_2)_3 \cdot ONa$ per 100 cc. sat. sol.		Vol. % C <sub>2</sub> H <sub>5</sub> OH	Gms. $C_6H_2(NO_2)_3 \cdot ONa$ per 100 cc. sat. sol.	
0	1.824		45	1.042	
5	1.426		50	1.125	
10	1.169		55	1.293	
15	0.964		60	1.277	
20	0.816		80	0.884	
25	0.721		90	0.547	
30	0.718		95	0.449	
35	0.755		100	2.683	
40	0.843				

## SOLUBILITY OF SODIUM PICRATE IN AQUEOUS SOLUTIONS OF ETHYL ALCOHOL--Cont.

## Results at 25°

	Gms. C <sub>6</sub> H <sub>2</sub> (NO <sub>2</sub> ) <sub>3</sub> ·ONa per 100 cc. sat. sol.		Gms. C <sub>6</sub> H <sub>2</sub> (NO <sub>2</sub> ) <sub>3</sub> ·ONa per 100 cc. sat. sol.
Vol. % C <sub>2</sub> H <sub>5</sub> OH		Vol. % C <sub>2</sub> H <sub>5</sub> OH	
0	4.280	50	3.409
5	3.741	55	3.313
10	3.326	60	3.245
15	3.017	65	3.047
20	2.816	70	2.777
25	2.744	75	2.465
30	2.789	80	1.948
35	2.994	85	1.537
40	3.145	90	1.247
45	3.313	95	0.873
		100	4.438

Data for the distribution of sodium picrate between diisopropyl acetone and water at 25° are given by Karpfen and Randles, 1953.

Data for the solubility of sodium picrate and the sodium salts of other nitrophenols in aqueous alcohol and acetone solutions at 25° are given by Fisher (1914).

10% sodium picrate by weight dissolve in acetonitrile at 25°. (Pleskov, 1948.)

SODIUM METHYL PICRATE C<sub>6</sub>H(NO<sub>2</sub>)<sub>3</sub>(CH<sub>3</sub>)ONa

C<sub>6</sub>H

3.15 gms. (0.0118 moles) dissolve in 100 gms. of water at 30°. (Dermer and Dermer, 1939.)

SODIUM CHLOROPICRATE C<sub>6</sub>H(NO<sub>2</sub>)<sub>3</sub>(Cl)ONa

C<sub>6</sub>H

31.2 gms. (0.110 moles) dissolve in 100 gms. of water at 30°. (Dermer and Dermer, 1939.)

# Na SODIUM

## C<sub>6</sub>H<sub>5</sub> SODIUM BENZENE SULFONATE NaC<sub>6</sub>H<sub>5</sub>SO<sub>3</sub>

### SOLUBILITY OF SODIUM BENZENE SULFONATE IN WATER

(Hauslick, 1935)			(Rhodes and Lewis, 1928)		
t°	Gm. Mols. NaC <sub>6</sub> H <sub>5</sub> SO <sub>3</sub> per 100 gms. H <sub>2</sub> O	Solid Phase	t°	Gms. NaC <sub>6</sub> H <sub>5</sub> SO <sub>3</sub> per 100 gms. sat. sol.	Solid Phase
3	0.125	NaC <sub>6</sub> H <sub>5</sub> SO <sub>3</sub> ·H <sub>2</sub> O	0	26.8	NaC <sub>6</sub> H <sub>5</sub> SO <sub>3</sub> ·2H <sub>2</sub> O
17	0.190	"	30	35.8	"
26	0.232	"	40	38.6	"
47	0.326	"	50	41.9	"
57	0.385	"	60	45.1	"
70	0.440	NaC <sub>6</sub> H <sub>5</sub> SO <sub>3</sub> ·?H <sub>2</sub> O	70	48.0*	NaC <sub>6</sub> H <sub>5</sub> SO <sub>3</sub> ·?H <sub>2</sub> O
81	0.513	"	80	51.1	"
93	0.555	"	105	58.5	"
120	0.680	"			

\*The hydrate transition (to anhydrous salt?) occurs at 66.8°.

### SOLUBILITY OF SODIUM BENZENE SULFONATE IN SODIUM SULFATE SOLUTIONS (Rhodes and Lewis, 1928)

Gms. NaC <sub>6</sub> H <sub>5</sub> SO <sub>3</sub> per 100 gms. sat. solution in:				
t°	Aq. 5% Na <sub>2</sub> SO <sub>4</sub>	Aq. 10% Na <sub>2</sub> SO <sub>4</sub>	Aq. 20% Na <sub>2</sub> SO <sub>4</sub>	Solid Phase
30	32.2	27.7	--	NaC <sub>6</sub> H <sub>5</sub> SO <sub>3</sub> ·2H <sub>2</sub> O
50	38.6	34.4	25.8	"
70	45.2	42.1	31.9	" ·?H <sub>2</sub> O

### SOLUBILITY IN METHANOL (Henstock)

At 15°, 6.51 gms. NaC<sub>6</sub>H<sub>5</sub>SO<sub>3</sub> dissolve in 100 gms. CH<sub>3</sub>OH.  
At 66.6°, 8.00 " " " " " " "

### SOLUBILITY OF OTHER BENZENE SULFONATES IN WATER

Compound and Formula	t°	Solubility
Na Benzene 1.3 Chloro Sulfonate NaC <sub>6</sub> H <sub>4</sub> ClSO <sub>3</sub>	18	4.37 gms./100 cc. sat. sol.(a)
Na Benzene 1.3 Chloro Sulfonate NaC <sub>6</sub> H <sub>4</sub> ClSO <sub>3</sub>	98	45.0 " "
Na Benzene 1.4 Chloro Sulfonate NaC <sub>6</sub> H <sub>4</sub> ClSO <sub>3</sub>	18	1.79 " "
Na Benzene 1.4 Chloro Sulfonate NaC <sub>6</sub> H <sub>4</sub> ClSO <sub>3</sub>	98	40.00 " "
Na Tri Isopropylbenzene Sulfonate NaC <sub>6</sub> H <sub>2</sub> (i-C <sub>3</sub> H <sub>7</sub> ) <sub>3</sub> SO <sub>3</sub>	10	0.063 moles/1000 gms. H <sub>2</sub> O(b)
Na Tri Isopropylbenzene Sulfonate NaC <sub>6</sub> H <sub>2</sub> (i-C <sub>3</sub> H <sub>7</sub> ) <sub>3</sub> SO <sub>3</sub>	20	.065 " "

(a) Ferrero and Bollinger, 1928

(b) Shuck and Lingafelter, 1949

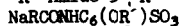
## SOLUBILITY OF OTHER BENZENE SULFONATES IN WATER--Cont.

Compound and Formula	t°	Solubility
Na Tri Isopropylbenzene Sulfonate $\text{NaC}_6\text{H}_2(\text{i-C}_3\text{H}_7)_3\text{SO}_3$	30	.071 moles/1000 gms. $\text{H}_2\text{O}$ (b)
Na Tri Isopropylbenzene Sulfonate $\text{NaC}_6\text{H}_2(\text{i-C}_3\text{H}_7)_3\text{SO}_3$	40	.16 " "
Na Tri Isopropylbenzene Sulfonate $\text{NaC}_6\text{H}_2(\text{i-C}_3\text{H}_7)_3\text{SO}_3$	50	.39 " "
Na 2.5 Diiodobenzene Sulfonate $\text{NaC}_6\text{H}_3\text{I}_2\text{SO}_3$	22.5	6.82 gms. per 100 gms. $\text{H}_2\text{O}$ (c)
Na 3.4 Diiodobenzene Sulfonate $\text{NaC}_6\text{H}_3\text{I}_2\text{SO}_3 \cdot \text{H}_2\text{O}$	22.5	3.47 " "

(b) Shuck and Lingafelter, 1949

(c) Boyle, 1909

Na 2-"R"-Amido-5-"R'"-Oxy Benzene Sulfonates:



Temperatures at which each Salt is 5% Soluble in Water  
(Adam and Pankhurst, 1946)

	R=			
	$\text{C}_{11}\text{H}_{23}$	$\text{C}_{15}\text{H}_{31}$	$\text{C}_{17}\text{H}_{35}$	$\text{C}_{17}\text{H}_{33}$
R' = $\text{CH}_3$	43.5°	65°	74.5°	16.5°
R' = $\text{C}_2\text{H}_5$	--	45.5°	--	--

Data for the solubility of  $\text{C}_8$ ,  $\text{C}_{12}$ ,  $\text{C}_{16}$ , and  $\text{C}_{18}$  alkyl sodium benzene sulfonates alone in water, and in mixtures, are given by Ogawa, 1952, in the form of graphs.

SODIUM PHENOL SULFONATE  $\text{NaC}_6\text{H}_4(\text{OH})\text{SO}_3$  $\text{C}_6\text{H}$ 

## SOLUBILITY IN WATER

t°	Gms. $\text{NaC}_6\text{H}_4(\text{OH})\text{SO}_3$ per 100 gms. $\text{H}_2\text{O}$	Reference
15	14.7 ( $d_{15} = 1.067$ )	(Greenish and Smith, 1901)
25	19.2 ( $d_{25} = 1.079$ )	(Seidell, 1910)

## Na SODIUM

### SOLUBILITY OF SODIUM PHENOL SULFONATE IN AQUEOUS ALCOHOL AT 25° (Seidell, 1910)

Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. C <sub>6</sub> H <sub>4</sub> (OH) SO <sub>3</sub> Na·2H <sub>2</sub> O per 100 Gms. Sat. Sol.	Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. C <sub>6</sub> H <sub>4</sub> (OH) SO <sub>3</sub> Na·2H <sub>2</sub> O per 100 Gms. Sat. Sol.
0 (=H <sub>2</sub> O)	1.079	19.38	60	0.919	7.5
10	1.054	17.4	70	0.886	5.1
20	1.030	15.5	80	0.852	2.9
30	1.004	13.6	90	0.820	1.1
40	0.977	11.7	95	0.810	0.8
50	0.950	9.7	100*	0.800	1.5

\*In the 100 percent C<sub>2</sub>H<sub>5</sub>OH solution, the solid phase, C<sub>6</sub>H<sub>4</sub>(OH)SO<sub>3</sub>Na·2H<sub>2</sub>O, became opaque.

## C<sub>7</sub>H SODIUM BENZOATE C<sub>6</sub>H<sub>5</sub>COONa

### SOLUBILITY OF SODIUM BENZOATE IN WATER (Sidgwick and Ewbank, 1922)

t°	Gms. C <sub>6</sub> H <sub>5</sub> COONa per 100 gms. sat. sol.	Solid Phase	t°	Gms. C <sub>6</sub> H <sub>5</sub> COONa per 100 gms. sat. sol.	Solid Phase
- 2.02	8.36	Ice	59.7	39.2	C <sub>6</sub> H <sub>5</sub> COONa
- 4.85	16.52	"	87.6	41.25	"
- 8.50	26.01	"	97.0	42.28	"
± 0.9	38.52	C <sub>6</sub> H <sub>5</sub> COONa	133.0	47.30	"
15.0	38.59	"	151.3	50.75	"
30.0	38.60	"	186.0	57.05	"
49.7	38.70	"	204.5	60.43	"

### THE SYSTEM BENZOIC ACID - SODIUM BENZOATE - WATER AT 14°

The curve representing this system consists of three branches. The first branch corresponds to solutions saturated with benzoic acid. The second represents solutions saturated with the double salt, C<sub>6</sub>H<sub>5</sub>COONa·2C<sub>6</sub>H<sub>5</sub>COOH and the third, solutions saturated with sodium benzoate. At the triple points the solutions have the following composition:

Gms. per 100 gms. sat. sol.		Solid Phase
C <sub>6</sub> H <sub>5</sub> COOH	C <sub>6</sub> H <sub>5</sub> COONa	
1.25	35.3	C <sub>6</sub> H <sub>5</sub> COOH + C <sub>6</sub> H <sub>5</sub> COONa·2C <sub>6</sub> H <sub>5</sub> COOH
1.46	40.4	C <sub>6</sub> H <sub>5</sub> COONa + "

SOLUBILITY OF SODIUM BENZOATE IN AQUEOUS ETHYL ALCOHOL AT 25°  
(Seidell, 1910)

Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. C <sub>6</sub> H <sub>5</sub> COONa per 100 Gms. Sat. Sol.	Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. C <sub>6</sub> H <sub>5</sub> COONa per 100 Gms. Sat. Sol.
0	1.155	35.0	60	0.975	21.3
10	1.132	35.3	70	0.927	15.4
20	1.110	33.7	80	0.877	8.8
30	1.086	31.5	90	0.831	2.8
40	1.055	28.9	95	0.812	1.3
50	1.020	25.6	100	0.795	0.6

100 gms. 86.5% glycerol ( $d = 1.2326$ ) dissolve 31.5 gms. C<sub>6</sub>H<sub>5</sub>COONa at 20°. C<sub>7</sub>H

100 gms. 98.5% glycerol ( $d = 1.2645$ ) dissolve 28.5 gms. C<sub>6</sub>H<sub>5</sub>COONa at 20°. (Holm, 1921, 1922.)

THE SYSTEM SODIUM BENZOATE - CAFFEINE - WATER

[Pellini, 1910 (25°, 40°);

Chambon, Bouvier and Devron, 1937 (37°, 90°)]

Freezing point data in this system are given by Fialkov and Skvirskaya, 1952.

Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase
C <sub>8</sub> H <sub>10</sub> N <sub>4</sub> O <sub>2</sub>	C <sub>7</sub> H <sub>5</sub> O <sub>2</sub> Na		C <sub>8</sub> H <sub>10</sub> N <sub>4</sub> O <sub>2</sub>	C <sub>7</sub> H <sub>5</sub> O <sub>2</sub> Na	
Results at 25°			Results at 40°		
2.13	0.0	C <sub>8</sub> H <sub>10</sub> N <sub>4</sub> O <sub>2</sub> ·H <sub>2</sub> O	4.64	0.0	C <sub>8</sub> H <sub>10</sub> N <sub>4</sub> O <sub>2</sub> ·H <sub>2</sub> O
8.32	6.67	"	31.43	25.31	"
38.10	45.00	"	56.82	69.68	"
51.74	76.75	" + C <sub>7</sub> H <sub>5</sub> O <sub>2</sub> Na·H <sub>2</sub> O	57.99	74.64	" + C <sub>7</sub> H <sub>5</sub> O <sub>2</sub> Na·H <sub>2</sub> O
46.27	76.68	"	55.98	74.02	C <sub>7</sub> H <sub>5</sub> O <sub>2</sub> Na·H <sub>2</sub> O
24.79	69.56	"	18.31	67.97	"
9.47	62.97	"	0.0	59.82	"
0.0	61.17	"			
Results at 37°			Results at 90°		
3.85	0.0	C <sub>8</sub> H <sub>10</sub> N <sub>4</sub> O <sub>2</sub>	83.5	0.0	C <sub>8</sub> H <sub>10</sub> N <sub>4</sub> O <sub>2</sub>
11.85	7.25	"	64.0	7.4	"
58.1	78.92	" + C <sub>7</sub> H <sub>5</sub> O <sub>2</sub> Na	93.2	99.4	" + C <sub>7</sub> H <sub>5</sub> O <sub>2</sub> Na
0.0	59.9	C <sub>7</sub> H <sub>5</sub> O <sub>2</sub> Na	0.0	76.5	C <sub>7</sub> H <sub>5</sub> O <sub>2</sub> Na

100 gms. methyl alcohol (CH<sub>3</sub>OH) dissolve 8.22 gms. C<sub>6</sub>H<sub>5</sub>COONa at 15° and 7.55 gms. at 66.2°. (b.pt.) (Henstock, 1934.)

# Na SODIUM

## SOLUBILITY OF SODIUM BENZOATE IN GLYCOL SOLUTIONS AT 25° (Palit, 1947)

In Ethylene Glycol - n-Amyl Alcohol Mixtures		In Propylene Glycol - Chloroform Mixtures	
Wt. % Glycol	Gms. $C_6H_5COONa$ per 100 gms. Solvent	Wt. % Glycol	Gms. $C_6H_5COONa$ per 100 gms. Solvent
100	24.87	100	15.44
80	21.95	80	13.13
60	17.09	60	10.24
40	12.08	40	7.25
0	1.25	20	3.58
		0	0.07

Freezing points are given for:

Na benzoate + Na stearate (Sokolov, 1954)

## $C_7H$ SODIUM o-HYDROXY BENZOATE $C_6H_4OH \cdot COONa$ (SODIUM SALICYLATE)

### SOLUBILITY OF SODIUM ORTHO HYDROXY BENZOATE IN WATER (Sidgwick and Ewbank, 1922)

t°	Gms. $C_6H_4OH \cdot COONa(o)$ per 100 gms. sat. sol.	Solid Phase
- 0.77	4.94	Ice
- 2.65	13.15	"
- 5.04	21.18*	"
- 1.5	20.06	$C_6H_4OH \cdot COONa \cdot 6H_2O$
+ 9.0	29.61	"
12.5	35.03	"
15.2	40.48	"
17.5	44.40	"
20.0	50.0	"
47.5	55.1	$C_6H_4 \cdot OH \cdot COONa$
78.5	59.32	"
114.0	64.16	"
137.0	67.95	"

\*unstable

### SOLUBILITY OF SODIUM SALICYLATE IN AQUEOUS ETHYL ALCOHOL AT 25° (Seidell, 1909, 1910)

Wt. % $C_2H_5OH$ in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. $C_6H_4OHCOONa$ per 100 Gms. Sat. Sol.	Wt. % $C_2H_5OH$ in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. $C_6H_4OHCOONa$ per 100 Gms. Sat. Sol.
0	1.256	53.56	60	1.066	38.40
10	1.235	52.10	70	1.016	33
20	1.205	50.20	80	0.957	25
30	1.176	48	90	0.885	15
40	1.142	45.50	92	0.8176 (15°)	11.74 <sup>a</sup>
50	1.106	42.20	92.3	0.864	12
			100	0.805	3.82

<sup>a</sup>Schnellbach, 1929

Sodium salicylate distributes itself between olive oil and water at 15° in the ratio of 0.156 gm.  $C_6H_4OHCOONa$  per 100 cc. oil layer and 1.444 gms. per 100 cc. aqueous layer. (Harrass, 1903.)

THE SYSTEM SODIUM SALICYLATE - CAFFEINE - WATER  
(Pellini and Amadori, 1912)

Freezing points in the system are given by these authors and by Fialkov and Skvirskaya, 1952.

Results at 25°			Results at 40°		
Gms. per 100	Gms. $H_2O$	Solid Phase	Gms. per 100	Gms. $H_2O$	Solid Phase
$C_8H_{10}N_4O_2$	$C_7H_5O_3Na$		$C_8H_{10}N_4O_2$	$C_7H_5O_3Na$	
2.13	0	$C_8H_{10}N_4O_2 \cdot H_2O$	4.64	0	$C_8H_{10}N_4O_2 \cdot H_2O$
38.36	30.76	"	59.49	37.47	"
55.23	47.31	"	86.49	62.47	"
74.32	68.81	"	95.94	69.15	"
16.78	124.96	$C_7H_5O_3Na$	26.93	131.52	$C_7H_5O_3Na$
13.22	121.27	"	10.75	124.35	"
9.03	120.54	"	0	119.66	"
0	115.43	"			

100 gms. methyl alcohol ( $CH_3OH$ ) dissolve 26.28 gms.  $C_6H_4OHCOONa$  at 15° and 34.73 gms. at 67.2°. (b.pt.) (Henstock, 1934.)

100 gms. propyl alcohol dissolve 1.16 gms.  $C_6H_4OHCOONa$  at ord. temp. (Schlamp, 1894.)

Data for the depression of the freezing-point of sodium salicylate solutions by theobromine are given by Pellini and Amadori, 1912.

SODIUM m-HYDROXY BENZOATE  $C_6H_4 \cdot OH \cdot COONa$

$C_7H$

SOLUBILITY OF SODIUM META HYDROXY BENZOATE IN WATER  
(Sidgwick and Ewbank, 1922)

Gms.			Gms.		
$C_6H_4 \cdot OH \cdot COONa(m)$	Solid	Phase	$C_6H_4 \cdot OH \cdot COONa(m)$	Solid	Phase
per 100 gms. sat. sol.			per 100 gms. sat. sol.		
t°			t°		
- 3.21	14.68	Ice	+ 10.0	58.78	$C_6H_4 \cdot OH \cdot COONa$
- 8.85	30.53	"	110.0	64.61	"
- 17.52	45.16	"	147.5	69.75	"



# Na SODIUM

## C<sub>7</sub>H SODIUM p-HYDROXY BENZOATE C<sub>6</sub>H<sub>4</sub>·OH·COONa

SOLUBILITY OF SODIUM PARA HYDROXY BENZOATE IN WATER  
(Sidgwick and Ewbank, 1922)

t°	Gms. C <sub>6</sub> H <sub>4</sub> ·OH·COONa(p) per 100 gms. sat. sol.	Solid Phase
- 0.77	5.075	Ice
- 2.07	10.43	"
+ 7.0	19.65	C <sub>6</sub> H <sub>4</sub> ·OH·COONa·5H <sub>2</sub> O
24.0	31.47	"
36.5	41.32	"
39.0	45.61	"(unstable)
43.0	45.61	C <sub>6</sub> H <sub>4</sub> ·OH·COONa
107.5	50.51	"
163.0	54.93	"

## SODIUM IODOSALICYLATE C<sub>6</sub>H<sub>5</sub>I(OH)COONa

SOLUBILITY OF THE 3-iodo AND 5-iodo SALTS IN WATER  
(Covello, 1941)

t°	Gms. per 100 gms. Sat. Sol.	
	Na 3-Iodo Salicylate	Na 5-Iodo Salicylate
18	6.38	4.37
40*	9.0	6.0
60*	14.0	10.0
80*	22.0	16.5
100*	33.0	25.0

\*Estimated from curves drawn by the author

## SODIUM XYLENE SULFONATES

## SODIUM CUMENE SULFONATE

SOLUBILITY OF SODIUM XYLENE AND SODIUM CUMENE SULFONATES IN WATER  
(Hauslick, 1935)

Na Xylene Sulfonate		Na Cumene Sulfonate	
t°	Gms. Mols. NaC <sub>6</sub> H <sub>3</sub> (CH <sub>3</sub> ) <sub>2</sub> SO <sub>3</sub> per 100 gms. H <sub>2</sub> O	t°	Gms. Mols. NaC <sub>6</sub> H <sub>3</sub> CH·(CH <sub>2</sub> ) <sub>3</sub> SO <sub>3</sub> per 100 gms. H <sub>2</sub> O
3	0.090	3	0.169
26	0.337	30	0.562
41	0.513	47	0.792
56	0.673	66	1.048
60	0.720	88	1.362
80	0.925	119	1.779
115	1.300		

Data for the system o-xylene sulfonate - benzoic acid - water at 30, 40, and 60° are given by Licht, Jr. and Wiener, 1950. Solubilities of O-xylene sulfonate in water are:

30°	28.73	gms.	per	100	gms.	sat.	sol.
40°	40.09	"	"	"	"	"	"
60°	46.53	"	"	"	"	"	"

SODIUM 2-CHLORO-3-NITRO-p-XYLENE SULFONATE  $C_6H(CH_3)_2(Cl)(NO_2)SO_3Na$   $C_7H$

93.4 gms. (0.325 moles) dissolve in 100 gms. of water at 30°. (Dermer and Dermer, 1939.)

SODIUM CAPRYLATE  $CH_3(CH_2)_6COONa$   $C_8H$

SOLUBILITY OF SODIUM CAPRYLATE IN GLYCOLS AT 25°  
(Palit, 1947)

Moles  $C_7H_{15}COONa$  per  
1000 gms. Glycol

Ethylene Glycol	1.746
Propylene Glycol	1.343

SODIUM DIETHYL BARBITURATE  $Na(C_8H_{11}O_3N_2)$

SOLUBILITY IN WATER  
(Puckner and Hilpert, 1909)

t°	5°	15°	25°	91°
Gms. Salt per 100 Gms. Sat. Sol.	6.08	16.87	17.18	32.50

100 gms. U.S.P. alcohol ( $d_{25} = 0.8063 = 93.6$  Wt. %  $C_2H_5OH$ ) dissolve 0.313 gm.  $Na(C_8H_{11}O_3N_2)$  ("Sodium Barbitol") at 25°. (Schnellbach and Rosin, 1931.)

# Na SODIUM

## SODIUM MANDELATE $\text{NaC}_8\text{H}_7\text{O}_3$ (Racemic)

EQUILIBRIUM IN THE SYSTEM RACEMIC SODIUM MANDELATE, RACEMIC MANDELIC ACID AND WATER AT 25°  
(Ross and Morrison, 1933)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{C}_8\text{H}_8\text{O}_3$	$\text{C}_8\text{H}_7\text{O}_3\text{Na}$		$\text{C}_8\text{H}_8\text{O}_3$	$\text{C}_8\text{H}_7\text{O}_3\text{Na}$	
16.9	0.0	$\text{C}_8\text{H}_8\text{O}_3$	7.8	6.4	1.1
17.7	1.6	"	6.3	6.9	"
18.9	2.9	"	4.0	8.3	"
19.7	3.7	" + 3.1	3.1	9.2	"
17.6	3.7	3.1	2.0	10.9	"
15.9	3.9	"	1.5	12.5	"
13.7	4.5	"	0.9	15.8	"
13.0	4.8	"	0.8	16.6	"
12.4	4.9	"	0.7	17.1	"
10.9	5.5	"	0.5	22.3	"
10.4	5.7	1.1	0.4	23.7	"
9.2	6.0	"	0.4	25.5	"
			0.3	30.6	"

3.1 =  $3\text{C}_8\text{H}_8\text{O}_3 \cdot \text{C}_8\text{H}_7\text{O}_3\text{Na}$ ; 1.1 =  $\text{C}_8\text{H}_7\text{O}_3\text{Na} \cdot \text{C}_8\text{H}_8\text{O}_3$

## $\text{C}_8\text{H}_7$ SODIUM MANDELATE $\text{NaC}_8\text{H}_7\text{O}_3$ (Levo)

THE SYSTEM LEVO SODIUM MANDELATE, LEVO MANDELIC ACID AND WATER AT 25°  
(Ross, Morrison and Johnstone, 1937)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{C}_8\text{H}_8\text{O}_3$	$\text{C}_8\text{H}_7\text{O}_3\text{Na}$		$\text{C}_8\text{H}_8\text{O}_3$	$\text{C}_8\text{H}_7\text{O}_3\text{Na}$	
10.1	0.0	$\text{C}_8\text{H}_8\text{O}_3$	12.3	11.3	$\text{C}_8\text{H}_8\text{O}_3 + 1.1$
10.0	0.9	"	8.9	11.6	1.1
10.1	1.7	"	7.4	11.9	"
11.0	4.3	"	5.1	13.0	"
12.2	8.5	"	0.8	32.6	"

1.1 =  $\text{C}_8\text{H}_7\text{O}_3 \cdot \text{NaC}_8\text{H}_7\text{O}_3$

## SOLUBILITY IN WATER

[Solid Phase  $2\text{Na}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 7\text{H}_2\text{O}$ ]

t°	Gms. $\text{Na}_2\text{C}_8\text{H}_4\text{O}_4$ per 100 gms. sat. sol.	Reference
0	40.56	Foote and Smith, 1924
	40.73	Smith and Sturm, 1933
25	43.79	Foote and Smith, 1924
	43.81	Smith and Sturm, 1933
	43.88	Smith and Hoegberg, 1941
30	45.27	Smith and Hoegberg, 1941
33	45.43	Foote and Smith, 1924
35	46.06	Foote and Smith, 1924
	45.66	Smith and Sturm, 1933
40	47.06	Smith and Hoegberg, 1941
50	50.60	Smith and Sturm, 1933

THE SYSTEM SODIUM PHTHALATE - PHTHALIC ACID - WATER  
(Smith and Sturm, 1933)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{C}_8\text{H}_6\text{O}_4$	$\text{C}_8\text{H}_4\text{O}_4\text{Na}_2$	Solid Phase	$\text{C}_8\text{H}_6\text{O}_4$	$\text{C}_8\text{H}_4\text{O}_4\text{Na}_2$	Solid Phase
<u>Results at 0°</u>			<u>Results at 35°</u>		
0.0	40.73	$2\text{Na}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 7\text{H}_2\text{O}$	0.0	45.66	$2\text{Na}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 7\text{H}_2\text{O}$
0.16	40.74	" + $2\text{NaHC}_8\text{H}_4\text{O}_4 \cdot \text{H}_2\text{O}$	0.34	45.90	" + $2\text{NaHC}_8\text{H}_4\text{O}_4 \cdot \text{H}_2\text{O}$
0.16	36.20	$2\text{NaHC}_8\text{H}_4\text{O}_4 \cdot \text{H}_2\text{O}$	0.39	42.03	$2\text{NaHC}_8\text{H}_4\text{O}_4 \cdot \text{H}_2\text{O}$
0.28	27.20	"	0.51	31.81	"
0.50	19.26	"	1.08	20.84	"
1.63	6.60	"	1.23	19.26	"
2.70	3.88	" + $\text{C}_8\text{H}_6\text{O}_4$	3.27	9.56	"
1.68	1.93	$\text{C}_8\text{H}_6\text{O}_4$	4.72	6.78	"
0.30	0.0	"	5.32	6.60	"
<u>Results at 25°</u>			5.83	6.38	" + $\text{C}_8\text{H}_6\text{O}_4$
			5.51	5.88	$\text{C}_8\text{H}_6\text{O}_4$
0.0	43.81	$2\text{Na}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 7\text{H}_2\text{O}$	4.31	4.15	"
0.28	44.04	" + $2\text{NaHC}_8\text{H}_4\text{O}_4 \cdot \text{H}_2\text{O}$	1.93	1.07	"
0.28	42.46	$2\text{NaHC}_8\text{H}_4\text{O}_4 \cdot \text{H}_2\text{O}$	0.98	0.0	"
0.31	41.30	"	<u>Results at 50°</u>		
0.31	37.20	"			
0.33	35.78	"	0.0	50.60	$2\text{Na}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 7\text{H}_2\text{O}$
0.48	29.22	"	0.55	50.93	" + $2\text{NaHC}_8\text{H}_4\text{O}_4 \cdot \text{H}_2\text{O}$
0.56	26.04	"	0.60	44.58	$2\text{NaHC}_8\text{H}_4\text{O}_4 \cdot \text{H}_2\text{O}$
0.82	20.17	"	0.86	33.75	"
1.41	13.87	"	1.68	22.20	"
1.85	10.85	"	4.13	12.17	"
2.82	7.58	"	5.91	9.19	"
4.48	5.52	" + $\text{C}_8\text{H}_6\text{O}_4$	6.82	8.47	"
3.51	3.94	$\text{C}_8\text{H}_6\text{O}_4$	8.69	8.35	" + $\text{C}_8\text{H}_6\text{O}_4$
1.98	1.67	"	5.27	4.30	$\text{C}_8\text{H}_6\text{O}_4$
0.68	0.0	"	1.75	0.0	"

# Na SODIUM

## THE SYSTEM SODIUM PHTHALATE - SODIUM CARBONATE - WATER (Smith and Hoegberg, 1941)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{Na}_2\text{CO}_3$	$\text{Na}_2\text{C}_8\text{H}_4\text{O}_4$	Solid Phase	$\text{Na}_2\text{CO}_3$	$\text{Na}_2\text{C}_8\text{H}_4\text{O}_4$	Solid Phase
Results at 25°			Results at 33°		
22.50	0.0	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	31.96	0.0	$\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$
18.13	7.95	"	29.85	2.55	"
16.54	10.35	"	27.81	5.90	"
13.96	15.66	"	25.18	9.10	"
11.25	21.84	"	21.90	14.17	"
9.72	25.96	"	19.72	17.67	"
9.27	27.54	"	17.28	21.69	"
8.13	31.47	"	16.4	24.12	" + $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
7.31	35.20	" + $2\text{Na}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 7\text{H}_2\text{O}$	15.80	24.76	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
4.67	38.40	$2\text{Na}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 7\text{H}_2\text{O}$	13.69	27.99	"
3.25	39.90	"	12.75	29.52	"
0.0	43.88	"	11.68	31.56	" + $2\text{Na}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 7\text{H}_2\text{O}$
			8.32	35.34	$2\text{Na}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 7\text{H}_2\text{O}$
			5.96	38.21	"
			3.66	41.01	"
			2.33	42.56	"
			0.0	45.43	"
Results at 30°			Results at 40°		
28.31	0.0	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	32.84	0.0	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
27.76	0.84	"	28.47	5.26	"
25.81	3.88	"	20.01	17.34	"
24.83	5.39	"	15.77	24.11	"
22.11	9.98	"	11.80	30.59	"
19.72	14.19	"	8.33	37.17	" + $2\text{Na}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 7\text{H}_2\text{O}$
18.64	16.41	"	7.17	38.49	$2\text{Na}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 7\text{H}_2\text{O}$
17.32	18.97	" + $\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$	3.27	43.23	"
16.93	19.65	$\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$	0.0	47.06	"
15.25	22.61	"			
12.99	26.92	"			
11.73	29.58	"			
10.71	32.26	" + $2\text{Na}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 7\text{H}_2\text{O}$			
8.04	35.69	$2\text{Na}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 7\text{H}_2\text{O}$			
5.11	39.08	"			
0.0	45.27	"			

## THE SYSTEM SODIUM PHTHALATE - SODIUM SULFATE - WATER (Foote and Smith, 1924)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{Na}_2\text{C}_8\text{H}_4\text{O}_4$	$\text{Na}_2\text{SO}_4$	Solid Phase	$\text{Na}_2\text{C}_8\text{H}_4\text{O}_4$	$\text{Na}_2\text{SO}_4$	Solid Phase
Results at 0°			Results at 25°		
40.56	0.0	$2\text{Na}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 7\text{H}_2\text{O}$	43.79	0.0	$2\text{Na}_2\text{C}_8\text{H}_4\text{O}_4 \cdot 7\text{H}_2\text{O}$
40.20	0.56	" + $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$	40.63	3.52	"
25.83	0.63	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$	39.92	4.57	" + $\text{Na}_2\text{SO}_4$
0.0	4.48	"	37.94	5.48	$\text{Na}_2\text{SO}_4$
			30.88	8.69	"
			24.62	12.62*	

\*Supersaturated with respect to  
 $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$

(Cont.)

## THE SYSTEM SODIUM PHTHALATE - SODIUM SULFATE - WATER--Cont.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{Na}_2\text{C}_3\text{H}_4\text{O}_4$	$\text{Na}_2\text{SO}_4$	Solid Phase	$\text{Na}_2\text{C}_3\text{H}_4\text{O}_4$	$\text{Na}_2\text{SO}_4$	Solid Phase
Results at 25°--Cont.			Results at 35°		
13.67	20.91*	$\text{Na}_2\text{SO}_4$	46.06	0.0	$2\text{Na}_2\text{C}_3\text{H}_4\text{O}_4 \cdot 7\text{H}_2\text{O}$
35.40	6.29	" + $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$	43.25	3.25	" + $\text{Na}_2\text{SO}_4$
34.06	6.39	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$	28.64	9.67	$\text{Na}_2\text{SO}_4$
27.52	7.59	"	11.25	22.38	"
21.09	9.67	"	0.0	33.10	"
17.47	11.12	"			
12.35	13.61	"	*Supersaturated with respect to $\text{C}_8\text{H}$ $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$		
10.14	14.78	"			
7.39	16.53	"			
6.18	17.35	"			
0.0	21.75	"			

SODIUM TETRACHLOROPHTHALATE  $\text{C}_6\text{Cl}_4(\text{COONa})_2$ SOLUBILITY OF SODIUM TETRACHLOROPHTHALATE IN WATER  
(Lawlor, 1947)

t°	Gms. $\text{C}_6\text{Cl}_4(\text{COONa})_2$ per 100 gms. Sat. Sol.	Density	Solid Phase
5	13.9	-	$\text{C}_6\text{Cl}_4(\text{COONa})_2 \cdot 5\text{H}_2\text{O}$
7	-	1.095	"
15	15.8	-	"
24.5	17.9	-	"
26	-	1.125	"
26.5	18.5	-	"
31	-	1.135	"
34	20.8	-	"
37.5	22.4	-	"
40	23.0	-	"
45.5	25.1	-	"
58.8	32.2	-	"
61.5	33.0	-	"
63.5	34.0	-	$\text{C}_6\text{Cl}_4(\text{COONa})_2 \cdot 5\text{H}_2\text{O} + \text{C}_6\text{Cl}_4(\text{COONa})_2$
75	34.6	-	$\text{C}_6\text{Cl}_4(\text{COONa})_2$
77	-	1.188	"
97	35.2	-	"

SODIUM CINNAMATE  $\text{C}_6\text{H}_5\text{CH:CHCOONa}$  $\text{C}_9\text{H}$ 100 gms.  $\text{H}_2\text{O}$  dissolve 9.1 gms. sodium cinnamate at 15.20°.

100 cc. 90% alcohol dissolve 0.625 gm. at 15-20°. (Squire and Caines, 1905.)

# Na SODIUM

## C<sub>9</sub>H SODIUM 8-QUINOLINOL-5-SULFONATE C<sub>9</sub>H<sub>6</sub>ONHSO<sub>3</sub>Na

Solubility product constants at 25° were determined by Nasanen and Vusitalo, 1954.

## C<sub>10</sub>H SODIUM GUANYLATE C<sub>10</sub>H<sub>13</sub>N<sub>5</sub>O<sub>7</sub>P

### SOLUBILITY OF SODIUM GUANYLATE IN AQUEOUS SOLUTIONS OF SODIUM ACETATE AND OF SODIUM CHLORIDE AT 20° (Feulgen and Rossenbeck, 1923)

Warm solutions of sodium guanylate were prepared and these cooled until a slight excess of the salt separated. They were then allowed to stand many hours in a thermostat at 20°. The nitrogen in a given volume of the saturated solution was determined and from this the amount of guanylate present was calculated.

Normality of aq. salt solution	Results for aq. CH <sub>3</sub> COONa solutions			Results for aq. NaCl solutions		
	Gms. per 100 cc. solution			Gms. per 100 cc. solution		
	CH <sub>3</sub> COONa	N	Na guanylate	NaCl	N	Na guanylate
0.0 (= H <sub>2</sub> O)	0.0	-	2.89	0.0	-	2.88
0.0625	0.86	0.42	2.45	0.37	0.49	2.85
0.25	3.45	0.315	1.81	1.46	0.29	1.68
1.00	13.81	0.08	0.48	5.85	0.12	0.67
2.00	27.22	0.04	0.20	-	-	-
4.00	54.44	0.020	0.11	23.4	0.035	0.20
		0.025	0.15		0.048	0.28

The results are considered of interest in showing the quantitative limits of the sodium acetate method for the determination of guanylic acid.

## C<sub>10</sub>H SODIUM CAMPHORATES C<sub>10</sub>H<sub>15</sub>O<sub>4</sub>Na

### SOLUBILITY IN AQUEOUS d CAMPHORIC ACID SOLUTIONS AT 13.5°-16° (Jungfleisch and Landrieu, 1914)

Gms. per 100 Gms. Sat. Sol.		Solid Phase
C <sub>10</sub> H <sub>16</sub> O <sub>4</sub>	C <sub>10</sub> H <sub>14</sub> O <sub>4</sub> Na <sub>2</sub>	
0.621	0	C <sub>10</sub> H <sub>16</sub> O <sub>4</sub>
2.03	4.19	"
2.87	8.32	"
3.03	10.05	"
2.97	7.80	" + C <sub>10</sub> H <sub>15</sub> O <sub>4</sub> Na·2C <sub>10</sub> H <sub>16</sub> O <sub>4</sub> ·2H <sub>2</sub> O

(Cont.)

SOLUBILITY IN AQUEOUS d CAMPHORIC ACID SOLUTIONS AT 13.5°-16°--Cont.

Gms. per 100 Gms. Sat. Sol.		Solid Phase	
$C_{10}H_{16}O_4$	$C_{10}H_{14}O_4Na_2$		
2.87	9.06	$C_{10}H_{15}O_4Na \cdot 2C_{10}H_{16}O_4 \cdot 2H_2O$	
2.94	10.46	"	
2.68	14.99	"	
2.64	17.53	"	
2.87	25.62	"	
2.89	27.41	"	
2.7%	30.69	"	
2.63	32.75	"	
2.29	40.10	$C_{10}H_{15}O_4Na \cdot H_2O$ (or $\frac{1}{2} H_2O$ )	$C_{10}H$
2.17	40.54	"	
1.06	47.04	"	
0.88	49.60	$C_{10}H_{14}O_4Na_2 \cdot 3H_2O$	
0	50.2	"	

$C_{10}H_{16}O_4$  = Camphoric acid.  $C_{10}H_{15}O_4Na \cdot 2C_{10}H_{16}O_4 \cdot 2H_2O$  = Monosodium d tricarphorate.  $C_{10}H_{15}O_4Na \cdot H_2O$  = Monosodium d camphorate.  
 $C_{10}H_{14}O_4Na_2 \cdot 3H_2O$  = Disodium d camphorate (neutral).

(The mixtures were kept in a cellar at a nearly constant temperature and shaken from time to time. Additional determinations at 17°-23° are also given.)

SODIUM 5 and 7-ISOQUINOLINE CARBOXYLATES  $C_9H_7NCOONa$ 

Data for the solubility in water at 25° and 100° are given by Tyson, 1939.

## SODIUM SALTS OF ETHYLENE DINITRILLO TETRA ACETIC ACID

SOLUBILITY AT 30°  
 (Astakhov and Kiseleva, 1950)

Salt	Moles salt per liter sat. sol.
$Na_2(CaN_2C_{10}H_{12}O_8) \cdot 4H_2O$	0.1
$Na_2(SrN_2C_{10}H_{12}O_8) \cdot 5H_2O$	0.098
$Na_2(BaN_2C_{10}H_{12}O_8) \cdot 8H_2O$	0.17



# Na SODIUM

## SODIUM ALKYL SULFONATES $\text{RSO}_3\text{Na}$

### SOLUBILITY OF SODIUM ALKYL SULFONATES IN WATER (Reed and Tartar, 1936)

	Compound	Formula	Gms. Compound per 100 gms. H <sub>2</sub> O at:	
			25°	60°
$\text{C}_{10}\text{H}$	Na <u>n</u> Octyl Sulfonate	$\text{NaCH}_3(\text{CH}_2)_6\text{CH}_2\text{SO}_3$	74.40	-
	Na <u>n</u> Decyl "	$\text{NaCH}_3(\text{CH}_2)_8\text{CH}_2\text{SO}_3$	4.55	-
	Na Lauryl "	$\text{NaCH}_3(\text{CH}_2)_{10}\text{CH}_2\text{SO}_3$	0.253	48.0
	Na Myristyl "	$\text{NaCH}_3(\text{CH}_2)_{12}\text{CH}_2\text{SO}_3$	0.041	38.8
	Na Cetyl "	$\text{NaCH}_3(\text{CH}_2)_{14}\text{CH}_2\text{SO}_3$	0.0073	6.49
	Na <u>n</u> Octa decyl "	$\text{NaCH}_3(\text{CH}_2)_{16}\text{CH}_2\text{SO}_3$	0.0010	0.131

The following very careful determinations show that these salts increase in solubility very slowly up to a certain temperature and very sharply beyond this definite critical concentration. This phenomenon is explained in terms of the critical micelle concentration. It was also found by hydration experiments that each salt forms a hydrate containing 3.5 mols. of H<sub>2</sub>O.

The following results are in terms of the grams of salt (designated  $\text{C}_{10}$ ,  $\text{C}_{12}$ , etc.) dissolved per 100 gms. H<sub>2</sub>O, given by Tartar and Wright, 1939.

$\text{C}_{10}$  = Sodium Decyl Sulfonate,  $\text{NaCH}_3(\text{CH}_2)_8\text{CH}_2\text{SO}_3$ .  
 $\text{C}_{12}$  = " Dodecyl " "  $(\text{CH}_2)_{10}$  "  
 $\text{C}_{14}$  = " Tetradecyl " "  $(\text{CH}_2)_{12}$  "  
 $\text{C}_{16}$  = " Hexadecyl " "  $(\text{CH}_2)_{14}$  "  
 $\text{C}_{18}$  = " Octadecyl " "  $(\text{CH}_2)_{16}$

$t^\circ$	$\text{C}_{10}$	$t^\circ$	$\text{C}_{12}$	$t^\circ$	$\text{C}_{14}$	$t^\circ$	$\text{C}_{16}$	$t^\circ$	$\text{C}_{18}$
15	0.733	20	0.134	25	0.040	37	0.013	47	0.0117
17	0.800	25	0.191	29	0.052	41	0.0205	54	0.0217
20	0.897	30	0.248	40	0.087	47.5	0.035	57	0.0270
23	1.04	32	0.277	41.7	0.129	48.25	0.0462	58	0.0362
24	1.22	34	0.360	43	0.270	49	0.056	59	0.0620
25	1.93	35	0.441	45	0.700	50	0.100	60	0.0820
27.38	6.43	36	0.950	46	1.38	53	0.351	61.5	0.177
29	11.02	37	1.78	47	2.20	55	0.88	65	0.90
31	18.70	38	2.97	48	3.28	56.5	1.60	67.01	2.00
32	23.68	40	6.54	49	5.08	58.0	2.60	69.05	5.60
34	36.70	41	9.60	50	8.20	60	6.00	70.23	11.5
36	53.5	43	18.20	51	12.3	61.96	11.55		
36.86	62.3	45	31.46	53	22.4	63.36	20.86		
		46	52.8	54	32.9				

Solubilities in other solutions are given below.

SODIUM DECYL SULFONATE  $\text{CH}_3(\text{CH}_2)_9\text{SO}_3\text{Na}$ 

The freezing points of dilute solutions of sodium decyl sulfonates were determined by Johnston and McBain, 1942,

SODIUM DODECYL SULFONATE  $\text{C}_{12}\text{H}_{25}\text{SO}_3\text{Na}$  $\text{C}_{12}\text{H}$ 

## SOLUBILITY IN SODIUM CHLORIDE SOLUTIONS

(Tarter and Cadle, 1939)

Gms. $\text{C}_{12}\text{H}_{25}\text{SO}_3\text{Na}$ per 100 gms. $\text{H}_2\text{O}$		Gms. $\text{C}_{12}\text{H}_{25}\text{SO}_3\text{Na}$ per 100 gms. $\text{H}_2\text{O}$	
t°		t°	
28	0.166	25	0.110
NaCl = 31	.202	NaCl = 30	.157
0.004 33	.233	0.008 33.5	.205
Molal 35	.305	Molal 35	.246
36	.623	36	.348

The freezing points of dilute sodium dodecyl sulfonate solutions were determined by Johnston and McBain, 1942.

SODIUM TETRADECYL SULFONATE  $\text{C}_{14}\text{H}_{29}\text{SO}_3\text{Na}$ 

## SOLUBILITY IN SODIUM CHLORIDE SOLUTIONS

(Tarter and Cadle, 1939)

In 0.004 Molal NaCl				In 0.008 Molal NaCl			
Gms. Na T.D.S. per 100 gms. $\text{H}_2\text{O}$		Gms. Na T.D.S. per 100 gms. $\text{H}_2\text{O}$		Gms. Na T.D.S. per 100 gms. $\text{H}_2\text{O}$		Gms. Na T.D.S. per 100 gms. $\text{H}_2\text{O}$	
t°		t°		t°		t°	
28	0.0126	41.5	0.0503	35	0.0110		
30	.0171	43	.0565	40	.0276		
33	.0204	44.6	.175	43.5	.059		
35	.026	46	.662	44	.083		
40	.047			46	.346		

SODIUM CETYL SULFATE  $\text{Na}[\text{C}_{16}\text{H}_{33}\text{SO}_4]$ 

At 42°, the solubility in 0.01 N  $\text{NH}_3$  is 5% (Adam and Pankhurst, 1946).

SODIUM DODECYL SULFATE  $\text{Na}[\text{C}_{12}\text{H}_{25}\text{SO}_4]$ 

At 18°, the solubility in 0.05 N  $\text{Na}_2\text{CO}_3$  is 5%. (Adam and Pankhurst, 1946).

# Na SODIUM

## SODIUM NAPHTHALENE SULFONATES $C_{10}H_7SO_3Na$

### SOLUBILITY IN WATER

Results for Na $\alpha$ -Naphthalene Sulfonate (Hauslick, 1935)			Results for Na $\beta$ -Naphthalene Sulfonate	
t°	Gm. Mols. $NaC_{10}H_7SO_3^a$ per 100 gms. $H_2O$	t°	Gms. $NaC_{10}H_7SO_3-\beta$ per 100 gms. $H_2O$	Reference
2	0.044	23.9	6.04	(Fischer, 1906)
25	0.074	25	5.87*	
37	0.089		$*d_{25} = 1.019$	
59	0.145			
78	0.241			
90	0.357			

### SOLUBILITY OF SODIUM $\beta$ NAPHTHALENE SULFONATE IN AQUEOUS HYDROCHLORIC ACID AT 23.9° (Fischer, 1906)

Normality of Aq. HCl	1.0 n	2 n	3 n	5 n
Gms. $C_{10}H_7SO_3Na$ per 100 gms. Aq. HCl	6.47	5.35	4.13	2.42

Data (in the form of triangular diagrams) for the solubility of sodium  $\beta$  naphthalene sulfonate in aqueous solutions of sodium chloride and sodium sulfate at various temperatures between 25° and 65° are given by Cooke, 1921. In one case it is mentioned that 100 gms. of a sat. solution contain 8.47 gms. of the  $\beta$  salt and 2.93 gms.  $NaCl$  at 65°.

### SOLUBILITY OF SODIUM NAPHTHALENE SULFONATE IN METHANOL (Henstock, 1934)

At 15° 1.37 gms. of anhydrous salt dissolve in 100 gms.  $CH_3OH$ .  
At 65.8° 2.10 " " " " " " " " " " " "

## SODIUM NAPHTHYL AMINE SULFONATES

### SOLUBILITIES IN WATER AT 15° (Braunschweig, 1922)

Compound and Formula	Gms. anhydrous compd. per 100 gms. sat. sol.
Sodium 2.6.8 Naphthylamine disulfonate $C_{10}H_5(NH_2)(SO_3Na)_2$	59.04
Sodium 2.5.7 Naphthylamine disulfonate $C_{10}H_5(NH_2)(SO_3Na)_2$	72.2
Sodium 2.6.8 Naphthylamine disulfonate $C_{10}H_5(NH_2)(SO_3)_2HNa$ (acid salt)	7.46
Sodium 2.5.7 Naphthylamine disulfonate $C_{10}H_5(NH_2)(SO_3)_2HNa$ (acid salt)	7.91

SODIUM CAPRATE  $\text{CH}_3(\text{CH}_2)_8\text{COONa}$  $\text{C}_{10}\text{H}$ SOLUBILITY OF SODIUM CAPRATE IN GLYCOLS AT 25°  
(Palit, 1947)

	Moles $\text{C}_9\text{H}_{19}\text{COONa}$ per 1000 gms. Glycol
Ethylene Glycol	0.823
Propylene Glycol	0.642

SODIUM PICROLINATE  $[\text{C}_{13}\text{H}_9\text{N}_5\text{O}_5]\text{Na}$ 

0.285 gms. (0.001 moles) dissolve in 100 gms. of water of 30°.  
(Dermer and Dermer, 1939.)

SODIUM FLAVIANATE (Dibasic)  $[\text{C}_{10}\text{H}_4\text{O}(\text{NO}_2)_2\text{SO}_3]\text{Na}_2$ 

9.8 gms. (0.027 moles) dissolve in 100 gms. of water at 30°.  
(Dermer and Dermer, 1939.)

SODIUM CAMPHO CARBONATE  $\text{C}_{10}\text{H}_{15}\text{O}\cdot\text{COONa}$ SOLUBILITY OF SODIUM CAMPHO CARBONATE IN SEVERAL SOLVENTS AT 7°  
(Picon, 1931)

Solvent	Formula	Gms. $\text{C}_{10}\text{H}_{15}\text{OCCOONa}$ per liter sat. solution
Water	$\text{H}_2\text{O}$	323.2
Methyl Alcohol	$\text{CH}_3\text{OH}$	284.7
Ethyl Alcohol	$\text{C}_2\text{H}_5\text{OH}$	35.36
Chloroform	$\text{CHCl}_3$	37.18

SODIUM DIPICRYLAMINATE  $\text{Na}[(\text{NO}_2)_3\text{C}_6\text{H}_2\text{NHC}_6\text{H}_2(\text{NO}_2)_3]$ 

## SOLUBILITY IN WATER

t°	Moles per liter	Gms. per liter	
20	0.110	50.7	(Treadwell and Hepenstrick, 1949)
25	.145	66.8	( " " " " )
30	.252	116.1*	(Dermer and Dermer, 1939)

\*Gms. per 1000 gms.  $\text{H}_2\text{O}$

# Na SODIUM

## C<sub>12</sub>H SODIUM LAURATE C<sub>11</sub>H<sub>23</sub>COONa

### THE SYSTEM SODIUM LAURATE - WATER (McBain, Brock, Vold and Vold, 1938)

The determinations were made by the synthetic method which consists in observing the temperatures at which phase changes occur in systems of known composition. In the following table,  $t^{\circ}_1$ , shows the upper temperature limits of the existence of liquid crystalline soap phases and  $t^{\circ}_2$ , shows the upper temperature limits of the existence of crystalline soap.

$t^{\circ}_1$	$t^{\circ}_2$	Wt. percent Na(CH <sub>3</sub> )(CH <sub>2</sub> ) <sub>10</sub> COOH in sat. sol.	$t^{\circ}_1$	$t^{\circ}_2$	Wt. percent Na(CH <sub>3</sub> )(CH <sub>2</sub> ) <sub>10</sub> COOH in sat. sol.
-	24	2.17	145	51	43.44
-	28	3.53	149	55	46.75
-	32	5.20	139	57	49.39
-	38	10.89	141	99	51.12
-	42	28.77	153	60	51.29
-	42	32.69	182	61	53.21
85	44	35.09	237	62.5	58.40
100	44	36.80	247	66	60.89
142	50	42.50	290	76	71.16
144	51	43.63	310	226	100.00

Additional data of McBain, Vold, and Frick, 1940

$t^{\circ}_1$	$t^{\circ}_2$	Wt. % CH <sub>3</sub> (CH <sub>2</sub> ) <sub>10</sub> COONa
313	-	95.3
296	-	89.5
294	-	85.4
290	-	81.3

McBain, Brock, Vold and Vold, 1938, give results for the system sodium laurate - sodium chloride - water at temperatures between 60° and 250°.

Results for the four component system sodium laurate - sodium palmitate - sodium chloride - water at 90°, for two constant ratios of sodium palmitate to sodium laurate, are given by McBain, Vold and Jameson, 1939.

Results for the system lauric acid - sodium hydroxide - water at 25° are given by Bury and Owens, 1936.

Results in the form of a triangular diagram for the system lauric acid - phenol - water at 25° are given by Jencic, 1934.

SOLUBILITY OF SODIUM LAURATE IN 80 TO 100 VOL. PERCENT ETHYL ALCOHOL  
(Ekwald and Myllus, 1932)

t°	Gms. Na(CH <sub>3</sub> )(CH <sub>2</sub> ) <sub>10</sub> COO per 100 cc. of:		
	80 Vol. % C <sub>2</sub> H <sub>5</sub> OH	96 Vol. % C <sub>2</sub> H <sub>5</sub> OH	99.9 Vol. % C <sub>2</sub> H <sub>5</sub> OH
0	1.98	0.61	0.42
8	2.63	0.86	0.54
12.5	3.65(13°)	1.01	0.67(16°)
20	6.62	1.31(19°)	0.74(20.5°)

SOLUBILITY OF SODIUM LAURATE IN GLYCOLS AT 25°  
(Palit, 1947)

C<sub>12</sub>H

Moles C<sub>11</sub>H<sub>23</sub>COONa per  
1000 gms. Glycol

Ethylene Glycol	0.536
Propylene Glycol	0.549

SOLUBILITY OF SODIUM LAURATE IN ETHYLENE GLYCOL - n-BUTYL  
ALCOHOL MIXTURES AT 25°.  
(Palit, 1947)

Wt. % Glycol in Solvent	0	20	40	60	80	100
Gms. CH <sub>3</sub> (CH <sub>2</sub> ) <sub>10</sub> COONa per 100 gms. Solvent	0.52	7.84	15.09	20.14	20.05	11.92

SODIUM MYRISTATE CH<sub>3</sub>(CH<sub>2</sub>)<sub>12</sub>COONa

C<sub>14</sub>H

EQUILIBRIUM IN THE SYSTEM SODIUM MYRISTATE - WATER  
(Vold, Reivere, and McBain, 1941)

T<sub>i</sub> is the temperature at which the isotropic soap solution separates  
an anisotropic liquid crystalline phase upon cooling.

T<sub>c</sub> is the temperature at which the last trace of "curd fibre" dis-  
appears on slow heating.

Wt. % soap	T <sub>i</sub>	T <sub>c</sub>	Wt. % soap	T <sub>i</sub>	T <sub>c</sub>	Wt. % soap	T <sub>i</sub>	T <sub>c</sub>	Wt. % soap	T <sub>i</sub>	T <sub>c</sub>
100.0	316	-	73.1	288	84	50.5	171	70	32.5	117	61
92.8	292	-	70.4	286	83	49.9	165	69	29.5	81	-
90.4	289	-	63.8	275	80	48.3	173	68	24.8	-	58
90.2	290	-	61.3	273	-	43.9	176	67	17.0	-	56
88.0	290	-	61.0	267	78	43.0	175	-	9.5	-	52
87.4	291	-	55.4	239	74	40.4	-	64	5.0	-	48
81.8	292	102	50.7	174	-	35.0	138	61	1.0	-	41
73.6	288	-									

# Na SODIUM

## SOLUBILITY OF SODIUM MYRISTATE IN GLYCOLS AT 25° (Palit, 1947)

	Molea $C_{13}H_{27}COONa$ per 1000 gms. Glycol
Ethylene Glycol	0.160
Propylene Glycol	0.197

## SOLUBILITY OF SODIUM MYRISTATE IN ETHYLENE GLYCOL - n-BUTYL ALCOHOL MIXTURES AT 25° (Palit, 1947)

Wt. % Glycol in Solvent	0	20	40	60	80	100
Gms. per 100 gms. Solvent	0.28	4.58	10.12	12.88	11.23	4.00

## $C_{14}H$ SODIUM ANTHRACENE SULFONATES $C_{14}H_9SO_3Na$ , $C_{14}H_8S_2O_6Na_2$

### SOLUBILITY IN WATER (Federov and Lodygin, 1942)

Salt	Gms. Salt per 100 gms. Sat. Sol.	
	20°	100°
$\alpha - C_{14}H_9SO_3Na$	0.0407	0.420
$\beta - C_{14}H_9SO_3Na$	.0088	.109
1,5 $C_{14}H_8S_2O_6Na_2 \cdot H_2O$	2.508	11.250
1,8 $C_{14}H_8S_2O_6Na_2 \cdot 3H_2O$	2.259	4.399
2,6 $C_{14}H_8S_2O_6Na_2 \cdot H_2O$	1.213	4.765
2,7 $C_{14}H_8S_2O_6Na_2 \cdot 2H_2O$	1.090	13.170

## SODIUM PHENANTHRENE SULFONATES

### SOLUBILITIES IN WATER AT 20° (Sandquist, 1912)

Compound	Formula	Gms. anhydrous salt per 100 gms. $H_2O$
Na 2 Phenathrene Sulfonate	$C_{14}H_9SO_3Na \cdot \frac{1}{2}H_2O$	0.42
Na 3 " "	$C_{14}H_9SO_3Na \cdot H_2O$	1.1
Na 10 " "	$C_{14}H_9SO_3Na \cdot 2H_2O$	1.63
Na 10-Chloro 3 or 6 sulfonate	$C_{14}H_8ClSO_2Na \cdot H_2O$	0.263 (Sandquist, 1917)

## SODIUM ANTHRAQUINONE SULFONATES

SOLUBILITY OF SODIUM ANTHRAQUINONE SULFONATES IN WATER  
(Flers-David, Krebsen and Anderau, 1927)

Compound and Formula	t°	Gms. Anhydrous (?) compound per 100 cc. H <sub>2</sub> O	
Na Anthraquinone 1.5 Disulfonate $\text{Na}_2\text{C}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2 \cdot 4\text{H}_2\text{O}$	18	66	
Na Anthraquinone 1.8 Disulfonate $\text{Na}_2\text{C}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2 \cdot 5\text{H}_2\text{O}$	18	66	
Na Anthraquinone 1.6 Disulfonate $\text{Na}_2\text{C}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2 \cdot 3\text{H}_2\text{O}$	18	100	$\text{C}_{14}\text{H}$
Na Anthraquinone 1.5 Chloro Sulfonate $\text{NaC}_{14}\text{H}_6\text{O}_2\text{ClSO}_3 \cdot \frac{1}{2}\text{H}_2\text{O}$	18	1.05	
Na Anthraquinone 1.8 Chloro Sulfonate $\text{NaC}_{14}\text{H}_6\text{O}_2\text{ClSO}_3 \cdot \text{H}_2\text{O}$	18	1.37	
Na Anthraquinone 1.8 Chloro Sulfonate $\text{NaC}_{14}\text{H}_6\text{O}_2\text{ClSO}_3 \cdot \text{H}_2\text{O}$	100	1.43	
Na Anthraquinone -2- Sulfonate $\text{NaC}_{14}\text{H}_7\text{O}_2\text{SO}_3 \cdot \text{H}_2\text{O}$	18	0.83*	
Na Anthraquinone -2- Sulfonate $\text{NaC}_{14}\text{H}_7\text{O}_2\text{SO}_3 \cdot \text{H}_2\text{O}$	100	21.0*	
Na Anthraquinone 2.6 Disulfonate $\text{Na}_2\text{C}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2 \cdot 2\text{H}_2\text{O}$	18	2.90*	
Na Anthraquinone 2.6 Disulfonate $\text{Na}_2\text{C}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2 \cdot 2\text{H}_2\text{O}$	100	18.33*	
Na Anthraquinone 2.7 Disulfonate $\text{Na}_2\text{C}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2 \cdot \text{H}_2\text{O}$	18	30.50*	

\*Gms. per 100 gme. sat. solution.

SODIUM PALMITATE  $\text{CH}_3(\text{CH}_2)_{14}\text{COONa}$  $\text{C}_{16}\text{H}$ THE SYSTEM SODIUM PALMITATE AND WATER  
(McBain, Lazarus and Pitten, 1930)

[ See also the two tables following ]

The determinations were made by the synthetic method. The column  $t_1$  shows the temperature above which the system consists of a single isotropic phase;  $t_c$  shows the temperature above which the soap is completely in solution and crystals have completely disappeared.



# Na SODIUM

## THE SYSTEM SODIUM PALMITATE AND WATER--Cont.

t° <sub>I</sub>	t° <sub>C</sub>	Gm. Equivalent NaCH <sub>3</sub> (CH <sub>2</sub> ) <sub>14</sub> COO per 1000 gms. H <sub>2</sub> O	t° <sub>I</sub>	t° <sub>C</sub>	Gm. Equivalent NaCH <sub>3</sub> (CH <sub>2</sub> ) <sub>14</sub> COO per 1000 gms. H <sub>2</sub> O
-	58	0.105	164	79.5	3.18
-	64	0.256	159	80	3.427
-	66.1	0.500	173	-	3.511
-	71.1	1.411	225	79.3	4.087
-	72.2	1.744	258.5	81.2	5.01
120	73.5	1.50	264.5	82	6.016
152	74.8	1.856	277.5	93	9.003
157.5	76.5	2.047	285	102	11.90
167	78	2.343	-	114	17.54
170	78.3	2.633	-	125	26.40
171	78	2.67	-	130	47.00
168.5	79	2.996	-	132	84.80
			290	134	100.00

Results at lower temperatures by Stauff, 1939

Data read from curves drawn by the author

t°	Moles per liter		t°	Moles per liter	
	Sat. Sol.			Sat. Sol.	
30	0.0020		45	0.0038	
35	.0024		50	.0060	
40	.0027		55	.0250	

## SOLUBILITY OF SODIUM PALMITATE IN VARIOUS SOLVENTS (Leggett, Vold, and McBain, 1940)

These and other data were correlated by means of Hildebrand's ideal solubility relationship by Bondi, 1948, 1950.

Maximum concentrations of sodium palmitate yielding an isotropic liquid phase:

Solvent	Gms. NaCH <sub>3</sub> (CH <sub>2</sub> ) <sub>14</sub> COO per 100 gms. Sat. Sol.						
	30°	50°	90°	150°	200°	250°	280°
Water	0.5	1.0	27.5	34.2	50.6	58.5	-
Palmitic Acid	-	-	41.9	64.4	63.3	-	97.2
Glycerol	0.3	1.0	15.8	50.8	53.6	-	91.0
o-Cresol	-	0.2	1.2	9.2	65.4	91.0	95.0
m-Cresol	1.0	2.7	10.0	52.0	73.0	93.0	97.0
p-Cresol	-	1.8	9.0	60.2	76.4	94.0	97.6
Ethyl Alcohol	1.3	2.3	9.7	69.6	87.5	94.8	97.0
Isopropyl Alcohol	0.4	0.6	1.0	24.0	75.0	94.0	97.6
n-Heptyl Alcohol	-	0.3	3.1	31.6	69.5	93.4	97.5
n-Cetyl Alcohol	-	-	1.0	5.8	44.9	85.4	95.0
n-Heptane	0.3	0.4	0.5	0.8	1.0	20.0	86.4
n-Cetane	0.1	0.1	0.3	0.5	1.4	86.4	94.5
Nujol	0.1	0.1	0.1	0.3	0.5	53.3	90.5
Diethylene Glycol	0.4	1.5	9.2	39.9	87.2	90.0	97.3
n-Butylamine	0.2	0.4	1.0	58.0	85.5	91	95
Acetic Acid	-	-	75.5	81.2	85.1	95.3	98.5
Ethyl Acetate	-	-	-	-	-	95.5	97.5
Acetamide	-	-	-	-	78.5	96.2	98.0

McBain, Lazarus and Pitten, 1930, give results for the system sodium palmitate + sodium chloride + water, from which the isotherms between 80° and 290° are constructed.

The complete equilibrium diagram of the system sodium palmitate + sodium chloride + water at 90°, has been determined by Vold and Ferguson, 1938, with greater precision than attempted for any other system composed of soap, inorganic electrolyte and water.

Solubility determinations and phase studies in the systems sodium palmitate - trisodium phosphate - water, sodium palmitate - tetrasodium pyrophosphate - water, sodium palmitate - sodium metasilicate - water (and other sodium silicate NaO/SiO<sub>2</sub> ratios) were made by Merrill and Getty, 1947.

100 gms. sat. solution in H<sub>2</sub>O contain 0.2 gm. sodium palmitate, C<sub>18</sub>H  
 100 gms. sat. solution in 5% aq. bile salts contain 1 gm. sodium palmitate.  
 100 gms. sat. solution in 5% aq. bile salts + 1% lecithin contain 2.4 gms. sodium palmitate. (Moore, Wilson and Hutchinson, 1909.)

SOLUBILITY OF SODIUM PALMITATE IN 70 TO 100 VOL. PERCENT ETHYL ALCOHOL  
 (Ekwall and Mylius, 1932)

t°	Gms. CH <sub>3</sub> (CH <sub>2</sub> ) <sub>14</sub> COONa per 100 cc:				
	70 Vol. % C <sub>2</sub> H <sub>5</sub> OH	80 Vol. % C <sub>2</sub> H <sub>5</sub> OH	90 Vol. % C <sub>2</sub> H <sub>5</sub> OH	96 Vol. % C <sub>2</sub> H <sub>5</sub> OH	99.9 Vol. % C <sub>2</sub> H <sub>5</sub> OH
-10	--	--	--	--	0.12
0	--	--	--	--	0.19
+ 5.5	1.16	--	--	--	--
8.0	--	1.16	0.67	0.40(7.5°)	--
12.0	1.47	--	0.84(14.°)	0.48(12.5°)	--
18.0	2.16	1.85(18.5°)	1.08(19.5°)	0.63(20°)	0.26(17°)
23.0	3.21	3.20(25°)	1.31(23.5°)	0.70(25°)	--

SOLUBILITY OF SODIUM PALMITATE IN GLYCOLS AT 25°  
 (Palit, 1947)

Moles C <sub>15</sub> H <sub>31</sub> COONa per 1000 gms. Glycol	
Ethylene Glycol	0.0426
Propylene Glycol	0.0679

SOLUBILITY OF SODIUM PALMITATE IN ETHYLENE GLYCOL -  
 n-BUTYL ALCOHOL MIXTURES AT 25°  
 (Palit, 1947)

Wt. % Glycol in Solvent	0	20	40	60	80	100
Gms. CH <sub>3</sub> (CH <sub>2</sub> ) <sub>14</sub> COONa per 100 gms. Solvent	0.08	2.49	5.85	7.14	5.16	1.19

# Na SODIUM

## SOLUBILITY OF SODIUM PALMITATE IN PINENE (Hattiangdi, 1949)

Gms. soap per t° 100 gms. sat. sol.		Gms. soap per t° 100 gms. sat. sol.	
30	0.04	110	1.65
50	0.25	120	1.77
70	0.56	130	1.94
90	1.04	140	2.20
100	1.57	150	2.92

## EQUILIBRIUM IN THE SYSTEM SODIUM PALMITATE - PALMITIC ACID (McBain and Field, 1933)

C<sub>16</sub>H

The previous determinations upon this system by Donnan and White, 1911, are incomplete and erroneous, resulting from imperfect separation of solid from liquid. The present results establish the existence of definite acid soaps of constant composition. The observed temperature  $t^{\circ}_c$  is that at which the last trace of solid crystal disappears on heating and  $t^{\circ}_1$  is the first temperature at which the homogeneous isotropic liquid becomes turbid or non-homogeneous on cooling.

Mol. fraction NaCH <sub>3</sub> (CH <sub>2</sub> ) <sub>14</sub> COO in sat. sol.		Mol. fraction NaCH <sub>3</sub> (CH <sub>2</sub> ) <sub>14</sub> COO in sat. sol.	
t° <sub>c</sub>		t° <sub>c</sub>	
62.8	0.0000	90.0	0.3995
59.2*	—	91.1**	—
60.7	0.0175	97.8	0.4161
61.1	0.0364	106.2	0.4395
65.2	0.0665	113.2	0.4673
67.9	0.1119	120.5	0.5010
70.0	0.1555	127.8	0.5310
72.3	0.2074	138.0	0.5709
73.6	0.2404	147.8	0.6155
74.2**	0.2747	154**	—
77.5	0.3034	— (t° <sub>1</sub> = 168.5)	0.6682
82.5	0.3335	— (t° <sub>1</sub> = 203.5)	0.7188
85.1	0.3599	216 (t° <sub>1</sub> = 316.0)	1.000
88.4	0.3850		

\*Eutectic

\*\*Transfer point

The acid soaps which are formed have the composition NaCH<sub>3</sub>(CH<sub>2</sub>)<sub>14</sub>COO·CH<sub>3</sub>(CH<sub>2</sub>)<sub>14</sub>COOH and 2NaCH<sub>3</sub>(CH<sub>2</sub>)<sub>14</sub>COO·CH<sub>3</sub>(CH<sub>2</sub>)<sub>14</sub>COOH. Further results upon the above system by Ekwall, 1933, confirm the existence of definite acid soaps but their compositions are given as NaCH<sub>3</sub>(CH<sub>2</sub>)<sub>14</sub>COO·2CH<sub>3</sub>(CH<sub>2</sub>)<sub>14</sub>COOH and 2NaCH<sub>3</sub>(CH<sub>2</sub>)<sub>14</sub>COO·CH<sub>3</sub>(CH<sub>2</sub>)<sub>14</sub>COOH.

SODIUM OLEATE  $C_{18}H_{33}O_2$  -  $CH_3(CH_2)_7COONa$  $C_{18}H$ THE SYSTEM SODIUM OLEATE - PHENOL - WATER AT 25°  
(Woodman, 1933)

The determinations were made by titrating one component into a mixture of the other two until homogeneity or heterogeneity resulted.

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
$NaC_{18}H_{33}O_2$	$C_6H_5OH$	$NaC_{18}H_{33}O_2$	$C_6H_5OH$	$NaC_{18}H_{33}O_2$	$C_6H_5OH$
0.0	8.27	10.45	0.0	36.91	48.41
0.09	8.67	12.62	2.14	29.29	59.22
0.23	9.94	13.71	4.60	20.37	69.16
0.48	12.19	14.61	7.39	15.68	76.70
1.72	16.96	17.22	11.48	13.24	78.37
1.80	38.16	21.29	14.36	6.27	87.26
2.04	45.11	25.87	16.24	0.0	94.74
2.25	57.54	34.85	21.58	2.09	92.15
1.50	64.62	36.57	27.99	3.08	91.62
1.11	65.88	39.60	29.34	9.44	86.03
0.80	67.36	43.75	32.88	11.29	83.42
0.72	68.04	43.57	34.94	12.57	81.58
0.52	68.36	44.25	35.16	13.52	81.92
0.0	70.34				

Similar results are given for the remaining ternary mixtures in the quaternary system, sodium oleate, phenol, toluene and water and are of practical value in the preparation of mixtures used for spraying.

EQUILIBRIUM IN THE SYSTEMS CRESOLS - SODIUM OLEATE - WATER  
(Bailey, 1923)

Especial attention was given to the purification of the sodium oleate. The determinations were made by the synthetic method.

Ortho Cresol + Sodium Oleate + Water at 20°		Meta Cresol + Sodium Oleate + Water at 20° at 60°		Para Cresol + Sodium Oleate + Water at 20°	
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
Cresol	Oleate	Cresol	Oleate	Cresol	Oleate
2.8	-	2.4	-	3.0	-
7.5	2.3	5.2	1.2	6.6	1.3
10.5	3.7	11.0	3.5	10.5	2.6
31.3	8.5	16.0	5.2	22.5	5.1
49.5	8.5	23.6	7.2	30.7	6.2
67.3	7.4	36.4	9.1	38.6	8.6
75.5	5.6	42.6	11.0	54.3	10.2
80.6	3.5	45.1	13.3	63.3	9.2
84.0	1.3	52.8	14.1	71.0	6.6
85.1	0.7	61.6	12.2	79.6	2.2
85.7	0.4	71.4	8.3	82.0	0.9
86.0	0.3	81.2	3.7	82.7	0.5
86.4	-	84.9	1.9	83.4	-
		87.2	-		

Results for equilibrium in the ternary systems and quaternary systems possible with the four components, sodium oleate, sodium chloride, ethyl acetate and water at 25° are given by Smith, 1932.

# Na SODIUM

## SOLUBILITY OF SODIUM OLEATE IN WATER AND AQUEOUS BILE SALTS (Moore, Wilson and Hutchinson, 1909)

Solvent	Gms. Oleate per 100 Gms. Sat. Sol.
Water	5
Aq. 5% Bile Salts	7.6
Aq. 5% Bile Salts + 1% Lecithin	11.6

The freezing points of dilute sodium oleate solutions were determined by Johnston and McBain, 1942.

C<sub>18</sub>H

## SOLUBILITY OF SODIUM OLEATE IN PINENE (Hattiangdi, 1949)

t°	Gms. soap per 100 gms. sat. sol.	t°	Gms. soap per 100 gms. sat. sol.
30	0.05	110	3.34
50	0.58	120	3.37
70	1.28	130	3.44
90	2.17	140	3.65
100	2.75	150	3.93

## SOLUBILITY OF SODIUM OLEATE IN MIXED SOLVENTS AT 25° (Palit, 1947)

Each mixture of solvents contained either ethylene glycol, diethylene glycol, or propylene glycol. Solubilities are given as gms. of sodium oleate per 100 gms. solvent.

Added Solvent	Wt. % Ethylene Glycol in Solvent					
	0	20	40	60	80	100
Ethyl Alcohol	1.61	8.49	15.65	21.61	23.68	16.43
n-Propyl Alcohol	1.13	10.46	21.24	28.50	28.85	16.43
n-Butyl Alcohol	0.98	12.88	25.35	32.28	32.90	16.43
n-Amyl Alcohol	.85	14.74	27.48	34.48	33.64	16.43

With Diethylene Glycol						
Ethyl Alcohol	1.61	8.13	12.41	15.46	14.91	8.05
n-Propyl Alcohol	1.13	-	16.03	19.92	18.74	8.05
n-Butyl Alcohol	0.98	10.46	19.26	23.23	21.26	8.05
n-Amyl Alcohol	.85	-	20.28	24.77	22.27	8.05
Methylene Chloride	.02	14.67	22.33	23.66	19.39	8.05
Chloroform	.02	18.04	25.05	26.51	20.14	8.05
Carbon Tetrachloride	.02	16.63	24.73	25.75	21.47	8.05
Ethylene Chloride	.02	10.38	17.22	19.68	15.00	8.05

(Cont.)

SOLUBILITY OF SODIUM OLEATE IN MIXED SOLVENTS AT 25°--Cont.  
(Palit, 1947)

	With Propylene Glycol					
	0	20	40	60	80	100
2-Ethylhexanol	.45	11.04	18.01	22.50	21.90	11.72
Lauryl Alcohol	.4	13.72	21.43	24.96	23.81	11.72
Cetyl Alcohol	Solid	Solid paste			24.29	11.72
Phenol	Solid	21.54	28.21	28.77	24.05	11.72
Cyclohexanol	.36	5.28	12.37	16.78	17.25	11.72
Benzyl Alcohol	.59	5.61	11.55	15.69	16.53	11.72
Ethylene Chloride	.02	10.61	18.73	22.03	21.45	11.72
Methyl Ethyl Ketone	.07	3.99	9.28	14.25	16.20	11.72
Dioxane	.06	1.45	4.56	7.93	10.91	11.72 C <sub>18</sub> H
Trimethylene Chlorohydrin	1.44	5.36	9.79	12.96	13.19	11.72
Trichloro-t-Butyl Alcohol			17.48	18.59	16.71	11.72

	With Propylene Glycol Wt. %					
	0	20.5	40.5	60.4	80.2	100
n-Propyl Alcohol	1.13	6.04	11.39	16.15	16.89	11.72
Isopropyl Alcohol	0.25	3.60	7.45	11.18	13.92	11.72
n-Butyl Alcohol	.98	7.97	14.51	18.35	18.86	11.72
Isobutyl Alcohol	.68	6.41	11.78	17.64	18.25	11.72
s-Butyl Alcohol	.42	3.92	9.42	14.33	15.88	11.72
t-Butyl Alcohol	.24	1.95	5.63	10.71	14.14	11.72
Allyl Alcohol	1.05	5.55	10.07	13.25	14.34	11.72
n-Amyl Alcohol	0.85	8.82	16.54	21.15	21.02	11.72
Isocamyl Alcohol	.69	7.72	15.30	19.83	20.17	11.72
s-Amyl Alcohol	.18	3.09	10.90	16.48	18.39	11.72
n-Hexyl Alcohol	.62	9.70	17.97	22.41	21.56	11.72
n-Octyl Alcohol	.58	12.53	20.75	25.12	23.65	11.72
Methylene Chloride	.02	12.11	22.89	26.29	23.99	11.72
Chloroform*	.02	16.14	26.45	28.20	26.17	11.72
Carbon Tetrachloride	.02	16.40	24.04	27.11	23.71	11.72
Acetone	.02	1.46	6.93	14.04	14.98	11.72
Ethyl Acetate	.06	4.36	10.90	15.35	16.68	11.72
Ethylene Chlorohydrin	1.80	6.02	9.86	12.72	14.09	11.72
Benzene (at 20°)	0.04	14.32	26.35	29.82	31.47	10.82

	With Propylene Glycol Wt. %					
	0	24.5	46.3	66.0	83.8	100
Ethyl Alcohol	1.61	5.18	8.77	12.41	12.87	11.72

	With Propylene Glycol Wt. %					
	0	23	44.4	64.2	82.7	100
t-Butyl Chloride	0.12	14.90	23.57	28.54	26.01	11.72

\*At 17.5% Propylene Glycol, the solubility is 14.09.

# Na SODIUM

## SODIUM $\alpha$ -NITRILE, $\alpha,\alpha$ -DIPHENYL, $\alpha$ -ETHYL SUCCINATE $(C_6H_5)_2(CH)CCH\ C_2H_5\ CO_2Na \cdot H_2O$

SOLUBILITY IN WATER  
 (Salmon-LeGagneur, 1956)

t°	Gms. salt per 100 cc. H <sub>2</sub> O	t°	Gms. salt per 100 cc. H <sub>2</sub> O
0	3.5	15	4.2
5	3.6	25	6.2
10	3.9	30	7.9
		40	20

In the presence of  $K^+$  the solubility is decreased.

## $C_{18}H$ SODIUM STEARATE $CH_3(CH_2)_{16}COONa$

THE SYSTEM SODIUM STEARATE - WATER  
 (McBain, Vold, and Frick, 1940)

$T_i$  is the temperature at which the isotropic soap solution separates an anisotropic liquid crystalline phase upon cooling.

$T_c$  is the temperature at which the last trace of "curd fibre" disappears on slow heating.

Wt. %	$T_i^\circ$	$T_c^\circ$	Wt. %	$T_i^\circ$	$T_c^\circ$	Wt. %	$T_i^\circ$	$T_c^\circ$
0.37	-	62.7	38.0	169	81.3	79.8	286	104
0.81	-	66.8	39.8	171	81.9	84.7	281	112
1.49	-	68.8	41.9	164	82.4	88.6	274	119
2.51	-	69.8	43.8	147	82.4	89.8	273	-
5.10	-	71.8	45.0	170	82.4	91.2	272	-
7.51	-	72.8	47.8	212	83	92.6	276	-
16.8	-	75.3	49.5	226	83	92.8	276	-
15.3	-	75.6	55.0	256	86	93.2	267	-
19.9	87	76.8	60.3	277	86	94.6	274	-
24.8	124	78.1	64.9	280	87	97.1	277	-
29.6	152	78.8	71.9	284	90	99.6	284	-
34.9	166	80.3	74.5	293	93	100.0	288	-

SOLUBILITY OF SODIUM STEARATE IN SEVERAL SOLVENTS  
 (Smith and McBain, 1947)

The determinations were made by the sealed tube method.

The temperatures are those at which, on cooling, anisotropic material began to separate from the homogeneous isotropic solution. After cooling the mixtures were studied visually and by microscopic examinations under polarized light and by photo micrography. These observations are reported in detail.

## SOLUBILITY OF SODIUM STEARATE IN SEVERAL SOLVENTS--Cont.

<u>In Cyclohexane</u>		<u>In p Xylene</u>		<u>In Cumene</u>	
(Crit. t. 281°)		(Crit. t. 348.5°)			
t°	Wt. % Stearate	t°	Wt. % Stearate	t°	Wt. % Stearate
115	0.44	220	19.5	222	11.3
160	7.9	232	28.6	228	23.1
195	11.5	244	43.7	238	33.4
222	18.3	216	56.3	245	43.7
232	25.1	>280	61.9		
240	33.2	261	87.8	<u>In n Butyl Benzene</u>	
243	39.6	263	90.8	193	19.9
>310	45.4			226	31.1
>310	52.8	<u>In o Xylene</u>		239	38.8
>300	72.0				
>307	83.0	200	10.2	<u>In p Cymene</u>	
269	93.3	216	19.9	118	9.5
285	100.	229	27.6	144	19.5
		240	38.1	171	27.6
<u>In Toluene</u>		<u>In m Xylene</u>			
(Crit.t.320.6°)				<u>In n Heptane</u>	
133	0.93	223	20.9	240	32.2
165	9.1	230	29.4		
225	18.9	244	44.1	<u>In Isooctane</u>	
244	36.0	<u>In Ethyl Benzene</u>		248	47.4
235	45.4	140	1.36	258	73.3
287	55.9	195	10.3		
331	60.3	227	19.0	<u>In Benzene</u>	
335	77.9	236	27.8	222	20.1
257	89.8	240	37.4	>238	29.9
264	94.6	250	46.8		
		>291	66.1		
		258	78.9		
		258	88.2		
		260	95.0		

SOLUBILITY OF SODIUM STEARATE IN GLYCOLS AT 25°  
(Palit, 1947; See also Rao and Palit, 1949)Moles  $C_{17}H_{35}COONa$   
per 1000 gms. Glycol

Ethylené Glycol	0.0156
Propylene Glycol	0.0299

Data for the solubility of sodium stearate in cetane and in cetane-water mixtures is given by Vold and Philipson, 1946.



# Na SODIUM

## SOLUBILITY OF SODIUM STEARATE IN ETHYLENE GLYCOL - n-BUTYL ALCOHOL MIXTURES AT 25° (Palit, 1947)

Wt. % Glycol in Solvent	0	20	40	60	80	100
Gms. per 100 gms. Solvent	0.05	1.47	3.37	3.79	2.16	0.48

## MIXTURES OF n-AMYL ALCOHOL + GLYCOLS (Palit, 1947)

C <sub>18</sub> H Glycol in Mixture	Wt. % Glycol in Solvent					
	0	20	40	60	80	100
CH <sub>2</sub> ClCHOHCH <sub>2</sub> OH	0.85	-	12.56	16.98	16.88	1.16
Monoacetin	.85	-	10.50	12.70	10.48	2.51
Glycerol	.85	-	34.62	42.68	34.36	8.53
Dibutyl Tartarate	.85	-	25.94	36.55	42.15	41.27
Phenol	.85	1.53	2.94	6.16	4.67	-

## MIXTURES OF CATECHOL + ETHYL ALCOHOL (Palit, 1947)

Ratio by weight; (Catechol : Ethanol)	10:90	30:80	40:60
Solubility	6.63	17.69	24.97

## MIXTURES OF BENZENE + ALCOHOLS (Palit, 1947)

Added Alcohol	Wt. % Alcohol in Solvent					
	0	20	40	60	80	100
Methanol	0.04	3.94	6.89	10.31	12.25	12.38
Cyclohexanol	.04	0.31	1.04	2.13	0.70	0.36

## SOLUBILITY OF SODIUM STEARATE IN PINENE (Hattiangdi, 1949)

t°	Gms. soap per 100 gms. sat. sol.	t°	Gms. soap per 100 gms. sat. sol.
30	0.045	110	2.10
50	0.43	120	2.29
70	0.85	130	2.55
90	1.56	140	3.01
100	1.98		

Results for the solubilization of sodium stearate in aqueous solutions of cresol, cyclohexanol, cyclohexylamine, t-butanol, urea, 2-ethylhexanol, 1-octanol, butyl cellosolve and other compounds are given by Merrill, 1950.

Data for the system sodium stearate - cetane are given by Stross and Abrams, 1950, 1951.

Melting points in the systems Na stearate - NaNO<sub>3</sub> and Na stearate - NaSCN are given by Sokolov, 1954.

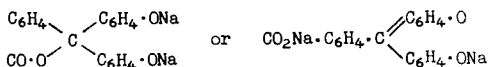
## SODIUM SALTS OF PHENOLPHTHALEIN

### THE SYSTEM SODIUM OXIDE - PHENOLPHTHALEIN ANHYDRIDE - WATER AT 25° (Bassett and Halton, 1923)

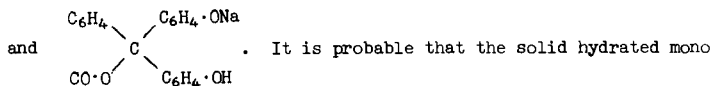
Saturation was secured by constant rotation in a thermostat for 3 days. Both the solutions and the solid phases were analyzed. The compositions of the latter were established by the "rest method."

The crystalline anhydrous disodium salt could be either

C<sub>18</sub>H



Since it is colorless it must be regarded as the diphenolic salt. The two hydrated forms of the disodium salt also have the phenolic structure. For the trisodium salt there is only one possible structure, namely,  $\text{CO}_2\text{Na}\cdot\text{C}_6\text{H}_4\cdot\text{C}(\text{C}_6\text{H}_4\text{ONa})_2\cdot\text{OH}$ , but two mono sodium salts are possible. They are  $\text{CO}_2\text{Na}\cdot\text{C}_6\text{H}_4\cdot\text{C}(\text{C}_6\text{H}_4\text{OH})_2\cdot\text{OH}$



sodium salts, which have been obtained in the present investigation, have the phenolic structure shown by the latter formula.

Gms. per 100 gms. sat. sol.

Phenolphthalein anhydride		Solid Phase
Na <sub>2</sub> O		
0.58	2.90	Phenolphthalein
2.71	13.74	"
4.25	22.43	"
6.11	31.96	"
6.95	36.06	Mono sodium salt + 8H <sub>2</sub> O
7.48	37.73	"
8.32	41.16	"
6.78	33.34	Mono sodium salt + 4H <sub>2</sub> O
9.31	37.36	"
9.88	41.45	"
10.06	44.06	"
11.00	45.55	Disodium salt, anhydrous
12.31	40.16	"
11.67	37.79	Disodium salt 4H <sub>2</sub> O
11.98	34.78	"
9.97	38.42	Disodium salt 8H <sub>2</sub> O
10.17	33.72	"
10.24	31.00	Tri sodium salt 14H <sub>2</sub> O
10.37	27.89	"
11.34	25.03	"
12.69	23.25	"

(Cont.)

## Na SODIUM

THE SYSTEM SODIUM OXIDE - PHENOLPHTHALEIN ANHYDRIDE - WATER AT 25°---Cont.

	Gms. per 100 gms. sat. sol.		Solid Phase
	Na <sub>2</sub> O	Phenolphthalein anhydride	
C <sub>18</sub> H	13.73	20.51	Tri sodium salt 13H <sub>2</sub> O
	14.29	16.91	"
	17.48	10.35	"
	19.8	9.12	Tri sodium salt 12H <sub>2</sub> O
	20.32	4.28	"
	23.46	1.37	"
	25.42	0.86	"
	27.01	0.11	Tri sodium salt 6H <sub>2</sub> O
	28.03	0.0	"
	30.74	0.0	"
	37.44	0.23	"
	39.88	0.0	" + NaOH·H <sub>2</sub> O

## SODIUM DEOXYCHOLATE C<sub>23</sub>H<sub>41</sub>OCOONa

SOLUBILITY OF SODIUM DEOXYCHOLATE IN WATER  
(Vold and McBain, 1941)

Temperatures of Formation of Isotropic Liquid:

Wt. % NaD	t°	Wt. % NaD	t°	Wt. % NaD	t°
0.0	0	49.9	35.6	74.9	114
16.0	-0.1	53.0	42.9	81.4	183
29.6	-0.9	56.2	47.2	89.5	271
38.3	-1.5	63.2	60.2	96.0	338
47.8	-2.9	69.8	63.8	100.0	approx. 362

The freezing points of dilute sodium deoxycholate solutions were determined by Johnston and McBain, 1942.

## SODIUM ROSIN SOAPS

SOLUBILITIES IN WATER  
(Merril and Getty, 1948)

N wood rosin (commonly used in yellow laundry soaps) with an acid number of 162 and saponification number of 184 (average M.W. of sodium soap = 349), and a hydrogenated rosin soap of average M.W. = 343 were used. The temperatures indicate the formation of an isotropic solution.

## SODIUM ROSIN SOAPS—Cont.

N Wood Rosin Soap in Water			Hydrogenated Rosin Soap					
			In Water			In 0.025N NaOH		
Wt. % Soap	t°		Wt. % Soap	t°		Wt. % Soap	t°	
10.1	1		10.2	69		10.1	40	
20.2	7		20.0	66		27.4	70	
29.1	14		34.8	98		30.0	72	
40.1	26		43.9	118		34.9	77	
49.1	35		50.2	132		50.2	106	
59.5	48		65.5	142		54.9	112	
69.5	42		59.9	147		60.0	119	
80.0	62		68.3	157		67.1	122	
90.6	116		80.0	117		75.4	108	
			82.1	78		77.6	105	
			84.8	130				

C<sub>18</sub>H

Data are also given for the solubility of hydrogenated rosin soap in sodium chloride solutions, sodium silicate solutions, and in mixtures of sodium chloride and sodium hydroxide.

## SODIUM CYANIDE NaCN

CN

SOLUBILITY OF SODIUM CYANIDE IN WATER  
(Frost, 1936)

t°	Gms. NaCN per 100 gms. sat. solution	Solid Phase	t°	Gms. NaCN per 100 gms. sat. solution	Solid Phase
- 4.0	5.50	Ice	+10.0	32.5	NaCN·2H <sub>2</sub> O
- 9.2	11.03	"	15.0	34.2	"
-12.5	13.90	"	20.4	37.02	"
-15.2	16.01	"	25.0	38.8 <sup>a</sup>	"
-19.5	19.11	"	25.4	39.1	"
-23.4	21.23	"	29.5	41.56	"
-26.4	23.46	" + NaCN·2H <sub>2</sub> O	34.0	44.82	"
-21.4	24.84	NaCN·2H <sub>2</sub> O	35.0	45.0	NaCN
-18.1	25.90	"		45.0 <sup>a</sup>	"
-14.8	26.5	"	55.0	45.2 <sup>a</sup>	"
- 7.6	27.9	"			
- 4.0	28.9	"			

<sup>a</sup>Oliver and Johnsen, 1954THE SYSTEM SODIUM CYANIDE - SODIUM HYDROXIDE - WATER  
(Oliver and Johnsen, 1954)

[Additional data are given by Kirejew and Wagranskaja, 1935, in the tables following.]

# Na SODIUM

## THE SYSTEM SODIUM CYANIDE - SODIUM HYDROXIDE - WATER--Cont.

A = NaCN

B = NaCN·2H<sub>2</sub>O

D = NaOH·H<sub>2</sub>O

E = NaCN·NaOH

Results at 25°					Results at 35°					Results at 55°				
CN	Sat. Sol.		d.	Solid Phase	Sat. Sol.		d.	Solid Phase	Sat. Sol.		d.	Solid Phase		
	Wt. %				Wt. %				Wt. %					
	NaCN	NaOH	NaCN	NaOH	NaCN	NaOH								
	38.8	0.0	-	B	45.0	0.0	-	A	45.2	0.0	-	A		
	37.8	2.5	1.225	B	37.2	8.2	1.270	A	38.1	7.6	1.265	A		
	35.6	6.4	1.255	B	28.3	16.8	1.312	A	30.2	16.1	-	A		
	34.5	8.9	-	B	21.5	25.6	1.370	A	18.8	32.9	1.433	A		
	35.5	9.5	-	B	19.9	26.7	1.379	A	17.1	45.9	1.547	A		
	33.7	10.2	1.290	A	15.5	37.5	1.454	A	17.2	46.8	-	E		
	32.7	11.5	-	A	14.7	43.7	1.508	A	16.5	47.5	-	E		
21.5	23.8	1.370	A	14.9	47.3	1.541	A	15.8	48.5	-	E			
14.1	38.7	1.488	A	13.4	48.2	-	E	14.8	49.7	-	E			
13.9	45.2	1.548	A	12.5	49.0	-	E	12.6	52.6	-	E			
13.2	46.2	-	D	11.3	49.6	-	E	10.3	56.0	1.623	E			
12.8	46.5	-	D	10.6	51.6	-	D	9.4	57.4	-	E			
11.0	46.8	-	D	10.3	51.8	-	D	9.3	58.3	-	E			
6.7	48.2	1.566	D	7.6	51.5	-	D	9.0	58.5	-	E			
3.7	49.2	-	D	6.5	52.5	-	D	8.6	58.2	-	D			
				3.7	51.6	-	D	7.7	57.0	-	D			
				2.4	52.3	-	D	6.7	57.2	-	D			
				0.0	55.0	-	D	3.5	57.9	-	D			
								0.0	61.4	-	D			

## SOLUBILITY OF SODIUM CYANIDE IN AQUEOUS SOLUTIONS OF SODIUM HYDROXIDE (Kirejew and Wagranskaja, 1935)

[See more complete data of Oliver and Johnsen, above]

Results at 0°			Results at 25°			Results at 40°		
Gms. per liter sat. sol.		d. of sat. sol.	Gms. per liter sat. sol.		d. of sat. sol.	Gms. per liter sat. sol.		d. of sat. sol.
NaOH	NaCN		NaOH	NaCN		NaOH	NaCN	
10	370	1.186	45	490	-	10	530	-
40	349	1.293	125	430	1.265	35	505	-
140	300	-	140	417	-	90	460	-
160	280	-	178	388	-	110	445	-
		1.332	210	365	-	164	400	-
		1.348	290	305	1.319	235	330	-
		-	420	220	-	290	305	-
		-	520	160	-	370	255	-

## SOLUBILITY OF SODIUM CYANIDE IN VARIOUS SOLVENTS

Solvent	t°	Solubility						Ref.
Methanol	15	6.44	gms. NaCN	per 100	gms. CH <sub>3</sub> OH			A
	67.4	4.10	"	"	"	"	"	A
Furfural	25	0.02	"	"	100	gms. sat. sol.		B
Sulfur Dioxide (Liq.)	0	0.018	"	"	100	gms. SO <sub>2</sub>		C

A = Henstock, 1934      B = Trimble, 1941      C = Jander and Ruppolt, 1937

Data for equilibrium in the system sodium cyanide - sodium chloride - liquid ammonia at different temperatures are given by Wassiliew, Ettinger and Galowkow, 1934.

Melting points are given for:

NaCN - NaCl	Truthe, 1912
NaCN - Na <sub>2</sub> CO <sub>3</sub>	Murphy, Tinsley and Hart, 1957

SODIUM FERROCYANIDE Na<sub>4</sub>Fe(CN)<sub>6</sub>

CN

## SOLUBILITY OF SODIUM FERROCYANIDE IN WATER

(Friend, Townley and Valiance, 1929)

The solid phase below 81.7 is Na<sub>4</sub>Fe(CN)<sub>6</sub>·10H<sub>2</sub>O.

The previous results of Conroy, 1898, and Farrow, 1926, differ only slightly from these at temperatures up to 65°.

t°	d. of sat. sol.	Gms. Na <sub>4</sub> Fe(CN) <sub>6</sub> per 100 gms. sat. sol.	t°	d. of sat. sol.	Gms. Na <sub>4</sub> Fe(CN) <sub>6</sub> per 100 gms. sat. sol.
0.65	1.0680	10.23	71.0	-	34.34
16.7	1.1079	14.69	75.25	-	35.82
25.35	1.1303	17.63	79.5	1.2809	38.26
35.75	1.1572	21.54	81.7*	-	-
49.65	1.1921	26.20	85.0	1.285	38.5 - 39.5
59.75	1.2180	30.35	104.0	1.285	38.5 - 39.5

\*tr. pt.

SOLUBILITY OF SODIUM FERROCYANIDE IN AQUEOUS SOLUTIONS OF AMMONIA AT 18°  
(Tettamanzi, 1933)

The solid phase was Na<sub>4</sub>Fe(CN)<sub>6</sub>·10H<sub>2</sub>O in all cases.

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
NH <sub>3</sub>	Na <sub>4</sub> Fe(CN) <sub>6</sub>	NH <sub>3</sub>	Na <sub>4</sub> Fe(CN) <sub>6</sub>	NH <sub>3</sub>	Na <sub>4</sub> Fe(CN) <sub>6</sub>
0.0	14.28	14.89	4.40	24.64	2.61
2.58	11.52	15.60	4.17	27.88	2.29
6.58	8.26	17.53	3.64	30.88	2.44
7.53	7.92	21.10	3.04	31.09	2.49
9.17	6.69	23.81	2.68		

## Na SODIUM

### SIMULTANEOUS SOLUBILITY OF SODIUM FERROCYANIDE AND SODIUM SULFATE IN WATER AT VARIOUS TEMPERATURES (Dominik, 1922)

t°	d of sat. sol.	Gms. per 100 cc. sat. sol.		t°	d of sat. sol.	Gms. per 100 cc. sat. sol.	
		Na <sub>4</sub> Fe(CN) <sub>6</sub>	Na <sub>2</sub> SO <sub>4</sub>			Na <sub>4</sub> Fe(CN) <sub>6</sub>	Na <sub>2</sub> SO <sub>4</sub>
10	1.136	8.94	7.33	34	1.357	4.95	42.20
14	1.147	9.46	8.58	42	1.353	8.64	38.69
23.5	1.228	8.64	19.53	55	1.299	16.42	31.47
32	1.357	4.90	42.25	63	1.300	27.85	28.08

## CN

### SOLUBILITY OF SODIUM FERROCYANIDE IN AQUEOUS SOLUTIONS OF ETHYL ALCOHOL AT 20° (Diaz de Reda and Bermejo, 1929)

Vol. % C <sub>2</sub> H <sub>5</sub> OH in solvent	Gms. Na <sub>4</sub> Fe(CN) <sub>6</sub> per 100 gms. sat. sol.	Vol. % C <sub>2</sub> H <sub>5</sub> OH in solvent	Gms. Na <sub>4</sub> Fe(CN) <sub>6</sub> per 100 gms. sat. sol.
0 ( = H <sub>2</sub> O)	16.77	45	0.259
10	6.745	50	0.186
15	4.535	55	0.133
20	2.909	60	0.073
25	1.618	65	0.041
30	1.126	70	0.025
35	0.614	80	0.007
40	0.481	85	0.000

## OCN SODIUM CYANATE NaOCN

100 gms. alcohol of d<sub>17</sub> = 0.799 dissolve 0.22 gm. NaOCN at 0° and 0.52 gm. at the b. pt.

100 gms. benzene dissolve 0.13 gm. NaOCN at the b. pt. (Cranston and Livingstone, 1926.)

### SOLUBILITY OF SODIUM CYANATE IN LIQUID AMMONIA (Abe and Okabe, 1955)

t°	0	15	25	35	45
Gms. NaOCN per 100 gms. NH <sub>3</sub>	1.38	1.15	0.98	0.85	0.72

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SOLUBILITY OF SODIUM CYANATE IN SALT SOLUTIONS IN LIQUID AMMONIA AT 0°  
(Abe and Okabe, 1955)

	Gms. per 100 gms. NH <sub>3</sub>			Gms. per 100 gms. NH <sub>3</sub>		
	NH <sub>4</sub> NO <sub>3</sub>	NaOCN		NH <sub>4</sub> NO <sub>3</sub>	NaOCN	
NH <sub>4</sub> NO <sub>3</sub>	2.35	3.05	NH <sub>4</sub> Cl	2.16	3.20	
added:	6.84	4.94	added:	4.32	4.21	
	8.70	5.39		9.37	6.18	
	11.6	6.11		12.7	7.16	
	19.9	7.51		18.6	7.94	
	28.3	8.11		28.6	8.43	
	35.4	8.47		40.2	8.42	
	42.2	8.50		54.4	6.82	
	45.3	8.41		64.0	5.89	OCN
	52.2	8.11				
	56.7	7.90				
	66.6	6.94				

## SODIUM THIOCYANATE NaSCN

SCN

SOLUBILITY OF SODIUM THIOCYANATE IN WATER  
(Hughes and Mead, 1929)

These determinations were made by observing the temperatures at which the last crystal in a known mixture of NaSCN·H<sub>2</sub>O began to show sharp or rounded edges with slow variations of temperature.

t°	Gms. NaCNS per 100 gms.		Solid Phase	t°	Gms. NaCNS per 100 gms.		Solid Phase
	H <sub>2</sub> O	sat. sol.			H <sub>2</sub> O	sat. sol.	
10.7	112.7	52.98	NaCNS·H <sub>2</sub> O	25	167.8*	62.66	NaCNS
17.3	127.5	56.01	"	25	165.9	62.39*(1)	"
21.3	139.3	58.21	"	33.8	172.4	63.29	"
25.0	142.6	58.78(1)	"	46.1	178.0	64.03	"
29.2	167.5	62.62	"	65.8	189.5	65.46	"
30.4†	-	-	" + NaCNS	73.8	196.2	66.24	"
15	164.5*	62.19	NaCNS	81.8	202.0	66.89	"
20	165.6*	62.36	"	101.4	225.6	69.29	"

\* These three metastable points are by Bump, 1932.

† tr. pt.

(1) Occleshaw, 1931.

The effect of the addition of 0.1 - 1.1 molar sodium thiocyanate on the mutual solubility of n-butyl alcohol and water is reported by Reber, McNabb, and Lucasse, 1942.



# Na SODIUM

## SOLUBILITY OF NaSCN IN ORGANIC SOLVENTS (Hughes and Mead, 1929)

The accuracy of these results is questioned by Partington and Winterton, 1934a, who found 20.66 gms. NaCNS per 100 gms.  $C_2H_5OH$  at  $25^\circ$ . They consider that saturation with excess of salt is a more accurate method than observation of the point at which the last crystal in a solution shows sharp or rounded edges.

Results for:

SCN	<u>Methyl Alcohol</u>		<u>Ethyl Alcohol</u>		<u>Acetone*</u>	
	t°	Gms. NaCNS per 100 gms. $CH_3OH$	t°	Gms. NaCNS per 100 gms. $C_2H_5OH$	t°	Gms. NaCNS per 100 gms. $(CH_3)_2CO$
	15.8	35.00	18.8	18.37	18.8	6.85
	24.7	40.04	35.8	19.05	29.2	9.50
	34.6	45.14	52.8	21.05	41.9	14.08
	48.0	50.98	61.8	22.60	51.0	18.61
	52.3	53.54	70.9	24.43	56.0	21.40

\*In the case of Acetone the equimolecular compound  $NaCNS \cdot (CH_3)_2CO$  was formed.

## THE SYSTEM SODIUM THIOCYANATE - SODIUM IODIDE - ALLYL ALCOHOL AT $25^\circ$ (Partington and Winterton, 1934)

Gms. per 100 gms. $CH_2CHCH_2OH$			Gms. per 100 gms. $CH_2CHCH_2OH$		
NaI	NaSCN	Solid Phase	NaI	NaSCN	Solid Phase
0.0	12.40	NaSCN	14.61	8.45	NaSCN
1.87	12.01	"	21.72	5.20	"
3.92	11.77	"	22.0	5.04	"
6.81	10.82	"	28.48	0.0	NaI
14.20	8.44	"			

Data for the effect of small quantities of NaSCN on the miscibility temperature of methanol and cyclohexane are given by Eckfeldt and Lucasse, 1943.

93.5 gms. NaCNS dissolve in 100 gms. of ethylenediamine at  $25^\circ$ . (Isbin and Kobe, 1945.)

100 gms. liquid ammonia ( $NH_3$ ) dissolve 205.5 gms. NaSCN at  $25^\circ$ . (Hunt, 1932.)

Melting points are given for

NaSCN +  $NaNO_3$  (Stehlik, 1956)

NaSCN + Na formate; + Na acetate; + Na propionate; + Na butyrate; + Na isobutyrate; + Na valerate; + Na isovalerate; + Na neovalerate; + Na caproate (Sokolov, 1954a)

SOLUBILITY OF SODIUM CARBONATE IN WATER  
(Kobe and Sheehy, 1948)

The authors made a critical survey of all the available data reported for this system, and compared temperature ranges, methods of determination, etc., and plotted the data on a large scale. The accuracy of each set of data was estimated and a smooth curve was drawn through the points. The results below were then read from the curve and their estimated accuracy is 0.4%.

Original results are given by Wells and McAdam, Jr. (1907), Mulder, Lowel (1851), Reich (1891), Eppel (1899), Ketner (1901-2), Greenish and Smith (1901), Osaka (1910-11), de Paepe (1911), Cocheret (1911), Freeth (1922), Seyer and Todd (1929), Mondain-Monval (1922), Hill and Baron (1927), Teeple (1929), Waldeck, Lynn and Hill (1932), Schroeder, Berk and Gabriel (1936), Foote and Vance (1933), and Keevil (1942). For densities see Hager, Kohlrausch, Schiff, Lunge, Wegscheider and Walter (1905), Flottmann (1928).

t°	Solid Phase	Gm. Moles per 1000 gms. H <sub>2</sub> O	Gms. $\text{Na}_2\text{CO}_3$ per 100 gms.		Density	Vapor Pressure mm. Hg
			H <sub>2</sub> O	Sat. Sol.		
- 2.10	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O} + \text{Ice}$	0.575	6.10	5.75	1.056	-
0	"	.66	7.00	6.54	-	-
5	"	.84	8.90	8.2	-	-
10	"	1.14	12.1	10.8	-	-
15	"	1.55	16.4	14.1	1.1515	12.3
20	"	2.09	22.2	18.1	1.1941	16.9
25	"	2.77	29.4	22.7	1.2416	21.4
30	"	3.70	39.2	28.2	1.342	26.8
32.00	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O} + \text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$	4.28	45.4	31.2	-	29.0
32.96	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O} + \text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$	4.71	49.9	33.3	-	29.5
30	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$	4.78	50.7	33.6	-	-
35.37	$\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O} + \text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$	4.67	49.5	33.1	-	34.0
40	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$	4.60	48.8	32.8	-	43.6
50	"	4.48	47.5	32.2	-	74.1
60	"	4.37	46.3	31.6	-	121.5
70	"	4.30	45.6	31.3	-	192.7
75	"	4.28	45.4	31.2	-	239.8
80	"	4.26	45.2	31.1	-	296.2
90	"	4.24	44.9	31.0	-	442.4
100	"	4.22	44.7	30.9	-	631.7
104.8	"	4.21	44.6	30.8	-	760.0
109	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O} + \text{Na}_2\text{CO}_3$	4.20	44.5	30.8	-	1.15 (Atm.)
110	$\text{Na}_2\text{CO}_3$	4.20	44.5	30.8	-	1.19 "
113	"	4.20	44.5	30.8	-	"
120	"	4.03	42.7	29.9	-	1.65 "
130	"	3.86	40.9	29.0	-	2.25 "
140	"	3.71	39.3	28.2	-	3.02 "
150	"	3.57	37.8	27.4	-	4.01 "
160	"	3.44	36.5	26.7	-	5.27 "
180	"	3.16	33.5	25.1	-	8.67 "
200	"	2.89	30.6	23.4	-	13.7 "
220	"	2.56	27.1	21.3	-	21.0 "
240	"	2.16	22.9	18.6	-	30.9 "
250	"	1.95	20.7	17.1	-	37.0 "
260	"	1.75	18.6	15.7	-	44.2 "
280	"	1.32	14.0	12.3	-	61.7 "
300	"	0.88	9.3	8.5	-	83.8 "
350	"	0.19	2.0	2.0	-	166 "

# Na SODIUM

The following data (below 30°) are those of Loewel (1851) and have not been redetermined since that time.

t°	Solid Phase	Gm. Moles per 1000 gms. H <sub>2</sub> O	Gms. Na <sub>2</sub> CO <sub>3</sub> per 100 gms.		Density
			H <sub>2</sub> O	Sat. Sol.	
0	$\beta$ -Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O	1.92	20.4	16.9	-
10	"	2.48	26.3	20.8	-
15	"	2.79	29.6	22.8	-
20	"	3.17	33.6	25.2	-
25	"	3.59	38.0	27.6	-
30	"	4.08	43.2	30.2	-
32.00	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O + Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O	4.28	45.4	31.2	-
34	$\beta$ -Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O	4.51	47.8	32.3	-
35.37	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O	4.67	49.5	33.1	-
0	$\alpha$ -Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O	3.01	31.9	24.2	-
10	"	3.57	37.8	27.4	-
15	"	3.92	41.6	29.4	-
20	"	4.32	45.8	31.4	-

## THE SYSTEM SODIUM CARBONATE - HYDROGEN PEROXIDE - WATER (Makarov and Chamova, 1951)

A = Na<sub>2</sub>CO<sub>3</sub>·10H<sub>2</sub>O

B = Na<sub>2</sub>CO<sub>3</sub>·H<sub>2</sub>O·1.5 H<sub>2</sub>O<sub>2</sub>

C = Na<sub>2</sub>CO<sub>3</sub>·H<sub>2</sub>O·2H<sub>2</sub>O<sub>2</sub>

D = Na<sub>2</sub>CO<sub>3</sub>·2H<sub>2</sub>O<sub>2</sub>

Results at 0°			Results at 10°			Results at 20°		
sat. sol. wt. %		Solid Phase	sat. sol. wt. %		Solid Phase	sat. sol. wt. %		Solid Phase
Na <sub>2</sub> CO <sub>3</sub>	H <sub>2</sub> O <sub>2</sub>		Na <sub>2</sub> CO <sub>3</sub>	H <sub>2</sub> O <sub>2</sub>		Na <sub>2</sub> CO <sub>3</sub>	H <sub>2</sub> O <sub>2</sub>	
6.40	0.0	A	11.1	0.0	A	18.00	0.0	A
14.62	1.32	A + B	13.40	0.45	A + B	19.36	0.64	A
8.12	4.15	B	16.66	1.19	A + B	25.90	1.02	A + B
5.47	13.02	B	16.34	1.37	B	11.93	2.31	B
7.08	21.13	B	9.91	1.86	B	5.14	9.30	B
9.31	21.67	B	10.02	2.82	B	6.20	15.11	B
7.74	24.72	B	6.82	5.94	B	6.04	23.83	B
8.25	28.97	B	6.05	7.50	B	7.43	29.94	B + C
6.94	37.27	B	5.84	9.35	B	7.80	39.27	C
11.34	43.28	B + C	5.09	17.07	B	8.07	43.06	C
7.39	48.70	C	5.48	19.60	B	7.76	58.00	C
7.28	57.18	C	5.53	22.66	B			
6.70	64.32	C + D	5.30	23.61	B			
8.67	64.50	D	6.43	26.14	B + C			
11.92	65.70	D	6.82	43.29	C			
9.75	71.88	D	6.92	43.45	C			
10.12	73.85	D	7.50	44.50	C			
			7.60	52.17	C			
			8.50	54.66	C			
			8.91	63.18	C + D			
			10.05	68.92	D			
			11.20	69.50	D			
			9.92	70.72	D			
			9.38	73.92	D			

## THE SYSTEM SODIUM CARBONATE - SODIUM HYDROXIDE - WATER

(Freeth, 1922.) The results of Hostalek, 1956, are in good agreement and are listed in the table following. Itkina, 1949, at 50°; Green and Frattali at 100°; Schroeder, Berk and Gabriel, 1936, above 100°. Additional data at 30° are given by Pischinger and Szaufarski, 1958, from 50°-140° by Prikhodko, 1932.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
Na <sub>2</sub> CO <sub>3</sub>	NaOH	Solid Phase	Na <sub>2</sub> CO <sub>3</sub>	NaOH	Solid Phase
at 0°			at 25°		
6.4	0.0	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O	22.7	0.0	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O CO
2.6	8.1	"	18.2	5.4	"
2.2	18.4	"	18.1	7.0	"
2.7	20.9	"	18.0	9.3	" + Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O
3.1	22.3	" + Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O	21.0	5.8**	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O
3.1	23.0	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O	17.6	9.7	"
		+ Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O	16.7	10.7	"
1.2	28.9	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O	15.4	12.7	" + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
0.0	29.6	NaOH·4H <sub>2</sub> O	1.2	30.6	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
			0.5	37.5	"
			0.5	42.4	" + Na <sub>2</sub> CO <sub>3</sub>
			4.5	47.1*	Na <sub>2</sub> CO <sub>3</sub>
			0.0	53.3	NaOH·H <sub>2</sub> O
at 15°			at 30°		
14.1	0.0	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O			
10.1	4.8	"			
7.5	13.8	"			
8.9	17.0	" + Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O			
7.7	19.3	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O	28.4	0.0	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O
7.9	19.4	" + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O	26.5	3.1	"
6.3	20.8	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O	26.7	3.5	" + Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O
4.1	23.9	"	25.7	4.0	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O
1.2	30.6	"	24.3	5.5	"
0.2	44.9	"	21.9	7.9	" + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
0.6	47.3	" + Na <sub>2</sub> CO <sub>3</sub>	19.0	9.8	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
0.7	49.8	Na <sub>2</sub> CO <sub>3</sub>	13.7	13.8	"
0.0	51.2	NaOH·H <sub>2</sub> O	0.9	31.2	"
0.0	37.5	NaOH·3½H <sub>2</sub> O	15.1	35.0*	" + Na <sub>2</sub> CO <sub>3</sub>
0.0	41.5	"	0.5	41.6	"
			2.5	44.5*	Na <sub>2</sub> CO <sub>3</sub>
			6.1	49.1*	"
			0.0	54.3	NaOH·H <sub>2</sub> O
at 20°			at 35°		
18.0	0.0	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O			
12.9	6.3	"			
11.6	12.7	"			
12.4	13.4	" + Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O	32.9	0.0	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O
11.7	14.7	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O	32.0	0.6	" + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
11.1	16.2	" + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O	25.3	4.9	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
5.2	22.0	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O	15.2	11.9	"
1.1	29.7	"	7.5	18.7	"
0.3	39.8	"	1.9	27.5	"
0.3	41.5	" + Na <sub>2</sub> CO <sub>3</sub>	0.5	34.2	"
5.4	43.9*	Na <sub>2</sub> CO <sub>3</sub>	0.5	39.2	" + Na <sub>2</sub> CO <sub>3</sub>
9.6	43.8*	"	0.2	39.5	Na <sub>2</sub> CO <sub>3</sub>
0.0	52.1	NaOH·H <sub>2</sub> O	0.2	44.8	"
			0.2	50.22	"
			0.0	55.4	NaOH·H <sub>2</sub> O

\*This solution was not clear.

\*\*Supersaturated solution.

(Cont.)

# Na SODIUM

## THE SYSTEM SODIUM CARBONATE - SODIUM HYDROXIDE - WATER--Cont.

Gms. per 100 gms. sat. sol.		Solid Phase
Na <sub>2</sub> CO <sub>3</sub>	NaOH	
<u>at 45°</u>		
32.2	0.0	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
14.5	12.1	"
1.4	28.1	"
0.5	37.8	"
0.5	38.3	" + Na <sub>2</sub> CO <sub>3</sub>
0.5	47.0	Na <sub>2</sub> CO <sub>3</sub>
0.2	52.4	"
0.0	57.8	NaOH·H <sub>2</sub> O
<u>at 50°</u>		
11.39	8.84	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
7.37	18.95	"
0.65	34.65	Na <sub>2</sub> CO <sub>3</sub>
<u>at 60°</u>		
31.8	0.0	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
22.5	6.1	"
14.2	12.2	"
6.9	19.4	"
1.1	32.6	"
0.8	34.4	" + Na <sub>2</sub> CO <sub>3</sub>
0.7	35.4	Na <sub>2</sub> CO <sub>3</sub>
0.3	42.3	"
0.3	52.2	"
0.0	63.5	NaOH·H <sub>2</sub> O
<u>at 100°</u>		
30.8	0.0	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
28.9	1.1	"

Gms. per 100 gms. sat. sol.		Solid Phase
Na <sub>2</sub> CO <sub>3</sub>	NaOH	
<u>at 100°--Cont.</u>		
27.5	2.0	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
23.8	4.6	"
20.2	7.6	"
16.6	10.5	"
12.8	13.8	"
9.4	17.1	"
7.6	19.0	"
5.5	21.9	"
4.8	24.2	"
3.6	27.0	"
2.7	29.7	"
<u>at 150°</u>		
37.5	0.0	
26.2	7.2	
13.4	19.5	
<u>at 250°</u>		
20.0	0.0	
14.2	8.1	
11.5	21.4	
10.0	40.0	
<u>at 350°</u>		
2.0	0.0	
4.9	8.1	
12.7	20.2	

### Results of Hostalek, 1956

These results are in general agreement with those of Freeth and others, above.

A = Na<sub>2</sub>CO<sub>3</sub>·10H<sub>2</sub>O

B = Na<sub>2</sub>CO<sub>3</sub>·7H<sub>2</sub>O

C = Na<sub>2</sub>CO<sub>3</sub>·H<sub>2</sub>O

D = Na<sub>2</sub>CO<sub>3</sub>

E = NaOH·H<sub>2</sub>O

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
Na <sub>2</sub> CO <sub>3</sub>	NaOH		Na <sub>2</sub> CO <sub>3</sub>	NaOH	
5 °C					
6.06	3.51	A	4.60	21.03	A + B
3.11	11.60	A	4.39	22.21	B + C
3.24	12.08	A	2.05	27.02	C
3.07	16.21	A	0.32	36.16	C
4.09	20.28	A	0.58	43.62	C + D

## THE SYSTEM SODIUM CARBONATE - SODIUM HYDROXIDE - WATER--Cont.

A =  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ B =  $\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$ C =  $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ D =  $\text{Na}_2\text{CO}_3$ E =  $\text{NaOH} \cdot \text{H}_2\text{O}$ 

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
$\text{Na}_2\text{CO}_3$	NaOH		$\text{Na}_2\text{CO}_3$	NaOH	
<u>10°C</u>			<u>40°C</u>		
9.18	2.10	A	24.63	5.23	C
5.51	9.02	A	10.08	16.20	C
6.19	19.54	A + B	9.14	17.38	C
5.94	21.97	B + C	3.31	24.86	C
3.74	24.45	C	0.53	36.17	C
0.62	32.78	C	0.56	38.41	C + D
0.25	40.07	C	0.38	41.73	D
0.56	46.58	C + D			
<u>15°C</u>			<u>45°C</u>		
8.18	19.00	B + C			
0.52	36.12	C	5.29	21.41	C
0.51	47.22	C + D	0.52	36.60	C + D
			0.43	38.38	D
<u>20°C</u>			<u>50°C</u>		
11.48	10.04	A			
11.59	11.01	A			
2.89	25.80	C	26.01	4.21	C
0.38	43.39	C	11.92	14.20	C
0.38	45.31	C + D	6.49	20.19	C
0.49	49.11	D	1.31	29.18	C
0.73	51.64	D + E	1.02	34.41	C + D
			0.24	52.73	D
<u>25°C</u>			<u>60°C</u>		
20.54	2.09	A			
17.50	7.42	A			
9.81	17.52	C			
0.50	43.69	C + D	28.02	1.96	C
0.58	47.31	D	20.99	7.22	C
			10.61	15.80	C
			1.62	31.40	C + D
			1.19	33.18	D
			0.28	60.10	D
<u>30°C</u>			<u>70°C</u>		
27.03	1.75	A			
23.22	6.63	C			
3.01	25.65	C			
0.60	41.86	C + D			
0.46	49.98	D			
<u>35°C</u>			25.20	3.90	C
			19.88	7.94	C
			10.14	16.20	C
28.20	3.02	C	7.98	18.71	C
20.71	7.19	C	3.82	25.87	C
0.42	39.91	C + D	2.71	27.40	C + D
0.26	48.16	D	0.30	60.07	D

CO

(Cont.)

# Na SODIUM

## THE SYSTEM SODIUM CARBONATE - SODIUM HYDROXIDE - WATER--Cont.

A =  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$   
D =  $\text{Na}_2\text{CO}_3$

B =  $\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$   
E =  $\text{NaOH} \cdot \text{H}_2\text{O}$

C =  $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$

CO

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
Na <sub>2</sub> CO <sub>3</sub>	NaOH		Na <sub>2</sub> CO <sub>3</sub>	NaOH	
80°C			100°C		
25.01	3.98	C	16.27	10.96	C
22.00	6.04	C	10.41	16.20	D
9.41	17.59	C	4.02	26.04	D
9.12	17.65	C	0.39	60.19	D
5.11	23.14	C + D	110°C		
4.00	25.28	D			
0.71	42.51	D	14.59	12.24	D
0.38	60.12	D	7.01	20.55	D
			4.44	24.94	D
			0.60	61.28	D
90°C			120°C		
21.20	6.34	C			
8.28	18.54	C + D	1.69	35.16	D
5.18	23.01	D	0.59	62.90	D

## THE SYSTEM $\text{Na}_2\text{CO}_3$ - NaCl - NaOH - $\text{H}_2\text{O}$ (Freeth, 1922)

Na10 =  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ ; Na7 =  $\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$ ; Na1 =  $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ ; NaH =  $\text{NaHCO}_3$ ; 1.1.2 =  $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$  (sodium seaquil carbonate).

Gms. per 100 gms. sat. sol.

$\text{Na}_2\text{CO}_3$	NaOH	NaCl	Solid Phase
<u>Results at 0°</u>			
2.4	8.4	17.3	Na10 + NaCl
2.4	14.3	12.7	" "
2.8	16.0	11.2	" " + Na7
2.9	20.5	4.2	" + Na7
2.9	19.9	8.5	Na1 + " + NaCl
3.4	22.1	4.2	" "
2.2	25.1	6.9	" + NaCl
1.9	23.0	6.5	" "
1.2	25.8	5.6	" "
0.6	29.2	4.3	" "
<u>Results at 15°</u>			
9.2	1.5	19.4	Na10 + NaCl
8.4	5.8	16.2	" "
8.7	7.2	14.9	" " + Na7
7.9	10.4	10.5	" + Na7
8.7	15.6	2.4	" "
7.5	10.6	12.7	NaCl + "

(Cont.)

THE SYSTEM  $\text{Na}_2\text{CO}_3$  -  $\text{NaCl}$  -  $\text{NaOH}$  -  $\text{H}_2\text{O}$ —Cont.

$\text{Na10} = \text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ ;  $\text{Na7} = \text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$ ;  $\text{Na1} = \text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ ;  $\text{NaH} = \text{NaHCO}_3$ ;  $1 \cdot 1 \cdot 2 = \text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$  (sodium sesqui carbonate).

Gms. per 100 gms. sat. sol.

Solid Phase

$\text{Na}_2\text{CO}_3$	$\text{NaOH}$	$\text{NaCl}$
--------------------------	---------------	---------------

Results at 15°—Cont.

7.2	12.5	11.7	$\text{NaCl} + \text{Na7} + \text{Na1}$
8.2	13.6	9.6	$\text{Na7} + \text{Na1}$
7.9	17.7	3.1	" "
1.9	23.1	7.4	$\text{NaCl} + "$
0.2	46.2	0.9	" "

CO

Results at 20°

12.8	1.7	16.9	$\text{Na10} + \text{Na7} + \text{NaC}$
11.6	9.5	6.9	" "
12.0	3.6	15.9	$\text{NaCl} + "$
9.6	8.5	13.4	" "
9.6	9.7	12.4	" " + $\text{Na1}$
10.1	12.4	7.5	$\text{Na1} + "$
10.6	15.5	1.9	" "
7.0	12.3	11.9	" + $\text{NaCl}$
1.2	25.1	6.6	" "
1.7	46.7	0.9	" "

Results at 25°

18.1	1.7	8.6	$\text{Na10} + \text{Na7}$
18.3	6.3	3.3	" "
15.9	1.7	15.0	$\text{NaCl} + "$
14.9	8.6	6.4	$\text{Na1} + "$
15.2	11.0	3.2	" + "
13.5	4.4	14.1	" + " + $\text{NaCl}$
9.1	8.9	13.5	" + $\text{NaCl}$
3.1	18.5	9.9	" "
0.3	41.5	1.5	" "
0.3	44.0	1.3	" "
0.5	45.7	1.1	" " + $\text{Na}_2\text{CO}_3$
0.2	49.9	1.0	$\text{NaCl} + \text{Na}_2\text{CO}_3$

Results at 30°

26.7	2.2	1.2	$\text{Na10} + \text{Na7}$
23.1	1.5	7.6	$\text{Na1} + "$
22.4	5.2	2.9	" "
6.0	12.4	12.5	" + $\text{NaCl}$
0.2	34.6	3.0	" + "
0.2	41.8	1.5	" + " + $\text{Na}_2\text{CO}_3$
0.2	51.3	1.0	$\text{Na}_2\text{CO}_3 + \text{NaCl}$

(Cont.)



# Na SODIUM

## THE SYSTEM $\text{Na}_2\text{CO}_3$ - $\text{NaCl}$ - $\text{NaOH}$ - $\text{H}_2\text{O}$ —Cont.

$\text{Na10} = \text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ ;  $\text{Na7} = \text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$ ;  $\text{Na1} = \text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ ;  $\text{NaH} = \text{NaHCO}_3$ ;  $1 \cdot 1 \cdot 2 = \text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$  (sodium sesqui carbonate).

Gms. per 100 gms. sat. sol.

$\text{Na}_2\text{CO}_3$        $\text{NaOH}$        $\text{NaCl}$       Solid Phase

### Results at 35°

	11.0	5.4	15.3	Na1 + NaCl
	4.6	14.7	11.8	" "
	1.4	24.9	7.0	" "
	0.3	40.8	1.8	" " + $\text{Na}_2\text{CO}_3$
CO	1.0	49.0	1.2	$\text{Na}_2\text{CO}_3$ + NaCl

### Results at 45°

	9.2	6.1	16.7	Na1 + NaCl
	2.9	18.1	10.8	" "
	0.4	33.4	3.8	" "
	0.3	37.2	2.7	" " + $\text{Na}_2\text{CO}_3$
	0.3	38.8	2.4	$\text{Na}_2\text{CO}_3$ + NaCl
	0.2	40.4	2.1	" "
	0.5	54.1	1.3	" "

### Results at 60°

	5.8	9.4	15.8	Na1 + NaCl
	2.6	18.1	11.3	" "
	1.7	22.3	8.4	" "
	0.5	33.2	4.3	" " + $\text{Na}_2\text{CO}_3$
	0.2	52.6	1.7	$\text{Na}_2\text{CO}_3$ + NaCl

### Invariant Point Temperatures

t°

21.0	Na10 + NaCl + Na7
26.2	Na7 + NaCl + Na1
19.7	Na10 + NaH + 1·1·2
31.0	Na10 + Na7 + 1·1·2
34.5	Na7 + Na1 + 1·1·2

Results for the system  $\text{Na}_2\text{CO}_3$  -  $\text{NaCl}$  -  $\text{Na}_2\text{SO}_4$  -  $\text{NaOH}$  -  $\text{H}_2\text{O}$  at 50° are given by Itkina, 1949, at 100° by Itkina, 1953.

THE SYSTEM SODIUM CARBONATE - SODIUM SULFATE - SODIUM  
HYDROXIDE - WATER AT 100°  
(Green and Frattali, 1946)

Gms. per 100 gms. Sat. Sol.      Gms. per 100 gms. Sat. Sol.

$\text{Na}_2\text{CO}_3$      $\text{Na}_2\text{SO}_4$      $\text{NaOH}$        $\text{Na}_2\text{CO}_3$      $\text{Na}_2\text{SO}_4$      $\text{NaOH}$

- Solid Phases  $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$  + Solid Solution -

28.5	3.2	0.0	17.9	1.9	8.6
28.0	3.1	0.9	17.4	2.0	8.7
26.4	2.9	2.5	14.0	1.7	12.0
25.4	2.8	2.6	10.8	1.2	15.4
23.3	2.6	4.2	8.0	0.8	18.9
23.8	2.5	3.8	5.0	0.6	23.2
21.5	2.3	5.4	3.2	0.5	26.9

CO

- Solid Phases  $\text{Na}_2\text{SO}_4$  + Solid Solution -

4.0	26.6	0.0	2.2	17.3	7.0
3.4	24.5	1.5	2.5	11.7	11.8
3.0	21.8	3.4	2.1	7.5	16.3
2.9	21.9	3.3	2.3	4.7	21.4
2.4	19.6	5.1	1.3	2.0	30.4

Data for the system  $\text{NaCl} - \text{Na}_2\text{CO}_3 - \text{Na}_2\text{SO}_4 - \text{NaOH} - \text{H}_2\text{O}$  at 25°, 50°, and 100° were determined by Makarov and Itkina, 1944, for solutions containing 48% NaOH.

SOLUBILITY OF SODIUM CARBONATE IN AMMONIA SOLUTIONS  
(Akhounov and Jeserova, 1936) (Akhounov, 1939)

The Solid Phase is  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$  throughout. Also see p. 924.

Wt. %  $\text{NH}_3$  in Solvent      Gms. per 100 gms. Sat. Sol.      Wt. %  $\text{NH}_3$  in Solvent      Gms. per 100 gms. Sat. Sol.

$\text{Na}_2\text{CO}_3$      $\text{NH}_3$        $\text{Na}_2\text{CO}_3$      $\text{NH}_3$

Results at 0°

17.97	0.93	17.80
6.81	3.09	6.60
4.44	3.75	4.27
2.64	5.32	2.50
0.0	6.63	0.0

Results at 10°

12.67	2.90	12.3
8.53	5.02	8.1
4.44	7.00	4.13
3.99	7.22	3.70
0.95	10.52	0.85
0.0	11.20	0.0

Results at 20°

23.10	2.57	22.5
16.41	4.61	15.65
12.31	6.64	11.50
9.08	9.74	8.20
5.70	12.49	5.00
4.44	14.50	3.80
3.46	14.63	3.30
0.0	17.60	0.0

# Na SODIUM

## SOLUBILITY OF SODIUM CARBONATE IN AMMONIA SOLUTIONS--Cont.

(Results of Guyer, Bieler, and Orelli, 1940)

The data were read from curves drawn by the authors. The results are in gms.  $\text{Na}_2\text{CO}_3$  per 100 gms. solvent. They agree roughly with those of Achoumov (above).

t°	% $\text{NH}_3$ in Solvent							
	5	10	15	20	30	40	60	80
-30	-	-	1.1	0.9	0.5	0.5	0.5	0.5
-10	-	-	1.7	1.3	0.6	0.3	0.3	0.3
0	4.8	3.7	3.0	2.3	1.5	1.0	0.6	0.6
20	-	-	6.4	4.3	1.5	0.3	0.2	0.2

### Low Temperature Results

(Achoumov and Jeserova, 1936)

t°	Gms. per 100 gms. Sat. Sol.		Solid Phase
	$\text{Na}_2\text{CO}_3$	$\text{NH}_3$	
- 2.10	5.93	0.0	Ice + $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$
- 4.3	5.44	0.70	"
- 7.2	3.21	2.70	"
- 8.0	1.75	4.36	"
- 15.3	1.06	6.55	"
-	0.2	34.0	"
-100.3	0.0	34.34	Ice + $\text{NH}_3 \cdot \text{H}_2\text{O}$

## THE SYSTEM SODIUM CARBONATE - SODIUM BROMIDE - WATER AT 30° (Cocharet, 1911)

Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
$\text{Na}_2\text{CO}_3$	NaBr		$\text{Na}_2\text{CO}_3$	NaBr	
27.98	0.0	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	18.11	19.32	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
27.54	2.41	"	8.45	33.39	"
26.72	4.06	"	6.90	36.13	"
26.23	6.26	" + $\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$	3.04	44.75	"
23.40	11.00	$\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$	2.99	45.31	" + $\text{NaBr} \cdot 2\text{H}_2\text{O}$
22.68	12.22	"	2.60	45.68	$\text{NaBr} \cdot 2\text{H}_2\text{O}$
19.86	16.88	"	0.0	49.40	"
19.57	16.95	" + $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$			

## THE SYSTEM SODIUM CARBONATE - SODIUM BICARBONATE - WATER

In addition to the results listed below, determinations were made by McCoy and Test (1911) at 25°, de Paepe (1911) at 25°, Makarow and Jakimow (1933) at 25°, Wegschneider and Mahl (1928) at eleven temperatures between 20° and 94.5°.

Results of Freeth, 1922

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
Na <sub>2</sub> CO <sub>3</sub>	NaHCO <sub>3</sub>	Solid Phase	Na <sub>2</sub> CO <sub>3</sub>	NaHCO <sub>3</sub>	Solid Phase
<u>Results at 0°</u>			<u>Results at 30°--Cont.</u>		
6.4	0.0	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O	27.1	1.3	Na <sub>2</sub> CO <sub>3</sub> +1.1.2
5.9	1.4	"	26.5	1.1	1.1.2
5.6	4.6	" + NaHCO <sub>3</sub>	26.1	1.2	"
4.0	5.1	NaHCO <sub>3</sub>	18.3	3.8	"
0.0	6.5	"	17.6	4.3	" + NaHCO <sub>3</sub>
			17.5	4.6	NaHCO <sub>3</sub>
			9.7	6.3	"
			0.8	9.1	"
			0.0	9.9	"
<u>Results at 15°</u>			<u>Results at 35°</u>		
14.1	0.0	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O	32.9	0.0	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O
13.8	1.8	"	32.8	0.3	"
13.0	4.3	" + NaHCO <sub>3</sub>	32.5	0.6	" + 1.1.2
6.0	6.0	NaHCO <sub>3</sub>	28.7	0.9	1.1.2
0.0	8.1	"	23.7	2.0	"
			17.3	4.7	" + NaHCO <sub>3</sub>
			9.7	6.7	NaHCO <sub>3</sub>
			0.0	10.6	"
<u>Results at 20°</u>			<u>Results at 45°</u>		
18.0	0.0	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O	32.2	0.0	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
17.3	2.9	"	31.7	0.9	" + 1.1.2
17.0	4.0	" + NaHCO <sub>3</sub>	27.3	1.3	1.1.2
6.3	6.5	NaHCO <sub>3</sub>	21.4	3.0	"
3.5	7.2	"	16.9	5.9	" + NaHCO <sub>3</sub>
0.0	8.7	"	8.7	8.0	NaHCO <sub>3</sub>
			0.8	11.3	"
			0.0	12.0	"
<u>Results at 25°</u>			<u>Results at 60°</u>		
22.7	0.0	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O	31.8	0.0	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
22.6	1.5	" + 1.1.2	30.7	1.3	" + 1.1.2
20.8	2.5	1.1.2	25.8	2.4	1.1.2
17.9	4.0	" + NaHCO <sub>3</sub>	16.9	7.4	" + NaHCO <sub>3</sub>
16.7	3.3	NaHCO <sub>3</sub>	8.5	10.1	NaHCO <sub>3</sub>
10.0	3.9	"	1.4	12.9	"
6.1	4.9	"			
0.0	9.3	"			
<u>Results at 30°</u>					
28.45	0.0	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O			
27.5	0.8	"			

(Cont.)

(Cont.)

CO

## THE SYSTEM SODIUM CARBONATE - SODIUM BICARBONATE - WATER--Cont.

Results of Hill and Bacon, 1927

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{Na}_2\text{CO}_3$	$\text{NaHCO}_3$			$\text{Na}_2\text{CO}_3$	$\text{NaHCO}_3$	
<u>Results at 24.87°</u>							
-	22.45	0.0	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	1.296	28.24	0.0	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$
1.238	22.20	0.86	"	1.307	28.09	0.76	" + 1.1.2
1.243	22.26	1.09	"	1.301	27.52	0.82	1.1.2
1.247	22.15	1.59	"	1.269	24.30	1.47	"
-	22.10	2.09	" + 1.1.2	1.256	23.39	1.79	"
1.240	20.90	2.49	1.1.2	1.239	21.00	2.65	"
1.228	19.31	3.18	"	1.226	18.54	3.91	"
1.225	18.60	3.57	"	1.216	17.52	4.45	" + $\text{NaHCO}_3$
1.216	17.85	4.00	" + $\text{NaHCO}_3$	1.160	11.84	5.60	$\text{NaHCO}_3$
1.179	13.61	4.90	$\text{NaHCO}_3$	1.112	6.06	7.30	"
1.152	10.88	5.50	"	1.068	0.25	9.71	"
1.125	8.11	6.13	"	-	0.0	9.8	"
1.076	8.21	2.10	"	<u>Results at 50°</u>			
1.06	9.11	0.2	"	1.331	32.16	0.0	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
-	9.3	0.0	"	1.337	31.92	0.48	" + 1.1.2
				1.260	23.79	2.40	1.1.2
				1.214	16.97	6.28	" + $\text{NaHCO}_3$
				1.196	14.90	6.80	$\text{NaHCO}_3$
				1.152	10.04	8.27	"
				1.112	4.78	9.93	"
				1.079	1.08	11.68	"
				-	0.0	12.40	"

Invariant Points:

(- 3.32°)	1.078	4.41	4.64	C + H + ICE
(+21.26°)	1.220	18.15	3.74	C + H + 1.1.2
( 31.98°)	1.334	31.32	0.16	C + 7 + 1.1.2
( 35.17°)	1.350	33.08	0.19	7 + 1.1.2 + A

1.1.2 =  $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$  (TRONA)C =  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ 7 =  $\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$ H =  $\text{NaHCO}_3$ A =  $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$

## THE SYSTEM SODIUM CARBONATE - SODIUM BICARBONATE - WATER--Cont.

Results of Waldeck, Lynn and Hill, 1934 at High Temperatures

The chromium nickel steel bomb which was used differed from that employed for the solubility of sodium carbonate in water up to 348° in that the sampling receptacle was set in from the top instead of on the side.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
Na <sub>2</sub> CO <sub>3</sub>	NaHCO <sub>3</sub>	Solid Phase	Na <sub>2</sub> CO <sub>3</sub>	NaHCO <sub>3</sub>	Solid Phase
<u>Results at 100°</u>			<u>Results at 170°</u>		
30.7	0.0	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O	26.0	0.0	Na <sub>2</sub> CO <sub>3</sub>
29.9	2.3	"	18.9	18.3	" + 1.1.2
29.1	4.2	" + 1.1.2	18.4	19.7	1.1.2
26.7	5.9	1.1.2	13.5	24.3	" + 1.3
25.3	7.1	"	9.7	28.4	1.3
23.6	8.2	"	7.5	31.2	" + NaHCO <sub>3</sub>
21.1	9.7	" + 1.3	3.6	31.7	NaHCO <sub>3</sub>
19.3	10.7	1.3	<u>Results at 190°</u>		
16.5	11.9	"	19.7	11.6	Na <sub>2</sub> CO <sub>3</sub>
13.4	14.4	"	17.2	20.7	"
12.7	14.4	" + NaHCO <sub>3</sub>	16.7	25.5	" + 1.1.2
15.3	13.8	NaHCO <sub>3</sub>	13.7	28.9	1.1.2
8.7	16.0	"	10.2	33.0	" + 1.3
1.2	18.5	"	7.0	35.0	1.3 + NaHCO <sub>3</sub>
<u>Results at 150°</u>			1.7	36.8	NaHCO <sub>3</sub>
27.5	0.0	Na <sub>2</sub> CO <sub>3</sub>	<u>Results at 200°</u>		
24.4	7.4	"	19.9	7.5	Na <sub>2</sub> CO <sub>3</sub>
20.9	15.9	"	16.9	20.3	"
23.1	10.2	" + 1.1.2	15.4	30.5	" + 1.3
22.4	11.9	1.1.2	13.0	32.4	1.3
20.7	15.4	" + 1.3	9.0	36.4	" + NaHCO <sub>3</sub>
13.8	20.0	1.3	6.1	38.6	NaHCO <sub>3</sub>
8.4	25.6	" + Na CO			
2.5	26.8	NaHCO <sub>3</sub>			

1.1.2 = Na<sub>2</sub>CO<sub>3</sub>·NaHCO<sub>3</sub>·2H<sub>2</sub>O; 1.3 = Na<sub>2</sub>CO<sub>3</sub>·3NaHCO<sub>3</sub>.

Results are also given for five additional invariant points.

THE SYSTEM Na<sub>2</sub>CO<sub>3</sub> - NaHCO<sub>3</sub> - NaCl - H<sub>2</sub>O  
(Freeth, 1922)

Additional experiments upon this system made at 30°, 49.7° and at 89.5° are reported by Wegscheider and Mehl, 1928. These authors employed solutions in which the ratio of NaCl to H<sub>2</sub>O was kept constant throughout. They make no reference to the previous results of Freeth,

# Na SODIUM

## THE SYSTEM $\text{Na}_2\text{CO}_3$ - $\text{NaHCO}_3$ - $\text{NaCl}$ - $\text{H}_2\text{O}$ —Cont.

$\text{Na10} = \text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ ;  $\text{Na7} = \text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$ ;  $\text{Na1} = \text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ ;  $\text{NaH} = \text{NaHCO}_3$ ;  
 $1.1.2 = \text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$  (sodium sesquicarbonate).

Gms. per 100 gms. sat. sol.

$\text{Na}_2\text{CO}_3$	$\text{NaHCO}_3$	$\text{NaCl}$
--------------------------	------------------	---------------

Solid Phase

Results at 0°

3.78	3.51	4.81	Na10 + NaH
2.89	2.83	9.53	"
2.39	2.14	15.14	"
2.63	0.92	21.32	"
2.77	1.11	22.84	" + 1.1.2
2.99	0.73	23.86	Na10 + NaCl + 1.1.2
2.72	0.96	23.88	NaH + NaCl + "
2.77	0.92	23.86	" "
1.30	0.73	25.05	" "

Results at 15°

11.42	4.05	3.06	Na10 + NaH
9.62	2.33	7.71	"
9.74	1.41	11.19	" + 1.1.2
9.33	2.06	11.58	" "
4.80	1.91	18.52	NaH + 1.1.2
8.48	1.38	15.24	Na10 + "
9.11	0.19	20.49	Na10 + 1.1.2 + NaCl
6.41	0.08	22.18	" "
4.70	0.31	23.22	" "
3.25	0.61	23.93	NaH + 1.1.2 + NaCl

Results at 20°

16.17	3.40	2.22	Na10 + NaH + 1.1.2
13.40	2.60	7.90	Na10 + 1.1.2
12.58	1.07	13.97	"
13.40	0.61	17.54	Na10 + 1.1.2 + NaCl
8.48	0.69	20.50	1.1.2 + NaCl
5.35	0.84	22.38	"
14.60	3.51	3.87	1.1.2 + NaH
12.70	3.09	6.03	"
11.52	2.86	7.64	"
6.99	2.83	13.43	"
2.60	1.53	23.74	1.1.2 + NaH + NaCl

Results at 25°

19.84	1.34	5.01	Na10 + 1.1.2
18.99	0.76	11.09	"
18.99	0.80	11.38	Na10 + 1.1.2 + Na7
18.36	0.53	12.84	1.1.2 + Na7
17.28	0.34	15.28	1.1.2 + Na7 + NaCl
13.28	0.61	17.72	1.1.2 + NaCl
7.28	0.53	21.35	"
11.35	2.90	7.57	1.1.2 + NaH
6.65	1.95	15.04	"
2.55	1.38	23.97	" + NaCl

(Cont.)

THE SYSTEM  $\text{Na}_2\text{CO}_3$  -  $\text{NaHCO}_3$  -  $\text{NaCl}$  -  $\text{H}_2\text{O}$ --Cont.

$\text{Na}10 = \text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ ;  $\text{Na}7 = \text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$ ;  $\text{Na}1 = \text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ ;  $\text{NaH} = \text{NaHCO}_3$ ;  
 $1 \cdot 1 \cdot 2 = \text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$  (sodium sesquicarbonate).

Gms. per 100 gms. sat. sol.

$\text{Na}_2\text{CO}_3$	$\text{NaHCO}_3$	$\text{NaCl}$	Solid Phase
<u>Results at 30°</u>			
26.61	0.99	3.65	1·1·2 + Na10 + Na7
22.63	0.61	9.88	" + Na1 + "
17.79	0.53	14.88	" + " + NaCl
13.20	0.99	17.69	" + NaCl
7.33	0.96	21.30	" "
11.21	3.32	7.70	" + NaH
6.70	2.25	14.96	" "
25.3	1.68	24.01	" " + NaCl

CO

Results at 35° (See also below)

21.96	0.12	8.30	1·1·2 + Na1
18.46	0.11	12.08	" "
30.27	0.57	1.97	" " + Na7
17.04	0.61	15.52	" " + NaCl
13.23	0.57	17.85	" + NaCl
7.42	0.61	21.41	" "
11.57	3.59	7.61	" + NaH
6.72	2.56	14.85	" "
5.52	2.10	16.97	" "
3.25	0.76	23.75	" " + NaCl
3.01	1.34	23.92	" " "

Results at 45°

23.35	1.03	7.84	1·1·2 + Na1
18.97	0.50	12.62	" "
14.34	0.61	17.40	" " + NaCl
9.25	0.15	20.62	" + NaCl
6.84	0.50	21.98	" "
6.29	0.76	22.35	" "
4.29	1.11	23.43	" "
12.44	5.08	5.38	" + $\text{NaHCO}_3$
10.75	3.29	8.91	" "
6.94	2.52	14.70	" "
3.04	1.99	23.91	" " + NaCl

Results at 60°

25.59	1.57	4.73	1·1·2 + Na1
18.87	0.80	11.94	" "
12.39	0.53	19.13	" " + NaCl
10.75	0.73	20.06	" + NaCl
14.00	6.11	3.73	" + $\text{NaHCO}_3$
8.99	4.16	11.34	" "
3.45	1.83	23.88	" " + NaCl
3.11	2.56	24.37	" " "



# Na SODIUM

## THE SYSTEM $\text{Na}_2\text{CO}_3$ - $\text{NaHCO}_3$ - $\text{NaCl}$ - $\text{H}_2\text{O}$ —Cont.

The following additional determinations of this system at  $35^\circ$  are given by Teeple, 1929.

Gms. per 100 gms. $\text{H}_2\text{O}$			Solid Phase
$\text{Na}_2\text{CO}_3$	$\text{NaHCO}_3$	$\text{NaCl}$	
24.8	-	24.0	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ + $\text{NaCl}$
-	2.0	35.2	$\text{NaHCO}_3$ + "
49.2	0.8	-	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ + 1:1:2 (trona)
21.8	6.2	-	$\text{NaHCO}_3$ + "
24.7	0.3	24.0	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ + " + $\text{NaCl}$
4.2	1.8	33.5	$\text{NaHCO}_3$ + " + "

CO

## THE SYSTEM $\text{Na}_2\text{CO}_3$ - $\text{NaHCO}_3$ - $\text{Na}_2\text{SO}_4$ - $\text{H}_2\text{O}$

H =  $\text{NaHCO}_3$

C =  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$

S =  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$

1:1:2 =  $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$

### Results at $20^\circ$

(Teeple, 1929)

### Results at $25^\circ$

(Makarow and Jakimow, 1933)

Gms. per 100 gms. $\text{H}_2\text{O}$			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
$\text{Na}_2\text{CO}_3$	$\text{NaHCO}_3$	$\text{Na}_2\text{SO}_4$		$\text{Na}_2\text{CO}_3$	$\text{NaHCO}_3$	$\text{Na}_2\text{SO}_4$	
-	5.4	17.1	H + S	-	-	-	-
6.9	-	15.8	S	16.5	3.86	5.88	H + 1:1:2
20.1	-	14.9	S + C	13.41	3.00	13.72	H + 1:1:2
20.3	-	12.5	C	19.48	1.84	8.50	C + 1:1:2
20.6	3.9	14.7	C + H + S	18.50	1.72	11.64	C + 1:1:2
20.8	4.8	8.1	C + H	14.70	1.58	16.50	S + 1:1:2
9.7	4.5	15.5	H + S	7.09	3.28	18.26	H + S
				11.08	2.54	17.05	H + S + 1:1:2
				17.62	1.36	16.21	C + S + 1:1:2

### Results at $100^\circ$

(Boryachek, Drozin, Zubakhina and Kutsyna, 1957)

Sat. Sol. Wt. %			Solid Phase
$\text{Na}_2\text{CO}_3$	$\text{Na}_2\text{SO}_4$	$\text{NaHCO}_3$	
29.28	-	4.39	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ + 1:1:2
26.73	2.62	5.34	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ + 1:1:2 + $\text{Na}_2\text{CO}_3 \cdot 2\text{Na}_2\text{SO}_4$
28.64	3.28	-	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ + $\text{Na}_2\text{CO}_3 \cdot 2\text{Na}_2\text{SO}_4$
20.37	5.02	7.55	$\text{Na}_2\text{CO}_3 \cdot 2\text{Na}_2\text{SO}_4$ + 1:1:2 + $3\text{NaHCO}_3 \cdot \text{Na}_2\text{CO}_3$
12.88	10.49	9.83	" + $\text{NaHCO}_3$ + $3\text{NaHCO}_3 \cdot \text{Na}_2\text{CO}_3$
8.55	14.63	10.32	" + $\text{NaHCO}_3$
5.44	19.19	8.92	" + $\text{NaHCO}_3$ + $\text{Na}_2\text{SO}_4$
4.01	26.20	-	" + $\text{Na}_2\text{SO}_4$
3.19	21.04	9.31	$\text{NaHCO}_3$ + $\text{Na}_2\text{SO}_4$
-	21.50	11.57	$\text{NaHCO}_3$ + $\text{Na}_2\text{SO}_4$
20.91	-	9.49	1:1:2 + $3\text{NaHCO}_3 \cdot \text{Na}_2\text{CO}_3$
14.49	-	13.30	$\text{NaHCO}_3$ + $3\text{NaHCO}_3 \cdot \text{Na}_2\text{CO}_3$

Data in this system at  $60^\circ$  are given by Makarov and Sedel'nikov, 1940.

## THE SYSTEM SODIUM CARBONATE - SODIUM CHLORIDE - WATER

(Freeth, 1922 from 0-60°; at about 100°, Makarov and Krasnikov, 1956;  
also: R. = Reich, 1911 M = Mondain-Monval, 1922 C = Cocheret, 1911)  
For additional data at -5°, 0°, +5° and 10° see Seshadri and Loba, 1957.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
Na <sub>2</sub> CO <sub>3</sub>	NaCl		Na <sub>2</sub> CO <sub>3</sub>	NaCl	
at 0°			at 30°		
6.6	0.0	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O	28.5	0.0	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O
4.3	4.5	"	27.0	3.7	"
3.7	8.2	"	26.9	3.9	" + Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O CO
3.1	12.3	"	(26.82)	(4.15)C	" + "
2.9	15.6	"	26.6	4.2	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O
2.8	20.4	"	24.6	7.2	"
2.8	24.2	" + NaCl	22.7	9.3	"
(3.16)	(25.5)M	" + "	22.5	10.2	" + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
0.0	26.3	NaCl	(22.75)	(10.24)C	" + "
at 15°			21.9	10.4	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
14.1	0.0	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O	20.5	11.1	"
9.9	9.9	"	21.2	12.9	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O + NaCl
8.7	14.7	"	17.7	15.0	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O + NaCl
(10.6)	(7.2)M	"	(18.0)	(14.12)C	" + "
(10.2)	(13.7)M	"	5.0	22.7	NaCl
9.2	20.2	" + NaCl	0.0	26.5	"
			at 35°		
(9.6)	(20.4)M	" + "	32.9	0.0	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O
(9.2)	(20.4)R	" + "	31.5	2.0	"
3.5	24.0	NaCl	31.0	2.5	" + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
(3.1)	(24.3)M	"	30.2	2.9	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
0.0	26.3	"	25.5	7.1	"
at 20°			16.8	16.1	" + NaCl
17.6	0.0	NaCO <sub>3</sub> ·10H <sub>2</sub> O	7.4	21.7	NaCl
15.5	4.0	"	4.0	24.0	"
			at 40°		
14.1	7.7	"	32.2	0.0	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
12.9	12.8	"	28.2	3.9	"
13.5	17.4	" + NaCl	24.4	7.3	"
6.9	22.0	NaCl	20.7	11.1	"
9.5	20.3	"	17.6	14.6	"
11.5	18.9	"	15.0	17.4	" + NaCl
0.0	26.4	"	10.3	20.2	NaCl
at 25°			3.6	24.2	"
22.7	0.0	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O	at 60°		
19.6	5.6	"	31.8	0.0	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
18.8	10.8	"	24.0	7.2	"
19.0	11.8	" + Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O	20.2	10.9	"
18.4	13.0	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O	16.6	14.5	"
17.3	15.5	" + NaCl	13.9	17.8	" + NaCl
7.9	21.3	NaCl			
0.0	26.4	"			

(Cont.)

# Na SODIUM

## THE SYSTEM SODIUM CARBONATE - SODIUM CHLORIDE - WATER--Cont.

at 105°-110°

	Gms. per 100 gms. sat. sol.		Solid Phase
	Na <sub>2</sub> CO <sub>3</sub>	NaCl	
(105°)	31.51	-	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
(105°)	29.03	2.00	"
(105°)	26.13	4.57	"
(106°)	19.40	10.77	" + ε Na <sub>2</sub> CO <sub>3</sub>
(107°)	17.83	12.50	ε Na <sub>2</sub> CO <sub>3</sub>
(107°)	17.93	12.60	"
(107°)	13.27	17.28	" + δ Na <sub>2</sub> CO <sub>3</sub>
(107°)	11.62	19.35	δ Na <sub>2</sub> CO <sub>3</sub>
(108°)	11.23	20.31	"
(109°)	8.85	23.37	"
(110°)	8.47	23.88	" + NaCl
(109°)	8.41	23.46	" + "
(109°)	-	28.62	NaCl

### Invariant Points

(Makarow, 1932)

t°	Gms. per 100 gms. sat. sol.		Solid Phase
	Na <sub>2</sub> CO <sub>3</sub>	NaCl	
-21.4	1.4	23.0	Ice + Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O + NaCl·2H <sub>2</sub> O
- 1.2	2.6	24.4	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O + NaCl·2H <sub>2</sub> O + NaCl
+21.0	15.1	16.7	" + Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O + "
22	15.8	16.7	+ " + "
"	16.3	14.7	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O + "
26.2	20.2	10.0	" + "
"	18.5	14.3	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O + " + NaCl
27.0	21.6	8.8	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O + "
"	19.2	13.6	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O + "
"	18.3	14.5	" + "

## THE SYSTEM Na<sub>2</sub>CO<sub>3</sub> - NaCl - Na<sub>2</sub>SO<sub>4</sub> - H<sub>2</sub>O

In addition to the results listed below, Makarov and Blidin, 1938 give data at 15°, 20°, 25° and 35°, in substantial agreement with those of Teeple.

THE SYSTEM  $\text{Na}_2\text{CO}_3 - \text{NaCl} - \text{Na}_2\text{SO}_4 - \text{H}_2\text{O}$ --Cont.Results at low temperatures

(Seshadri and Loba, 1957)

Sat. Sol. Wt. %				Solid Phase	Sat. Sol. Wt. %				Solid Phase
NaCl	Na <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> CO <sub>3</sub>	density		NaCl	Na <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> CO <sub>3</sub>	density	
<u>Results at -5°</u>					<u>Results at +5°</u>				
23.58	0.68	0.66	1.196	S+Cl <sub>2</sub>	3.57	3.29	6.29	1.121	S+C
21.75	1.10	2.12	1.200	S+C+Cl <sub>2</sub>	9.47	2.13	5.14	1.145	"
21.60	0.80	2.20	1.220	"	11.24	2.33	4.84	1.158	"
18.42	0.54	2.29	1.175	"	17.52	2.11	4.64	1.212	"
16.48	0.81	2.11	1.155	"	21.42	2.14	4.86	1.242	"
5.68	0.94	3.39	1.090	I+C+S	21.24	2.13	4.71	1.240	"
3.47	1.25	3.97	1.081	"	23.81	1.77	1.69	1.222	"
					21.69	2.07	4.69	1.242	S+C+Cl
<u>Results at 0°</u>					<u>Results at 10°</u>				
3.19	1.82	3.72	1.082	S+C					
5.25	1.67	3.25	1.091	"	6.07	4.62	7.76	1.167	S+C
12.90	1.02	2.83	1.142	"	11.98	3.90	6.87	1.210	"
14.24	0.96	2.85	1.150	"	14.28	3.48	6.45	1.216	"
16.03	1.22	3.26	1.170	"	14.52	3.35	6.17	1.216	"
17.89	1.31	3.39	1.190	"	18.68	3.94	6.78	1.265	"
22.20	0.80	2.63	1.210	"	19.41	3.56	6.33	1.265	S+C+Cl
23.50	0.77	2.47	1.223	S+C+Cl	19.58	3.44	6.41	1.265	"
24.85	1.10	1.45	1.215	S+Cl	20.47	3.75	6.60	1.260	C+Cl
					20.65	2.86	6.04	1.255	"
					21.94	3.75	3.04	1.238	S+Cl
					20.08	3.74	6.08	1.262	"

S =  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$   
 C =  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$

Cl = NaCl  
 l = ice

Cl2 =  $\text{NaCl} \cdot 2\text{H}_2\text{O}$ Results from 20° to 100°  
(Teeple, 1929)

Gms. per 100 gms. H <sub>2</sub> O				Solid Phase	Gms. per 100 gms. H <sub>2</sub> O				Solid Phase
Na <sub>2</sub> CO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	NaCl			Na <sub>2</sub> CO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	NaCl		
Results at 20°									
20.1	14.9	-	C·10 + S·10	-	12.1	26.2	S·10		
20.3	12.5	-	C·10	-	11.0	31.8	S + Cl		
6.9	15.8	-	S·10	13.5	-	28.9	Cl		
19.8	-	25.4	C·10 + Cl	18.8	13.8	11.5	C·10+S·10+B		
18.0	-	9.9	C·10	19.7	11.2	17.3	C·10 + B		
17.4	-	17.2	"	19.2	13.8	7.2	C·10 + S·10		
-	13.0	29.0	S·10 + S	21.1	6.2	23.2	" + Cl + B		
-	12.5	11.8	S·10	11.0	14.1	21.4	" + S + B		
-	11.7	20.4	"	8.3	10.5	28.5	Cl + " + B		

C-10 =  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ ; C-1 =  $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ ; S-10 =  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ ; S =  $\text{Na}_2\text{SO}_4$ ; Cl = NaCl; B = Burkeite,  $\text{Na}_2\text{CO}_3 \cdot 2\text{Na}_2\text{SO}_4$ .

(Cont.)

# Na SODIUM

## THE SYSTEM $\text{Na}_2\text{CO}_3 - \text{NaCl} - \text{Na}_2\text{SO}_4 - \text{H}_2\text{O}$ --Cont.

### Results from 20° to 100°--Cont. (Teepie, 1929)

Gms. per 100 gms. $\text{H}_2\text{O}$				Gms. per 100 gms. $\text{H}_2\text{O}$			
$\text{Na}_2\text{CO}_3$	$\text{Na}_2\text{SO}_4$	$\text{NaCl}$	Solid Phase	$\text{Na}_2\text{CO}_3$	$\text{Na}_2\text{SO}_4$	$\text{NaCl}$	Solid Phase
Results at 35°				Results at 75°			
-	9.2	33.6	S + Cl	-	6.8	35.5	S + Cl
24.8	-	23.9	C·1 + Cl	16.4	-	30.8	C·1 + Cl
45.8	6.9	-	C·1 + B	42.9	5.4	-	C·1 + B
18.5	34.3	-	S + B	7.9	39.0	-	S + B
CO 24.2	2.7	23.2	C·1 + Cl + B	16.6	1.4	30.3	C·1 + B + Cl
4.6	8.8	30.7	S + Cl + B	1.5	6.7	35.2	S + B + Cl
Results at 50°				Results at 100° (also see below)			
-	7.3	33.7	S + Cl	-	6.5	37.3	S + Cl
20.9	-	27.0	C·1 + Cl	-	-	33.5	Cl + C·1
44.4	6.3	-	C·1 + B	15.1	-	37.2	Cl + S + B
12.6	36.7	-	S + B	1.2	6.7	33.1	Cl + C·1 + B
20.2	2.0	26.4	C·1 + Cl + B	14.9	0.9		
2.9	7.7	32.9	S + Cl + B				

C·10 =  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ ; C·1 =  $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ ; S·10 =  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ ; S =  $\text{Na}_2\text{SO}_4$ ; Cl = NaCl; B = Burkeite,  $\text{Na}_2\text{CO}_3 \cdot 2\text{Na}_2\text{SO}_4$ .

### Results of Sedelnikov, 1944<sup>a</sup> at 100° differing from those of Teepie, above:

Gms. per 100 gms. Sat. Sol.			Density	Solid Phase
$\text{Na}_2\text{CO}_3$	$\text{NaCl}$	$\text{Na}_2\text{SO}_4$		
31.26	-	-	-	C·1
18.14	11.98	-	1.3221	"
9.93	22.35	-	1.3122	C·1 + Cl
-	28.15	-	-	Cl
-	25.96	4.51	1.2676	Cl + S
-	16.73	9.40	1.2471	S
-	11.93	14.46	1.2572	S
-	-	29.9	-	S
3.4	-	26.52	1.3403	S + D
11.11	-	18.75	1.3441	D
19.73	-	10.09	1.3505	D
23.27	-	6.75	-	D
28.32	-	4.09	1.3873	C·1 + D
25.04	3.34	4.09	1.3776	C·1 + D
16.66	12.91	2.52	1.3345	C·1 + D
12.17	18.38	1.55	1.3233	C·1 + D
9.91	21.95	1.21	1.3212	C·1 + D + Cl
8.87	22.36	1.29	1.3101	D + Cl
2.22	25.53	2.85	1.2779	"
0.73	25.53	4.48	1.2772	Cl + D + S
1.86	12.64	12.35	1.2790	D + S

Cl = NaCl      C·1 =  $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$       -S =  $\text{Na}_2\text{SO}_4$       D = n  $\text{Na}_2\text{CO}_3 \cdot m \text{Na}_2\text{SO}_4$

A detailed investigation of the five component system  $\text{Na}_2\text{CO}_3 - \text{NaHCO}_3 - \text{Na}_2\text{SO}_4 - \text{NaCl} - \text{H}_2\text{O}$  between  $20^\circ$  and  $60^\circ$  was carried out by Makarov and Sedelnikov, 1940.

Data for the system  $\text{Na}_2\text{CO}_3 - \text{NaHCO}_3 - \text{NaCl} - \text{Na}_2\text{SO}_4 - \text{H}_2\text{O}$  at  $30^\circ$ ,  $45^\circ$ , and  $60^\circ$  have been determined by Sedelnikov, 1945 for solutions which yield  $\text{NaHCO}_3$  upon crystallization.

THE SYSTEM SODIUM CARBONATE - SODIUM CHLORATE - WATER AT  $24.2^\circ$   
(Iljinsky, 1924)

The solutions were actively shaken at constant temperature and the attainment of equilibrium controlled by successive determinations of density and by analyses. The  $\text{Na}_2\text{CO}_3$  was determined by titration with  $0.1 \text{ N HCl}$ . The chlorate, by boiling with excess of Mohr's salt and titrating with chromate (?).

CO

d of sat. sol.	Gms. per 100 gms. $\text{H}_2\text{O}$		Solid Phase	d of sat. sol.	Gms. per 100 gms. $\text{H}_2\text{O}$		Solid Phase
	$\text{Na}_2\text{CO}_3$	$\text{NaClO}_3$			$\text{Na}_2\text{CO}_3$	$\text{NaClO}_3$	
1.224	28.5	0.0	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	1.433	22.0	66.3	$\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$
1.236	26.8	5.2	"	1.430	22.5	66.5	"
1.250	25.9	10.7	"	1.443	21.8	69.3	"
1.274	24.7	16.1	"	1.443	22.2	69.4	"
1.277	25.1	16.4	"	1.440	22.1	69.8	"
1.293	24.3	20.7	"	1.442	21.4	71.0	" + $\text{NaClO}_3$
1.299	24.3	22.6	"	1.444	20.7	71.8	$\text{NaClO}_3$
1.381	24.5	45.1	"	1.439 <sup>†</sup>	11.7	84.0	"
1.383	24.65	46.2	" + $\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$	1.431	5.3	91.8	"
1.391	24.8	47.3	$\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$	1.432	7.7	92.0	"
1.386	24.8	47.5	"	1.431	7.7	93.5	"
1.404	23.7	53.2	"	1.431	5.0	93.8	"
1.410	23.8	54.1	"	1.425	2.5	94.9	"
-	23.2	58.5	"	1.438	3.9	95.2	"
1.425	23.9	60.6	"	1.441	5.5	95.6	"
1.421	23.3	61.6	"	1.429	0.0	98.6	"
1.425	23.0	61.9	"	1.462	0.0	116.4	"*
1.436	22.5	66.2	"	1.466	16.2	100.8	" + $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ *

\*at  $40^\circ$

THE SYSTEM SODIUM CARBONATE - SODIUM CHROMATE - WATER AT  $35^\circ$   
(Druzhinin, 1938)

Saturated Solution Wt. %		Solid Phase Wt. %		Solid Phase
$\text{Na}_2\text{CrO}_4$	$\text{Na}_2\text{CO}_3$	$\text{Na}_2\text{CrO}_4$	$\text{Na}_2\text{CO}_3$	
0.0	33.70	0.0	85.49	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
11.20	25.17	0.0	85.49	"
21.23	18.51	0.0	85.49	"
30.38	12.30	72.80	27.20	* $2\text{Na}_2\text{CrO}_4 \cdot \text{Na}_2\text{CO}_3$ ]
37.55	7.09	73.98	26.02	
41.33	5.18	75.40	24.60	
43.73	3.32	76.00	24.00	
47.60	0.0	69.10	0.0	$\text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O}$

\*The compound  $2\text{Na}_2\text{CrO}_4 \cdot \text{Na}_2\text{CO}_3$  is similar to Glaserite in that it forms limited solid solutions with each of its components.

# Na SODIUM

## THE SYSTEM SODIUM CARBONATE - SODIUM IODIDE - WATER AT 30° (Cocheret, 1911)

Gms. per 100 Gms. Sat. Sol.			Gms. per 100 Gms. Sat. Sol.		
Na <sub>2</sub> CO <sub>3</sub>	NaI	Solid Phase	Na <sub>2</sub> CO <sub>3</sub>	NaI	Solid Phase
26.5	2.4	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O	13.1	29.1	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
25.5	4.7	"	10.4	33.3	"
24.4	8.6	"	4.2	46.0	"
24.3	9.5	" + Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O	2.7	51.0	"
23.0	11.2	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O	0.9	57.6	"
20.8	14.0	"	0.3	65.6	" + NaI·2H <sub>2</sub> O
18.7	18.4	"	0	65.5	NaI·2H <sub>2</sub> O
CO 15.3	25.4	" + Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O			

## THE SYSTEM SODIUM CARBONATE - SODIUM IODATE - WATER (Foote and Vance, 1933)

Gms. per 100 gms. sat. sol.				Gms. per 100 gms. sat. sol.			
t°	NaIO <sub>3</sub>	Na <sub>2</sub> CO <sub>3</sub>	Solid Phase	t°	NaIO <sub>3</sub>	Na <sub>2</sub> CO <sub>3</sub>	Solid Phase
0	0.0	6.42	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O	40	0.50	32.68	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
"	0.82	6.29	" + NaIO <sub>3</sub> ·5H <sub>2</sub> O	"	1.79	32.04	" + NaIO <sub>3</sub> ·H <sub>2</sub> O
"	2.42	0.0	NaIO <sub>3</sub> ·5H <sub>2</sub> O	"	2.00	29.87	NaIO <sub>3</sub> ·H <sub>2</sub> O
25	0.0	22.60	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O	"	11.71	0.0	"
"	0.52	22.44	"	50	0.0	32.16	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
"	2.16	22.22	" + NaIO <sub>3</sub> ·H <sub>2</sub> O	"	1.30	31.52	"
"	2.54	18.82	NaIO <sub>3</sub> ·H <sub>2</sub> O	"	2.48	31.27	" + NaIO <sub>3</sub> ·H <sub>2</sub> O
"	8.66	0.0	"	"	3.34	25.44	NaIO <sub>3</sub> ·H <sub>2</sub> O
40	0.0	32.83	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O	"	14.06	0.0	"

Data for the system Na<sub>2</sub>CO<sub>3</sub> - Na<sub>2</sub>MoO<sub>4</sub> - H<sub>2</sub>O at 25° are given by Zvorykin and Perel'man, 1957. No solid solutions nor compounds are formed. The invariant solution contains 33.7% Na<sub>2</sub>CO<sub>3</sub>, 19.16% Na<sub>2</sub>MoO<sub>4</sub>.

## THE SYSTEM SODIUM CARBONATE - SODIUM NITRATE - WATER

### Results of Kremann and Zitek, 1909

Gms. per 100 Gms. H <sub>2</sub> O			Solid Phase
t°	Na <sub>2</sub> CO <sub>3</sub>	NaNO <sub>3</sub>	
10	11.98	0	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O
10	8.75	70.48	" + NaNO <sub>3</sub>
10	0	80.5	NaNO <sub>3</sub>
24.2	28.55	0	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O
24.2	26.33	45.96	" + Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O
24.2	24.63	54.43	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O
24.2	21.8	62.7	" + NaNO <sub>3</sub>
24.2	5.96	84.45	NaNO <sub>3</sub>
24.2	0	91.3	"

### Results of Fedotieff and and Koltunoff, 1914

Gms. per 100 Gms. H <sub>2</sub> O		
t°	Sp. Gr. of Sat. Sol.	NaNO <sub>3</sub> NaHCO <sub>3</sub>
0	1.356	72.74 1.41
15	1.183	29.06 3.40
15	1.285	54.56 2.16
15	1.377	83.20 1.57
30	-	95.14 1.80

THE SYSTEM SODIUM CARBONATE - SODIUM SULFIDE - WATER  
(Beremzhanov, Uvalieva and Bekturov, 1955)

## Results at 30°

Sat. Sol. Wt. %		Solid Phase
Na <sub>2</sub> S	Na <sub>2</sub> CO <sub>3</sub>	
0	29.06	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O
2.99	25.88	"
4.26	23.44	"
4.50	23.40	"
5.01	19.26	"
10.16	16.32	" + Na <sub>2</sub> S·9H <sub>2</sub> O
10.51	15.77	Na <sub>2</sub> S·9H <sub>2</sub> O
11.18	16.21	"
12.52	14.37	"
15.68	10.45	"
16.60	10.87	"
16.32	10.16	"
19.10	4.32	"
21.30	1.46	"
23.13	0	"

## Results at 60°

Sat. Sol. Wt. %		Solid Phase
Na <sub>2</sub> S	Na <sub>2</sub> CO <sub>3</sub>	
0	31.92	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
2.60	27.20	"
6.50	22.40	"
6.60	21.25	"
6.70	25.4	" + Na <sub>2</sub> S·6H <sub>2</sub> O
13.81	14.42	Na <sub>2</sub> S·6H <sub>2</sub> O
14.20	13.36	"
16.10	10.29	"
16.80	10.66	"
17.49	10.28	"
23.55	7.55	"
24.03	7.05	"
25.40	6.70	"
27.12	1.50	"
29.50	0	"

CO

## Results at 80°

Sat. Sol. Wt. %		Solid Phase
Na <sub>2</sub> S	Na <sub>2</sub> CO <sub>3</sub>	
0	31.38	Na <sub>2</sub> CO <sub>3</sub> ·H <sub>2</sub> O
1.66	26.53	"
4.46	25.81	" + Na <sub>2</sub> S·6H <sub>2</sub> O
14.74	23.12	Na <sub>2</sub> S·6H <sub>2</sub> O
10.30	15.88	"
11.39	12.95	"
13.99	11.54	"
15.10	8.70	"
16.40	9.10	"
18.64	6.24	"
25.81	4.46	"
26.0	4.20	"
28.30	1.82	"
31.7	0	"



# Na SODIUM

## THE SYSTEM SODIUM CARBONATE - SODIUM SULFATE - WATER

(Caspary, 1924; Makarov and Jakimow, 1933; Dawkins, 1922; Druzhinin, 1938 (DZ); Green and Frattali, 1946; Makarov and Krasinkov, 1956. For data from -5° to +10° see Seshadri and Loba, 1957.)

The compound  $2\text{Na}_2\text{SO}_4 \cdot \text{Na}_2\text{CO}_3$  is similar to glaserite in that it forms limited solid solutions with each of its components.

$\text{SlO} = \text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ ;  $\text{ClO} = \text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ ;  $\text{C7} = \text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$ ;  $\text{Cl} = \text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ ;  $1-2 = \text{Na}_2\text{CO}_3 \cdot 2\text{Na}_2\text{SO}_4$ ;  $\text{SS} = \text{solid solution}$ ; \*metastable.

CO	t*	Sat. Sol. Wt. %		Solid Phase	t*	Sat. Sol. Wt. %		Solid Phase
		$\text{Na}_2\text{CO}_3$	$\text{Na}_2\text{SO}_4$			$\text{Na}_2\text{CO}_3$	$\text{Na}_2\text{SO}_4$	
	- 2.45	5.21	2.00	ClO + SlO + Ice ClO + Ice ClO " + SlO	50	32.2	0.0	Cl
	- 2.1	5.75	0.0			29.7	5.5	" + 1-2
	15.0	14.1	0.0			11.4	22.2	1-2 + $\text{Na}_2\text{SO}_4$
		12.3	8.0			0.0	31.8	
		0.0	11.8					
	19.1	15.97	4.97 (1.19)	ClO " + SlO SlO " " " + SlO " + " SlO " "	75	31.45	0.0	Cl
		14.92	9.05 (1.22)			29.0	4.8	" + 1-2
		14.82	9.50 (1.23)			7.6	24.2	1-2 + $\text{Na}_2\text{SO}_4$
		14.53	10.47 (1.29)			0.0	30.4	$\text{Na}_2\text{SO}_4$
		13.84	10.69 (1.28)		100	30.8	0.0	C-1
		12.13	11.06 (1.26)			29.6	2.1	"
		9.22	11.89 (1.21)			28.8	3.4	C-1 + S.S.
		4.85	13.17 (1.15)			28.4	3.2	"
	20	17.75	0.0			28.6	3.4	"
		14.95	11.2			24.8	5.4	S.S.
		0.0	16.25	SlO		22.6	6.6	"
	25	22.94	0.0	ClO		18.5	9.4	"
		21.77	3.76	"		17.3	10.3	GF.
		21.05	6.01	"		14.9	13.1	"
		19.60	10.03	"		13.6	14.0	"
		18.87	12.75	"		8.8	19.4	"
		18.61	14.59	"		6.8	22.0	"
		18.28	16.38	" + SlO		4.2	26.4	S.S. + S.
		17.9	16.2	" + "		2.9	28.0	S
		15.14	16.64	SlO		1.5	28.3	S
		9.11	18.12	"	103-105*	0.0	30.0	S
		3.54	20.20	"		31.51	0.0	Cl
		0.0	21.97	"		28.57	4.25	Cl + SS
	30°	27.15	0.0	ClO		21.98	8.79	SS
		25.8	8.6	" + 1-2		19.56	10.62	"
		15.5	19.5	1-2 + $\text{Na}_2\text{SO}_4$		16.04	13.51	"
		10.2	25.1	SlO + $\text{Na}_2\text{SO}_4$		10.83	19.25	"
		0.0	29.3	"		6.67	23.94	"
						5.36	26.05	S*
						4.39	26.93	"
	35°	33.70	0.0	Cl		3.92	27.40	"
		28.71	5.98	1-2		3.73	27.80	"
		19.61	13.44	1-2		3.71	27.06	"
		13.51	20.62	1-2		3.48	27.52	"
		13.16	20.96	1-2		4.93	25.31	SS
		0.0	33.18	S		3.47	27.16	SS + C S
		33.0	0.0	C7		1.60	28.88	SS
		30.0	5.7	" + 1-2		0.81	29.09	"
		14.3	20.6	1-2 + $\text{Na}_2\text{SO}_4$	150°	0.0	27.70	"
		0.0	33.15	$\text{Na}_2\text{SO}_4$				
	50°	28.64	5.35					(also see table following)
		28.52	5.87			26.9	0.0	C
		25.71	7.52			27.0	1.1	"
		19.37	12.92			26.9	1.9	"
		12.55	20.35			25.4	3.8	1-2 + C
		10.52	22.47			18.6	8.1	1-2(SS)
		10.21	23.10			12.5	12.5	"
		5.06	27.31			7.3	18.4	"
						6.9	20.4	"
						1.7	29.7	1-2 + S

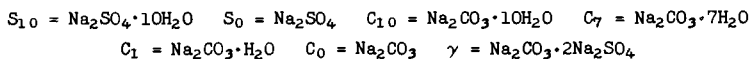
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# Na SODIUM

## THE SYSTEM $\text{Na}_2\text{CO}_3 - \text{Na}_2\text{SO}_4 - \text{NaOH} - \text{H}_2\text{O}$ at $25^\circ$ Itkina and Kokhova, 1953

[Results in this system at  $150^\circ$   $250^\circ$  and  $350^\circ$  are given by Schroder, Berk and Gabriel, 1936.]



	Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
	NaOH	$\text{Na}_2\text{SO}_4$	$\text{Na}_2\text{CO}_3$		NaOH	$\text{Na}_2\text{SO}_4$	$\text{Na}_2\text{CO}_3$	
CO	0.0	16.98	18.35	$S_{10} + C_{10}$	8.46	4.99	16.70	$C_{10} + \gamma$
	0.67	14.91	17.15	$S_{10} + C_{10} + \gamma$	9.13	4.56	16.39	$C_7 + C_{10} + \gamma$
	1.92	16.93	14.22	$S_{10} + \gamma$	10.14	3.45	16.15	$C_7 + \gamma$
	3.77	17.91	10.78		10.83	3.37	15.60	
	2.00	17.94	7.47	$S_{10}$	8.59	5.01	16.40	
	3.66	17.85	7.03		8.03	5.75	16.54	
	5.24	18.15	8.09	$\gamma$	7.70	6.72	16.45	$C_7 + C_1 + \gamma$
	7.33	19.72	0.0	$S_{10} + S_0$	12.01	2.43	15.12	
	5.90	18.76	5.87	$S_0$	18.43	1.67	7.78	$C_1 + \gamma$
	5.37	18.77	7.06	$S_{10} + S_0 + \gamma$	24.66	0.63	3.48	
	5.67	18.46	6.86	$S_0 + \gamma$	35.28	0.08	0.43	$C_1 + C_0 + \gamma$
	9.53	14.35	4.62		42.10	0.04	0.34	
	19.26	5.27	1.67		48.30	0.20	0.32	$C_0 + \gamma$
	31.48	1.02	0.42		7.52	0.0	17.51	$C_{10}$
	48.20	0.32	0.28	$C_{10} + \gamma$	9.13	0.0	18.02	$C_{10} + C_7$
	1.65	13.92	18.54		9.91	0.0	16.99	$C_7$
	4.52	9.08	18.63		12.61	0.0	15.81	$C_7 + C_1$
	8.50	4.93	16.99		19.03	0.0	7.77	$C_1$
					40.29	0.0	0.11	$C_1 + C_0$

Data for the system  $\text{Na}_2\text{CO}_3 - \text{UO}_2\text{CO}_3 - \text{H}_2\text{O}$  at  $26^\circ$  are given Blake, et al, 1956. The double salt  $\text{Na}_4\text{UO}_2(\text{CO}_3)_3$  is formed. The solubility of this salt in various salt solutions is given in the table following. Blake's results for the solubility of  $\text{UO}_2\text{CO}_3$  in  $\text{Na}_2\text{CO}_3$  solutions are listed under  $\text{UO}_2\text{CO}_3$ .

## SOLUBILITY OF $\text{Na}_4\text{UO}_2(\text{CO}_3)_3$ IN VARIOUS SALT SOLUTIONS (Blake et al, 1956)

[moles  $\text{Na}_4\text{UO}_2(\text{CO}_3)_3$  per liter]

molarity of solvent	at $26^\circ$					at $30^\circ$	
	NaCl	$\text{NaCl} + \text{Na}_2\text{CO}_3^a$	$\text{Na}_2\text{SO}_4$	$\text{NaClO}_4$	$\text{Na}_2\text{CO}_3$	$\text{Na}_2\text{CO}_3$	$\text{NaHCO}_3$
0	0.286	0.286	0.286	0.286	0.286	0.265	0.265
0.3	-	-	0.168	-	0.173	-	0.178
0.5	-	0.126	0.135	0.134	0.130	0.136	0.144
1.0	0.075	0.063	-	0.056	-	0.071	0.078
1.5	0.034	0.034	0.045	0.028	-	-	-
2.0	0.020	0.020	0.035	0.015	-	0.025	-
2.5	0.012	-	-	0.008	-	-	-
3.0	0.006	-	0.011	0.005	-	0.010	-
3.5	0.003	-	-	0.002	-	-	-
4.0	0.0025	-	-	-	-	-	-

<sup>a</sup>0.28 M NaCl, remainder  $\text{Na}_2\text{CO}_3$

Hydrothermal studies in the system  $\text{Na}_2\text{CO}_3 - \text{SiO}_2 - \text{H}_2\text{O}$  from 300-400°, up to 1500 atm. are reported by Butuzov and Bryatov, 1957.

Barber and Ali, 1950 report the solubility of  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$  in methanol to be 2.1 gms.  $\text{Na}_2\text{CO}_3$  per liter at 15°.

#### SOLUBILITY OF SODIUM CARBONATE IN AQUEOUS SOLUTIONS OF ETHYL ALCOHOL

##### Results of Linebarger, 1892 at 20°

Wt. % alcohol	Gms. $\text{Na}_2\text{CO}_3$ per 100 gms. sat. sol.
44	1.7
46	1.13
48	0.9
50	0.84
54	0.80

##### Results of Ketner 1901-02 at 21°

Gms. per 100 gms. sat. sol.	
$\text{Na}_2\text{CO}_3$	$\text{C}_2\text{H}_5\text{OH}$
18.5	0
12.7	6.2
6.9	15.3
3.2	26.1
1.2	39.2
0.2	58.2
0.1	67.1
0.006	73.3

CO

##### Results of Cocheret, 1911 at 30°

Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
$\text{Na}_2\text{CO}_3$	$\text{C}_2\text{H}_5\text{OH}$		$\text{Na}_2\text{CO}_3$	$\text{C}_2\text{H}_5\text{OH}$	
26.61	2.64	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	0.40	63.20	$\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$
26.14	3.41*	"	0.11	73.06	" + $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
1.38	44.81*	"	0.07	78.19	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
0.62	52.99	"	0.06	90.95	"
0.53	55.70	" + $\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$	0.03	95.06	" + $\text{Na}_2\text{CO}_3$
0.51	56.56	$\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$	-	98.46	$\text{Na}_2\text{CO}_3$

\*Between these two concentrations, the mixtures separate into two liquid layers.

##### Results of Ketner, 1901-02 for the composition of conjugate liquids

The mixtures were so made that alcoholic and aqueous layers were formed, and these were brought into equilibrium with the solid phase. Isotherms showing the compositions of the conjugated liquids at 28.2°, 29.7° and 40° are also given.

t°	Gms. per 100 Gms. Alcoholic Layer			Gms. per 100 Gms. Aq. Layer			Solid Phase
	$\text{C}_2\text{H}_5\text{OH}$	$\text{Na}_2\text{CO}_3$	$\text{H}_2\text{O}$	$\text{C}_2\text{H}_5\text{OH}$	$\text{Na}_2\text{CO}_3$	$\text{H}_2\text{O}$	
35	62.9	0.3	36.8	1	32.4	66.6	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
40	61	0.4	38.6	1.2	31.9	66.9	"
49	61	0.4	38.6	1.2	31.5	67.3	"
68	55.8	0.9	43.3	2.3	28.8	68.9	"
31.2	52.4	0.8	46.8	-	29.3	-	$\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}(\beta)$

(Cont.)

# Na SODIUM

## SOLUBILITY OF SODIUM CARBONATE IN AQUEOUS SOLUTIONS OF ETHYL ALCOHOL--Cont.

t°	Gms. per 100 Gms. Alcoholic Layer			Gms. per 100 Gms. Aq. Layer			Solid Phase
	C <sub>2</sub> H <sub>5</sub> OH	Na <sub>2</sub> CO <sub>3</sub>	H <sub>2</sub> O	C <sub>2</sub> H <sub>5</sub> OH	Na <sub>2</sub> CO <sub>3</sub>	H <sub>2</sub> O	
31.9	54.8	0.7	44.5	1.7	29.8	68.5	Na <sub>2</sub> CO <sub>3</sub> ·7H <sub>2</sub> O(β)
32.3	56.1	0.6	43.3	1.5	30.2	68.3	"
33.2	58.1	0.5	42.4	1.4	31	67.6	"
27.7	Crit. sol. ±14% C <sub>2</sub> H <sub>5</sub> OH ±13% Na <sub>2</sub> CO <sub>3</sub> ±73% H <sub>2</sub> O						
28.2	23.5	7.3	69.2	7.9	18.6	73.5	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O
29	32.7	3.8	63.5	4.3	22.7	73.0	"
29.7	40	2.1	57.9	2.9	25.5	71.6	"
CO 30.6	47.8	1.2	51	2.3	27.8	69.9	"

Cocheret, 1911 gives data for the solubility of Na<sub>2</sub>CO<sub>3</sub> + NaBr and of Na<sub>2</sub>CO<sub>3</sub> + NaCl in Aq. C<sub>2</sub>H<sub>5</sub>OH at 30°.

## THE SYSTEM SODIUM CARBONATE - NORMAL PROPYL ALCOHOL - WATER AT 20° (Frankforter and Temple, 1915)

(Note. In this paper the results for the binodal curve are reported in terms of gms. per 100 gms. solvent (water + alcohol), instead of gms. per 100 gms. of the homogeneous liquid (sodium carbonate + water + alcohol).)

Gms. per 100 Gms. Alcohol + Water			Gms. per 100 Gms. Alcohol + Water		
Na <sub>2</sub> CO <sub>3</sub>	Alcohol	Water	Na <sub>2</sub> CO <sub>3</sub>	Alcohol	Water
16.568	3.409	96.591	1.990	31.537	68.463
15.363	4.472	95.528	1.338	40.796	59.204
11.696	6.595	93.405	0.930	46.933	53.067
8.415	9.176	90.824	0.567	53.875	46.125
6.669	11.221	88.779	0.298	59.507	40.493
4.138	15.785	84.215	0.160	63.568	36.432
2.878	21.099	78.901	0.109	75.159	24.841

(additional data of Linebarger, 1892)

Wt. Per cent Alcohol	Gms. Na <sub>2</sub> CO <sub>3</sub> per 100 Gms. Sol.	Wt. per cent Alcohol	Gms. Na <sub>2</sub> CO <sub>3</sub> per 100 Gms. Sol.
28	4.4	48	1.3
38	2.7	50	1.2
44	1.7	54	0.9
46	1.5	62	0.4

THE SYSTEM SODIUM CARBONATE - ISO PROPYL ALCOHOL - WATER AT 25°  
(Ginnings and Chen, 1931)

The results which were determined by the titration method locate the binodal curve, a tie line, \*, and the plait point, PP.

Gms. per 100 gms. of the three constituents		Gms. per 100 gms. of the three constituents		
Na <sub>2</sub> CO <sub>3</sub>	iso Propyl Alcohol	Na <sub>2</sub> CO <sub>3</sub>	iso Propyl Alcohol	
0.10	63.5*	11.70	8.96	
0.91	47.6	14.50	5.61	
2.34	35.8	17.33	3.24	
6.54	19.34	19.18	2.15	
6.3	19.9 PP	19.60	1.60*	
9.35	12.8			CO

THE SYSTEM SODIUM CARBONATE - TERTIARY BUTYL ALCOHOL - WATER AT 30°  
(Ginnings and Robbins, 1930)

The points on the binodal curve of this system were determined by observing the appearance or disappearance of clouding in a mixture of weighed amounts of Na<sub>2</sub>CO<sub>3</sub> and one of the liquids upon addition of a weighed amount of the other. Tie lines, \*, were located by determination of Na<sub>2</sub>CO<sub>3</sub> in two liquid phases in contact with each other, and from these the plait point, PP, was found by plotting.

Gms. per 100 gms. of the 3 constituents		Gms. per 100 gms. of the 3 constituents		Gms. per 100 gms. of the 3 constituents	
Na <sub>2</sub> CO <sub>3</sub>	(CH <sub>3</sub> ) <sub>3</sub> COH	Na <sub>2</sub> CO <sub>3</sub>	(CH <sub>3</sub> ) <sub>3</sub> COH	Na <sub>2</sub> CO <sub>3</sub>	(CH <sub>3</sub> ) <sub>3</sub> COH
-	97.0*	3.3	22.4	9.7	6.8
-	70.0*	4.0	19.7	10.4	6.1
-	55.0*	4.5	- *	11.2	5.2
0.7	52.3	4.6	18.1	12.9	4.0
1.0	50.0	5.0	16.6	14.1	3.3
1.3	41.3	5.4	15.3	15.3	3.1
1.8	35.4	6.0	11.9	16.0	2.5
2.0	35.0 PP.	7.2	9.9	18.9	1.5
2.1	30.8	7.7	- *	25.2	0.6*
2.8	26.2	8.0	8.6		

The plait point, PP, of the above system at 25° was found by Ginnings, Herring and Webb, 1933, to have the composition

2.1 gms. Na<sub>2</sub>CO<sub>3</sub> + 32.2 gms. (CH<sub>3</sub>)<sub>3</sub>COH + 35.7 gms. H<sub>2</sub>O.

These authors also give the following composition of the plait point of the system, sodium potassium carbonate + tertiary butyl alcohol + water at 25°.

2.6 gms. NaKCO<sub>3</sub> + 31.6 gms. (CH<sub>3</sub>)<sub>3</sub>COH + 35.8 gms. H<sub>2</sub>O.

The remaining points on the binodal curves for these systems are not given but only the values of a series of arbitrary constants calculated from them by means of empirical equations.

THE SYSTEM Na<sub>2</sub>CO<sub>3</sub> - ALLYL ALCOHOL - WATER AT 20°  
(Frankforter and Temple, 1915)

Gms. per 100 gms. alcohol + water			Gms. per 100 gms. alcohol + water		
Na <sub>2</sub> CO <sub>3</sub>	alcohol	H <sub>2</sub> O	Na <sub>2</sub> CO <sub>3</sub>	alcohol	H <sub>2</sub> O
0.456	61.112	38.888	3.414	37.126	62.874
0.708	56.334	43.666	4.739	32.166	67.834
1.011	51.930	48.070	7.774	23.753	76.247
1.468	48.109	51.891	10.079	18.407	81.593
2.580	41.052	58.948			

100 gms. H<sub>2</sub>O dissolve 229.2 gms. sugar + 24.4 gms. Na<sub>2</sub>CO<sub>3</sub>, or 100 gms. sat. aq. solution contain 64.73 gms. sugar + 6.89 gms. Na<sub>2</sub>CO<sub>3</sub> at 31.25°. (Köhler, 1897.)

SOLUBILITY OF Na<sub>2</sub>CO<sub>3</sub> IN AQ GLYCEROL AT 20°  
(Ossendowski, 1907 (1); Holm, 1921, 1922 (2))

15-16°(1) "Glycerol", d=1.256	98.3 Gms. Na <sub>2</sub> CO <sub>3</sub> per 100 gms. solvent
20°(2) 86.5% glycerol, d=1.2326	108-123 " " " " "
20°(2) 98.5% " , d=1.2645	78-102 " " " " "

100 gms. saturated solution in glycol contain 3.28-3.4 gms. sodium carbonate. (de Coninck, 1905.)

THE SYSTEM SODIUM CARBONATE, PYRIDINE, WATER  
(Limbosch, 1909)

[Additional data in graphic form are given by Timmermans and Lewin, 1953 and by Arakawa, Kawaguchi and Kato, 1958. The binodal curve and plait point of the system sodium carbonate + pyridine + water at 25° has been determined by Ginnings, Webb and Hinohara, 1933, but the authors do not give their experimental results but only the values of a series of arbitrary constants calculated from them by means of empirical equations.]

Very pure materials were used. The boiling-point (cor.) of the pyridine was 115°-115.07°. Increasing amounts of this pyridine were added to aqueous solutions of sodium carbonate contained in glass tubes. After the tubes were sealed they were placed in a bath and the temperature noted at which the liquid mixture passed from a homogeneous to an opalescent condition. During the observation, the contents of the tubes were stirred by means of pieces of iron, moved with the aid of a magnet on the outside of the tube.

Per cent of Na <sub>2</sub> CO <sub>3</sub>	Per cent of Pyridine	t° of Sat.	Per cent of Na <sub>2</sub> CO <sub>3</sub>	Per cent of Pyridine	t° of Sat.
0.129	66.2	12	0.129	77.8	11 (-59)
0.129	66.4	25	1.01	47.6	17
0.129	67.7	36	1.01	49.9	36
0.129	69.2	44	1.01	51.2	55
0.129	73.5	53	1.01	52.2	72
0.129	74.8	51.5	1.01	56.1	107
0.129	76.1	25.5(-64)	1.01	60.6	111

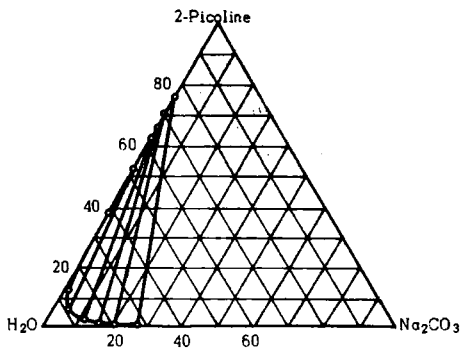
(Cont.)

## THE SYSTEM SODIUM CARBONATE, PYRIDINE, WATER--Cont.

Per cent of $\text{Na}_2\text{CO}_3$	Per cent of Pyridine	t° of Sat.	Per cent of $\text{Na}_2\text{CO}_3$	Per cent of Pyridine	t° of Sat.
1.01	66.8	110	5.23	32.5	155
1.01	75.1	86.5	5.23	36.6	196
1.01	76.9	71	5.23	37.2	200+
1.01	78.1	*	5.23	55.4	*
2.50	36.3	22	6.12	23.5	120
2.50	37.9	53.25	6.12	25.5	132
2.50	39.2	74.5	6.12	28.4	152
2.50	40	94	6.99	13.8	54.2(40.5)
2.50	43.6	147	6.99	15.4	81 (17)
2.50	47.6	185	6.99	19.5	117
2.50	50	199	6.99	22.7	142
2.50	53.3	197	6.99	25.1	158
2.50	59.4	173	6.99	27.6	169
2.50	69.2	123	6.99	32.6	180+
2.50	73.8	110	9.36	8.50	64 (26)
2.50	74.8	*	9.36	9	78 (18)
3.49	30.3	-0.5	9.36	11.4	106.5
3.49	32.6	39	9.36	13.8	127
3.49	34.3	86.5	9.36	16.3	148
3.49	36.7	107	9.36	20.1	169
3.49	37.4	123	9.36	25	180+
3.49	42.5	194	9.36	50	180+
3.49	69.6	167	18.1	2.12	48 (18)
3.49	71.2	*	18.1	2.25	66
5.23	23.3	63(27.5)	18.1	2.70	79
5.23	23.7	70(20.5)	18.1	4.20	108
5.23	24.6	79	18.1	5.40	126
5.23	26.2	96	18.1	6.80	155
5.23	28.7	111			

\*Precipitate of  $\text{Na}_2\text{CO}_3$ . Results in parentheses show lower temperatures of saturation.

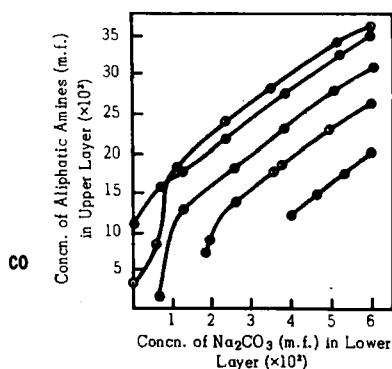
THE SYSTEM SODIUM CARBONATE + 2-PICOLINE + WATER AT 30°  
(Arakawa, Kawaguchi and Kato, 1958)





## Na SODIUM

THE SYSTEMS  $\text{Na}_2\text{CO}_3$  - ALIPHATIC AMINE - WATER AT  $30^\circ$   
(Arakawa and Kawaguchi, 1958)



Results for the compositions  
of conjugate liquids.

m.f. = mole fraction

- = heptylamine
- = hexylamine
- = amylamine
- = butylamine
- = propylamine

Melting point data are given for the following systems:

$\text{Na}_2\text{CO}_3 + \text{Na}_2\text{CrO}_4$	(Vilinyanskii and Pudovkina, 1947)(diagram only)
$\text{Na}_2\text{CO}_3 + \text{Fe}_2\text{O}_3$	(Knick and Kohlmeier, 1940)
$\text{Na}_2\text{CO}_3 + \text{Fe}_2\text{O}_3 + \text{Na}_2\text{O}$	( " " " " )
$\text{Na}_2\text{CO}_3 + \text{NaCl}$	(Volkov and Bergman, 1940)(LeChatelier, 1894)
	(Sackur, 1911-12)
$\text{Na}_2\text{CO}_3 + \text{NaF}$	(Volkov and Bergman, 1940)
$\text{Na}_2\text{CO}_3 + \text{NaCl} + \text{NaF}$	( " " " " )
$\text{Na}_2\text{CO}_3 + \text{NaOH}$	(Seward, 1942)(Differs from previous work.)
	(No solid solutions were found.)
$\text{Na}_2\text{CO}_3 + \text{Na}_2\text{SO}_4$	(LeChatelier, 1894)(Sackur, 1911-12)(Amadori, 1912)
	(Sackur, 1911-12)
$\text{Na}_2\text{CO}_3 + \text{KCl}$	(Sackur, 1911-12)
$\text{Na}_2\text{CO}_3 + \text{NaI}$	(Nyankovskaya, 1952, 1953)
$\text{Na}_2\text{CO}_3 + \text{NaBr}$	(Gromakov, 1951)
$\text{Na}_2\text{CO}_3 + \text{Na}_2\text{SO}_4 + \text{NaF}$	(Bergman and Rubleva, 1957)
$\text{Na}_2\text{CO}_3 + \text{Na}_2\text{SO}_4 + \text{NaCl}$	(Bergman and Sementsova, 1958)

## HCO SODIUM BICARBONATE $\text{NaHCO}_3$

### SOLUBILITY IN WATER

Results from  $-2$  to  $60^\circ$  were read from a curve drawn through the data of Dibbitts (1874), Fedotieff (1904), Makarov and Wachsberg (1930), Waldeck, Lynn, and Hill (1934), Boroyavlenskii and Manannikova (1955), Freeth (1922), Luzhnaya and Kosyachkova (1956), Makarov and Jakimow (1933). Results above  $100^\circ$  are those of Waldeck, Lynn and Hill (1934).

## SOLUBILITY IN WATER--Cont.

[Solid Phase  $\text{NaHCO}_3$ ]

t°	Gms. $\text{NaHCO}_3$ per 100 Gms. Sat. Sol.	t°	Gms. $\text{NaHCO}_3$ per 100 Gms. Sat. Sol.	t°	Gms. $\text{NaHCO}_3$ per 100 Gms. Sat. Sol.
-2.23	6.26	30	9.96	100	19.1
0	6.48	35	10.61	150	27.2
5	7.00	40	11.29	170	32.0
10	7.52	45	11.95	190	37.5
15	8.10	50	12.64	200	43.0
20	8.72	55	13.35		
25	9.32	60	14.10		

HCO

Data for the solubility of  $\text{NaHCO}_3$  in water saturated with  $\text{CO}_2$  from 30° to 70° and from 10 to 70 atm. pressure is given by Utida, 1940.

THE SYSTEM SODIUM BICARBONATE - SODIUM CHLORIDE - WATER  
(Freeth, 1922)

Additional data at 25° and 38° are in the table following. The results in parentheses are by Toporescu, 1922.

## Results at 0°

Gms. per 100  
gms. sat. sol.NaHCO<sub>3</sub> NaCl

6.5 0.0  
2.7 8.8  
1.1 19.8  
0.6 25.9

## Results at 15°

Gms. per 100  
gms. sat. sol.NaHCO<sub>3</sub> NaCl

8.1 0.0  
3.8 8.6  
2.0 16.4  
0.9 (0.77) 26.1 (26.1)

Solid Phase  
at Each  
Temperature

NaHCO<sub>3</sub>  
"  
"  
" + NaCl

## Results at 20°

Gms. per 100  
gms. sat. sol.NaHCO<sub>3</sub> NaCl

8.7 0.0  
4.2 8.5  
1.7 19.5  
1.0 26.1

## Results at 25°

Gms. per 100  
gms. sat. sol.NaHCO<sub>3</sub> NaCl

9.3 0.0  
3.2 12.7  
1.8 19.7  
1.2 26.0

## Results at 30°

Gms. per 100  
gms. sat. sol.NaHCO<sub>3</sub> NaCl

9.9 0.0  
4.9 8.8  
1.9 19.5  
1.2 26.1

Solid Phase  
at Each  
Temperature

NaHCO<sub>3</sub>  
"  
"  
" + NaCl

## Results at 35°

Gms. per 100  
gms. sat. sol.NaHCO<sub>3</sub> NaCl

10.6 0.0  
4.7 10.3  
2.1 19.6  
1.3 26.2

## Results at 45°

Gms. per 100  
gms. sat. sol.NaHCO<sub>3</sub> NaCl

12.0 0.0  
5.8 10.5  
2.7 19.2  
1.5 26.2

## Results at 60°

Gms. per 100  
gms. sat. sol.NaHCO<sub>3</sub> NaCl

14.1 0.0  
7.4 10.0  
3.7 19.1  
2.2 26.4

Solid Phase  
at Each  
Temperature

NaHCO<sub>3</sub>  
"  
"  
" + NaCl

# Na SODIUM

## THE SYSTEM SODIUM BICARBONATE - SODIUM CHLORIDE - WATER--Cont.

Data of Boroyavlenskii and Manannikova

	at 25°			at 38°		
	Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
	NaHCO <sub>3</sub>	NaCl		NaHCO <sub>3</sub>	NaCl	
HCO	9.29	0.0	NaHCO <sub>3</sub>	11.16	0.0	NaHCO <sub>3</sub>
	7.98	1.57	"	10.7	0.61	"
	7.00	3.5	"	10.14	1.48	"
	5.97	5.14	"	9.46	2.91	"
	5.14	6.78	"	8.37	5.91	"
	4.27	8.95	"	7.2	8.61	"
	3.9	11.05	"	6.14	10.43	"
	2.94	13.92	"	5.39	11.23	"
	1.95	19.16	"	4.16	14.87	"
	1.4	21.43	"	3.65	17.00	"
	1.22	24.84	"	2.99	18.69	"
	1.00	25.84	" + NaCl	2.56	20.6	"
	0.0	26.54	NaCl	2.07	22.37	"
				1.83	23.48	"
				1.71	24.4	"
				1.5	25.59	"
				1.23	25.75	" + NaCl
				0.0	26.69	NaCl

## THE SYSTEM SODIUM BICARBONATE - SODIUM CHLORIDE - WATER UNDER 1.2 ATMOSPHERES PRESSURE OF CARBON DIOXIDE (Neumann and Doake, 1928)

Results at 20°		Results at 30°		Results at 40°	
Gms. per 1000 cc. sat. sol.		Gms. per 1000 gms. sat. sol.		Gms. per 1000 cc. sat. sol.	
NaCl	NaHCO <sub>3</sub>	NaCl	NaHCO <sub>3</sub>	NaCl	NaHCO <sub>3</sub>
0.0	90.8	0.0	104.2	0.0	119.6
45.5	61.7	34.1	80.0	98.5	56.9
143.0	33.3	103.2	47.3	178.6	35.6
310.9	9.92	311.3	12.6	311.9	15.6
312.3	0.0	314.4	0.0	316.0	0.0

SOLUBILITY OF SODIUM BICARBONATE IN AQUEOUS SOLUTIONS OF SODIUM  
CHLORIDE SATURATED WITH CO<sub>2</sub>  
(Fedotieff; see also Reich, 1891)

t°	Wt. of 1 cc. Solution	Mols. per 1000 Gms. H <sub>2</sub> O		Grams per 1000 Gms. H <sub>2</sub> O		
		NaCl	NaHCO <sub>3</sub>	NaCl	NaHCO <sub>3</sub>	
0	-	0.0	0.82	0.0	69.0	
"	1.208	6.0	0.09	350.1	7.7	
15	1.056	0.0	1.05	0.0	88.0	
"	1.063	0.52	0.82	30.2	68.6	
"	1.073	1.03	0.64	60.1	53.6	
"	1.096	2.11	0.41	123.1	34.8	
"	1.127	3.20	0.28	187.2	23.0	
"	1.158	4.39	0.19	256.9	16.1	
"	1.203	6.06	0.12	354.6	10.0	
30	1.066	0.0	1.31	0.0	110.2	
"	1.079	1.02	0.87	59.9	72.8	
"	1.100	2.08	0.56	121.9	47.3	
"	1.127	3.18	0.38	186.3	32.0	
"	1.156	4.38	0.27	256.0	22.3	
"	1.199	6.12	0.17	358.1	13.9	
45	1.077	0.0	1.65	0.0	138.6	
"	1.086	1.04	1.12	60.7	94.0	
"	1.115	2.65	0.62	155.2	52.0	
"	1.127	3.24	0.52	189.4	43.4	
"	1.155	4.38	0.37	256.1	30.7	
"	1.198	6.18	0.23	361.5	19.5	

HCO

THE SYSTEM SODIUM BICARBONATE, SODIUM CHLORIDE,  
SODIUM SULFATE AND WATER AT 20°  
(Teepie, 1929)

Gms. per 100 gms. H <sub>2</sub> O				Gms. per 100 gms. H <sub>2</sub> O			
NaHCO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	NaCl	Solid Phase	NaHCO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	NaCl	Solid Phase
5.4	17.1	--	NaHCO <sub>3</sub> +S.10	-	13.0	29.0	S.10+S
-	12.5	11.8	S.10	2.1	13.2	27.8	NaHCO <sub>3</sub> +S.10+S
-	11.7	20.4	"	2.0	12.5	25.8	" + "
-	12.1	26.2	"	1.7	10.8	31.4	" +NaCl+S

S.10 = Na<sub>2</sub>SO<sub>4</sub>·10H<sub>2</sub>O; S = Na<sub>2</sub>SO<sub>4</sub>.

THE SYSTEM SODIUM BICARBONATE - SODIUM SULFATE - WATER

Results of Nishizawa, 1920

t°	Gm. mols. per 1000 gm. mols. H <sub>2</sub> O		Solid Phase
	NaHCO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	
15.0	18.53	0.0	NaHCO <sub>3</sub>
15.0	12.75	14.18	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
30.0	23.61	0.0	NaHCO <sub>3</sub>
30.0	8.55	48.84	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
40.0	26.92	0.0	NaHCO <sub>3</sub>
40.0	9.45	57.14	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O

# Na SODIUM

## THE SYSTEM SODIUM BICARBONATE - SODIUM SULFATE - WATER--Cont.

Results of Fedotieff and Kolosoff, 1923 at 35°				Results of Makarov, and Jakimow, 1933 at 25°		
d of sat. sol.	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	NaHCO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>		NaHCO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	
1.05	11.66	0.0	NaHCO <sub>3</sub>	9.39	0.0	NaHCO <sub>3</sub>
1.13	8.81	7.10	"	5.75	9.87	"
1.22	5.67	17.38	"	6.03	11.14	"
1.31	4.69	36.05	"	4.14	20.58	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
1.41	3.65	46.31	" + Na <sub>2</sub> SO <sub>4</sub>	4.16	20.68	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
				3.77	20.80	"
				0.0	21.90	"

HCO

## Results of Luzhnaya and Kosyachkova, 1956 at 50°

Density	Sat. Sol. Wt. %		Solid Phase
	NaHCO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	
1.0835	12.64	0.0	NaHCO <sub>3</sub>
1.1454	9.42	10.21	"
1.2221	6.61	19.25	"
1.3110	4.02	29.68	" + Na <sub>2</sub> SO <sub>4</sub>
1.3109	3.90	29.70	" + "
1.3107	4.05	29.65	" + "
--	2.40	30.52	Na <sub>2</sub> SO <sub>4</sub>
1.3118	0.0	31.92	"

## THE SYSTEM NaHCO<sub>3</sub> - Na<sub>2</sub>SO<sub>4</sub> - (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> - H<sub>2</sub>O

The following results are also given by Nishizawa, 1920, for solutions simultaneously saturated with sodium bicarbonate, sodium sulfate and the double salt, 1.1.4 = Na<sub>2</sub>SO<sub>4</sub>·(NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>·4H<sub>2</sub>O.

t°	Gms. mols. per 1000 gms. mols. H <sub>2</sub> O			Solid Phase
	NaHCO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	
15.0	12.84	26.22	45.86	NaHCO <sub>3</sub> + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O + 1.1.4
30.0	7.85	55.03	31.83	NaHCO <sub>3</sub> + Na <sub>2</sub> SO <sub>4</sub> + 1.1.4
40.0	11.26	49.33	45.41	NaHCO <sub>3</sub> + Na <sub>2</sub> SO <sub>4</sub> + 1.1.4

SOLUBILITY OF SODIUM BICARBONATE IN AQUEOUS AMMONIUM BICARBONATE  
SOLUTIONS SATURATED WITH CO<sub>2</sub>  
(Fedotieff, 1901)

t°	Wt. of 1 cc. Solution	Mols. per 1000 Gms. H <sub>2</sub> O		Grams per 1000 Gms. H <sub>2</sub> O		
		NH <sub>4</sub> HCO <sub>3</sub>	NaHCO <sub>3</sub>	NH <sub>4</sub> HCO <sub>3</sub>	NaHCO <sub>3</sub>	
0	1.072	1.39	0.58	109.4	48.2	
"	-	0.0	0.82	0.0	69.0	
15	1.056	0.0	1.05	0.0	88.0	
"	1.061	0.29	0.95	23.0	80.0	
"	1.065	0.56	0.89	44.0	74.6	
"	1.073	1.08	0.79	85.7	66.7	
"	1.090	2.16	0.71	170.6	59.2	
30	-	0.0	1.65	0.0	138.6	HCO
"	-	2.91	0.83	230	70.0	

SOLUBILITY OF SODIUM BICARBONATE IN ORGANIC SOLVENTS

Solvent	t°	Solubility					
alcohol, sp. gr. 0.941	15.5	1.2	gms. NaHCO <sub>3</sub>	per	100	gms. solvent*	
glycerol	15.5	8	"	"	"	"	*
86.5% glycerol of d=1.2326	20	4.05	"	"	"	"	**
98.5% " " $\bar{d}$ =1.2645	20	7.86	"	"	"	"	**

\*Ossendowski, 1907

\*\*Holm, 1921, 1922

SODIUM OXALATE Na<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>2</sub>

COO

SOLUBILITY OF SODIUM OXALATE IN WATER

The results of Flöttmann, 1928; Foote and Vance, 1933(a); Boulanger, 1936; and of Britton and Jarret, 1936(a), were plotted and values taken from the average curve. The more recent data of Norris, 1951 are given separately.

t°	Gms. Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub> per 100 gms. sat. sol.	
	Ave.	N.
0	2.62	2.67
10	2.96	3.01
15 (d = 1.0253)	3.13	--
20 (d = 1.0255)	3.30	3.39
25 (d = 1.0254)	3.48	--
30	3.67	3.76
40	4.01	4.04
50	4.37	4.34
60	4.70	4.60
70	5.05	4.91
80	5.40	5.24
100	6.10	5.87



THE SYSTEM NaOH -  $\text{H}_2\text{C}_2\text{O}_4$  -  $\text{H}_2\text{O}$ --Cont.Freezing Point Data

	Sat. Sol. Wt. %		Solid Phase		Sat. Sol. Wt. %		Solid Phase
	$\text{C}_2\text{O}_3$	$\text{Na}_2\text{O}$			$\text{C}_2\text{O}_3$	$\text{Na}_2\text{O}$	
(-0.90°)	1.44	1.23	C D	(-0.30°)	0.634	0.274	B C
(-4.20°)	0.285	4.27	C D	(-0.93°)	2.60	0.0	A
(-8.00°)	0.189	7.04	C D	(-0.96°)	2.77	0.128	B

Boiling Point Data

(116.0°)	63.0	0.0	A	(100.4°)	0.12	5.70	C D
(105.1°)	32.9	3.62	B C	(104.4°)	0.36	10.7	C D
(102.4°)	17.8	3.96	B C	(109.6°)	0.15	17.3	C D
(101.5°)	10.5	4.50	B C				

$\underline{A} = \text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ ;  $\underline{B} = \text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O} + \text{NaHC}_2\text{O}_4 \cdot \text{H}_2\text{O}$ ;  $\underline{BC} = \text{NaHC}_2\text{O}_4 \cdot \text{H}_2\text{O}$

$\underline{C} = \text{NaHC}_2\text{O}_4 \cdot \text{H}_2\text{O} + \text{Na}_2\text{C}_2\text{O}_4$ ;  $\underline{CD} = \text{Na}_2\text{C}_2\text{O}_4$ ;  $\underline{D} = \text{Na}_2\text{C}_2\text{O}_4 + \text{NaOH}$ ;  $\underline{E} = \text{NaOH}$

## THE SYSTEM SODIUM OXALATE - OXALIC ACID - WATER

(Hill, Goulden, and Hatton, 1946)

Also see the work of Norris, 1941 (above) and Foote and Andrew, 1905 (below).

Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
$\text{H}_2\text{C}_2\text{O}_4$	$\text{Na}_2\text{C}_2\text{O}_4$	Density		$\text{N}_2\text{C}_2\text{O}_4$	$\text{Na}_2\text{C}_2\text{O}_4$	Density	
<u>Results at 0°</u>				<u>Results at 25°</u>			
3.4	0.0	1.013	H·2	10.2	0.0	1.043	H·2
3.5	0.3	1.012	H·2+1:1:2	10.3	1.0	1.048	H·2+1:1:2
3.3	0.3	1.015	1:1:2	8.8	0.9	1.044	1:1:2
0.3	0.8	-	1:1:2	5.3	1.0	1.027	1:1:2
0.2	1.3	1.007	1:1:2	4.3	1.1	1.022	1:1:2
0.1	2.9	-	1:1:2+N	0.4	3.7	1.025	1:1:2+N
0.0	2.71	-	N	0.0	3.6	1.023	N
<u>Results at 60°</u>				<u>Results at 80°</u>			
31.6	0.0	1.129	H·2	47.4	0.0	-	H·2
31.5	1.7	1.138	H·2	48.1	3.7	-	H·2
31.8	2.8	1.148	H·2	47.4	1.3	-	H·2
31.6	3.3	1.151	H·2+1:1:2	48.2	4.9	-	H·2+1:1:2
30.7	3.1	1.144	1:1:2	47.3	4.5	-	1:1:2
19.3	3.0	1.091	1:1:2	37.5	5.2	-	1:1:2
9.4	3.5	1.044	1:1:2	29.6	5.2	-	1:1:2
1.7	5.8	1.034	1:1:2 + N	22.2	5.4	-	1:1:2
1.1	5.3	1.028	N	10.0	5.4	-	1:1:2
0.0	4.6	1.020	N	3.3	7.8	-	1:1:2 + N
				2.4	6.9	-	N
				0.9	5.9	-	N
				0.0	5.3	-	N

H·2 =  $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$

N =  $\text{Na}_2\text{C}_2\text{O}_4$

1:1:2 =  $\text{H}_2\text{C}_2\text{O}_4 \cdot \text{Na}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$



# Na SODIUM

## THE SYSTEM SODIUM OXALATE - OXALIC ACID - WATER--Cont.

Results of Foote and Andrew, 1905 at 25°

Gms. per 100 Gms. Solution		Mols. per 100 Mols. H <sub>2</sub> O		Solid Phase
H <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	H <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	
10.20	-	2.274	-	H <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·2H <sub>2</sub> O
10.50	0.83	2.370	0.130	H <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·2H <sub>2</sub> O + HNaC <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O
9.15	0.71	2.032	0.106	Double Salt, HNaC <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O
6.88	0.86	1.493	0.125	
1.14	1.25	0.234	0.172	
0.47	3.20	0.098	0.446	HNaC <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O + Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>
0.42	3.85	0.090	0.541	
-	3.60	-	0.502	

## HCOO SODIUM BINOXALATE NaHC<sub>2</sub>O<sub>4</sub>

### SOLUBILITY IN WATER (Norris, 1951)

Earlier data in agreement with these are given by Allvard, 1864; Koppel and Cahn, 1908; Lamouroux, 1899 and Flottmann, 1928.

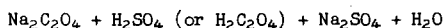
#### Solid Phase NaHC<sub>2</sub>O<sub>4</sub>·H<sub>2</sub>O

t°	Gms. NaHC <sub>2</sub> O <sub>4</sub> per 100 gms. sat. sol.	t°	Gms. NaHC <sub>2</sub> O <sub>4</sub> per 100 gms. sat. sol.	t°	Gms. NaHC <sub>2</sub> O <sub>4</sub> per 100 gms. sat. sol.
0	0.925	40	3.43	80	11.0
10	1.20	50	4.70	90	13.4
20	1.60	60	6.42	100	15.9
30	2.28	70	8.58	100.99	16.2

### SOLUBILITY OF SODIUM BINOXALATE IN AQUEOUS SOLUTIONS OF HYDROCHLORIC ACID AT 20°

Gms. per 100 gms. sat. solution		Solid Phase
HCl	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O	
0.0	1.86	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O
2.90	4.32	"
6.47	5.80	"
9.56	5.97	"

#### Data for equilibrium in the quaternary system



at 24.71° are given by Elöd and Acker, 1938. The available results for the ternary systems were used and especial attention given to the determination of the mono variant points of the quaternary system. The results are expressed according to the Jänecke method in terms of gram molecules of H<sub>2</sub>O to dissolve one gm. mol. of salt mixture of determined composition.

THE SYSTEM SODIUM OXALATE - SODIUM CHLORIDE - WATER  
(Colani, 1916)

t°	Gms. per 100 gms. sat. sol.	Solid Phase
15	0.027 Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub> + 26.28 NaCl	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub> + NaCl
50	0.063 " + 26.64 "	" + "

THE SYSTEM SODIUM OXALATE - SODIUM IODATE - WATER  
(Foote and Vance, 1933a)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase	HC00
NaIO <sub>3</sub>	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>		NaIO <sub>3</sub>	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>		
Results at 0°			Results at 25°			
0.0	2.62	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	0.0	3.56	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	
1.16	2.46	" + NaIO <sub>3</sub> ·5H <sub>2</sub> O	4.28	3.01	"	
2.42	0.0	NaIO <sub>3</sub> ·5H <sub>2</sub> O	6.43	2.41	" + NaIO <sub>3</sub> ·H <sub>2</sub> O	
			8.66	0.0	NaIO <sub>3</sub> ·H <sub>2</sub> O	
Results at 40°			Results at 50°			
0.0	4.09	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>				
5.63	2.98	"	0.0	4.37	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	
9.31	2.38	" + NaIO <sub>3</sub> ·H <sub>2</sub> O	9.26	2.70	"	
10.26	1.25	NaIO <sub>3</sub> ·H <sub>2</sub> O	11.67	2.31	" + NaIO <sub>3</sub> ·5H <sub>2</sub> O	
11.71	0.0	"	12.69	1.13	NaIO <sub>3</sub> ·5H <sub>2</sub> O	
			14.06	0.0	"	

THE SYSTEM SODIUM OXALATE - SODIUM NITRATE - WATER  
(Colani, 1916)

t°	Gms. per 100 gms. sat. sol.	Solid Phase
15	0.051 Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub> + 45.86 NaNO <sub>3</sub>	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub> + NaNO <sub>3</sub>
50	0.047 " + 53.06 "	" + "

THE SYSTEM SODIUM OXALATE - SODIUM SULFATE - WATER  
(Hill, Goulden, and Hatton, 1945 at 25°, 60°;  
Colani, 1916 at 15°, 50°)

Gms. per 100 gms. Sat. Sol.		Density	Solid Phase
Na <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>		
<u>Results at 15°</u>			
10.26	0.86	-	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O + Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>
<u>Results at 25°</u>			
22.0	0.0	1.196	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
22.0	0.5	1.200	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub>
19.7	0.5	1.182	Na <sub>2</sub> SO <sub>4</sub>
14.7	0.8	1.155	"
5.9	1.7	1.060	"
0.0	3.6	1.023	"

(Cont.)

# Na SODIUM

## THE SYSTEM SODIUM OXALATE - SODIUM SULFATE - WATER--Cont.

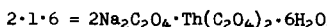
Gms. per 100 gms. Sat. Sol.		Density	Solid Phase
Na <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>		
<u>Results at 50°</u>			
31.95	0.22	-	Na <sub>2</sub> SO <sub>4</sub> + Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>
<u>Results at 60°</u>			
31.2	0.0	-	Na <sub>2</sub> SO <sub>4</sub>
30.7	0.3	1.289	Na <sub>2</sub> SO <sub>4</sub> + Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>
28.6	0.4	1.269	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>
20.2	0.7	1.177	"
10.1	1.7	1.088	"
0.0	4.6	1.020	"

HCOO

HC00

## THE SYSTEM SODIUM OXALATE - THORIUM OXALATE - WATER AT 25° (Britton and Jarrett, 1936a)

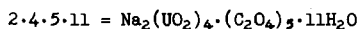
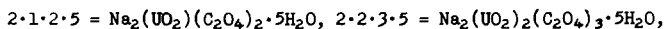
Gm. Mols. per liter sat. sol.		Solid Phase	Gm. Mols. per liter sat. sol.		Solid Phase
Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	Th(C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub>		Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	Th(C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub>	
0.2670	0.0	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	0.1945	0.04430	2·1·6
0.2672	0.00361	"	0.1679	0.05128	" + Th(C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub> ·6H <sub>2</sub> O
0.2793	0.01166	"	0.1408	0.04634	Th(C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub> ·6H <sub>2</sub> O
0.3022	0.03036	"	0.09158	0.03051	"
0.3110	0.03490	"	0.07554	0.02998	"
0.3184	0.03900	" + 2·1·6	0.05520	0.01550	"
0.3257	0.04543	2·1·6	0.04839	0.01338	"
0.2879	0.03852	"	0.03844	0.009055	"
0.2281	0.03920	"	0.02005	0.002762	"
			0.01002	0.000901	"



## THE SYSTEM SODIUM OXALATE - URANYL OXALATE - WATER (Colani, 1917)

### Results at 15°

Gms. per 100 Gms. Sat. Sol.		Solid Phase
Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	UO <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	
3.09	0	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>
4.93	3.14	" + 2·1·2·5
1.80	5.01	2·1·2·5 + 2·4·5·11
0.80	2.65	2·4·5·11 + UO <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·3H <sub>2</sub> O
0	0.47	UO <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·3H <sub>2</sub> O

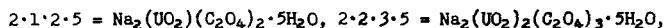


(Cont.)

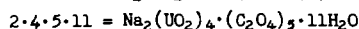
## THE SYSTEM SODIUM OXALATE - URANYL OXALATE - WATER--Cont.

## Results at 50°

Gms per 100 Gms. Sat. Sol.		Solid Phase
Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	UO <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	
4.28	0	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>
9.03	13.69	" + 2·1·2·5
4.62	12.33	2·1·2·5 + 2·2·3·5
3.60	9.84	2·2·3·5 + 2·4·5·11
1.01	3.58	2·4·5·11 + UO <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·3H <sub>2</sub> O
0	1	UO <sub>2</sub> ·C <sub>2</sub> O <sub>4</sub> ·3H <sub>2</sub> O



HCOO

THE SYSTEM SODIUM OXALATE - ZINC OXALATE - WATER AT 18°  
(Britton and Jarrett, 1936)

Gm. Mola. per liter sat. sol.		Solid Phase	Gm. Mols. per liter sat. sol.		Solid Phase
Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	ZnC <sub>2</sub> O <sub>4</sub>		Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	ZnC <sub>2</sub> O <sub>4</sub>	
0.240	0.000	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	0.100	0.0052	ZnC <sub>2</sub> O <sub>4</sub> ·2H <sub>2</sub> O
0.254	0.0133	"	0.080	0.00326	"
0.262	0.0250	"	0.060	0.00191	"
0.273	0.0337	"	0.040	0.00110	"
0.245	0.0325	ZnC <sub>2</sub> O <sub>4</sub> ·2H <sub>2</sub> O	0.020	0.00055	"
0.224	0.0275	"	0.010	0.00026	"
0.200	0.0217	"	0.000	-	"
0.150	0.0120	"			

THE SYSTEM SODIUM OXALATE - ZIRCONIUM OXALATE - WATER  
(Boulanger, 1936)

Results at 39°		Results at 52°		Solid Phase at Each Temperature
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	ZrOC <sub>2</sub> O <sub>4</sub>	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	ZrOC <sub>2</sub> O <sub>4</sub>	
4.0	0.0	4.40	0.0	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>
4.20	0.07	4.59	0.20	"
4.22	0.20	5.13	0.29	"
4.23	0.41	4.98	0.54	"
4.63	0.66	5.00	0.90	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·ZrOC <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·2H <sub>2</sub> O(?)
4.80	0.66	5.14	0.99	"
4.50	0.64	5.19	1.12	"
4.41	0.63	5.20	1.14	"
4.31	0.77	5.34	1.36	"
4.21	0.82	5.29	1.40	"
3.95	0.99	5.00	1.30	Unfilterable gel
3.67	1.31	4.95	1.72	"
3.30	1.15	3.86	1.50	"

## Na SODIUM

SOLUBILITY OF SODIUM OXALATE IN AQUEOUS UREA AND DIOXANE SOLUTIONS AT 18°  
(Pederson, 1941)

Moles CO(NH <sub>2</sub> ) <sub>2</sub> per liter of Solvent	Moles Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub> per liter Sat. Sol.	Moles Dioxane per liter of Solvent	Moles Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub> per liter Sat. Sol.
0.000	0.2467	0.333	0.2095
.500	.2392	.667	.1777
1.000	.2312	1.000	.1490

At 25°, 0.064 gms. sodium oxalate dissolve in 100 gms. ethylene glycol.  
" " 0.028 " " " " " " " propylene glycol.  
(Palit, 1947)

100 gms. 95% formic acid dissolves 8.8 gms. Na<sub>2</sub>C<sub>2</sub>O<sub>4</sub> at 19.3°.  
(Aschan, 1913)

## CS SODIUM THIO CARBONATE Na<sub>2</sub>CS<sub>3</sub>

100 gms. ethyl alcohol of d = 0.941 dissolve 5.55 gms. Na<sub>2</sub>CS<sub>3</sub> at 15.5°.

## Cl SODIUM CHLORIDE NaCl

### THE SYSTEM SODIUM CHLORIDE - WATER

Mulder; de Coppet, 1883; Andrae, 1884; Raupénstrauch, 1885; Berkeley, 1904; Cocheret, 1911; Matignon, 1909a; Raoult; Biltz; Kahlenberg; Rodebush, 1918; Klein and Svenberg, 1920; Cornec and Krombach, 1932; Ilvinski and Sagaidotschny, 1931; Kupper, 1927; Wright, 1927; Scott and Frazier, 1927; Cornec and Neumeister, 1929; Gerassimow, 1930; Flottmann, 1928.

Above 100°, Tilden and Shenstone, 1884; Achumow and Wassiljew, 1932; Cornec and Krombach, 1932; Froehlich, 1929; Schroeder, Gabriel and Partridge, 1935; Schiffrers and Wunderlich, 1937.

The results of various investigators generally agree within 1-2 parts per thousand.

### Solid Phase Ice

t°	Gms. NaCl per 100 gms.		t°	Gms. NaCl per 100 gms.	
	H <sub>2</sub> O	sat. sol.		H <sub>2</sub> O	sat. sol.
- 3.48	6.11	5.76	-14.33	22.25	18.20
- 5.17	8.92	8.19	-14.77	22.99	18.70
- 6.32	10.77	9.73	-16.21	24.75	19.85
- 8.52	14.20	12.42	-18.73	27.70	21.7
- 9.41	15.46	13.39	-20.56	29.70	22.9
-11.04	17.87	15.15			

(Cont.)

## THE SYSTEM SODIUM CHLORIDE - WATER--Cont.

t°	Gms. NaCl per 100 gms.		t°	Gms. NaCl per 100 gms.	
	H <sub>2</sub> O	sat. sol.		H <sub>2</sub> O	sat. sol.
<u>Solid Phase ICE + NaCl·2H<sub>2</sub>O</u>			<u>Solid Phase NaCl, cont.</u>		
- 21.2	30.4	23.3	30	36.04	26.50
			40	36.33	26.65
			50	36.67	26.83
			60	37.07	27.05
			70	37.51	27.27
			80	38.00	27.54
			90	38.52	27.80
			100	39.4	28.2
			118	39.8	28.5
			140	42.1	29.6
			150	42.2	29.7
			160	43.6	30.4
			180	44.9	31.0
			200	46.2	31.6
			250	51.7	34.1
			300	59.5	37.3
			350	72.1	41.9
			374	79.5	44.3
			400	86.5	46.4
			450	103.3	50.8
<u>Solid Phase NaCl·2H<sub>2</sub>O</u>					
- 15	32.1	24.30			
- 10	33.3'	25.00			
- 5	34.5	25.65			
0	35.7	26.30			
<u>Solid Phase NaCl·2H<sub>2</sub>O + NaCl</u>					
+ 0.1	35.7	26.3			
<u>Solid Phase NaCl</u>					
0	35.63	26.28			
10	35.72	26.31			
15 <sup>a</sup>	35.76	26.34			
20 <sup>b</sup>	35.82	26.38			
25 <sup>c</sup>	35.92	26.43			

Cl

<sup>a</sup>density = 1.2024<sup>b</sup>density = 1.2001<sup>c</sup>density = 1.1979

## SOLUBILITY OF NaCl IN WATER AT HIGH PRESSURES

Results for the solubility of sodium chloride in water at 30° under pressures up to 4000 bars (metric atmospheres) are given by Adams and Hale, 1931. Measurements of the volume changes at pressures up to 12,000 bars for aqueous sodium chloride solutions ranging from 0 to 25 weight percent concentration, are given by Adams, 1931. Other results for the influence of pressure upon the solubility of sodium chloride in water are given by v. Stackelberg, 1896; Cohen, Inouye and Buwen, 1910, and by Sill, 1916.

## SOLUBILITY OF NaCl IN STEAM

(Styrikovich, Khaibullin and Tskhvirashvili, 1955)

Additional data, especially in the critical region are given by Copeland, Silverman and Benson, 1953; Ölander and Liander, 1950; Schröer, 1927; Styrikovich, 1950; Aleinikov, Kostrinkin, Novi and Taratuta, 1956.

(Cont.)

## Na SODIUM

## SOLUBILITY OF NaCl IN STEAM--Cont.

Pressure (Atm.)	Wt. % NaCl in Vapor Phase					
	400°	425°	450°	500°	550°	580°
30	0.0001	0.0002	0.0002	0.0003	0.0007 (0.0002) <sup>a</sup>	-
100	0.0003 (0.0008) <sup>b</sup>	0.0003	0.0003	0.0004	0.0008	-
140	0.0019	0.0013	0.0009	0.0009	0.0013	-
150	(0.0033) <sup>b</sup>	0.0019	0.0015	-	-	-
180	-	0.0045	0.0030	0.0023	0.0025	-
200	(0.014) <sup>b</sup>	-	-	0.004-0.006	-	-
300	-	-	-	0.046	(0.016) <sup>a</sup>	(0.0170) <sup>c</sup>
2000	-	-	-	0.0014	-	-

<sup>a</sup>Deeva and Kot, 1958<sup>b</sup>Spillner, 1940<sup>c</sup>Styrikovich and Khokhlov, 1957SOLUBILITY OF SODIUM CHLORIDE IN DEUTERIUM OXIDE  
(Eddy and Menzies, 1940)

t°	Gms. NaCl per 100 gms. D <sub>2</sub> O	t°	Gms. NaCl per 100 gms. D <sub>2</sub> O	t°	Gms. NaCl per 100 gms. D <sub>2</sub> O
- 5	29.1	60	31.8	130	35.6
0	29.3	70	32.2	140	36.3
10	29.7	80	32.7	150	36.9
20	30.1	90	33.2	160	37.6
30	30.5	100	33.8	170	38.4
40	30.9	110	34.3	180	39.1
50	31.3	120	34.9		

SOLUBILITY OF SODIUM CHLORIDE IN WATER - DEUTERIUM OXIDE MIXTURES AT 25°  
(Chang and Chu, 1939)

W = Gms. NaCl per 100 gms. solvent

M = Moles NaCl per 55.51 moles of solvent

D <sub>2</sub> O		NaCl		D <sub>2</sub> O		NaCl	
Wt. %	Mole %	W	M	Wt. %	Moles%	W	M
0.0	0.0	35.92	6.145	64.60	62.14	32.45	5.938
0.02	0.02	35.89	6.140	75.71	73.71	31.86	5.899
17.49	16.01	35.02	6.096	89.99	89.00	31.10	5.849
39.89	37.38	33.77	6.018	92	-	30.5 <sup>a</sup>	-
52.33	49.69	33.11	5.979	99.59	99.54 <sup>a</sup>	30.56	5.811
				100	100	30.56	5.811

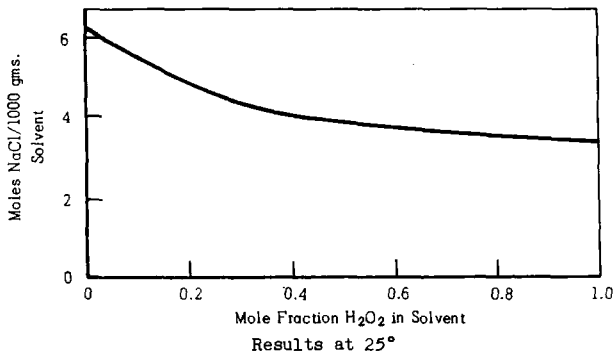
<sup>a</sup>(Taylor, Gaby and Eyring, 1933)

For the solvent HDO the authors give W = 33.24, M = 5.978

The change in solubility of NaCl with particle size in the range .07 - .3 mm. was studied by Jones, Burgess and Amis, 1955. Increases of the order of 6 - 12% were observed.

#### SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS SOLUTIONS OF HYDROGEN PEROXIDE

Floyd and Gross, 1955 present the results of their determinations and those of previous authors graphically. All the results lie on a single smooth curve; the values at 0, 15 and 25° are indistinguishable.



Cl

(Akerlof and Turk, 1935)

Wt. % H <sub>2</sub> O <sub>2</sub> in solvent	Gm. Mols. NaCl per 1000 gms. solvent	Wt. % H <sub>2</sub> O <sub>2</sub> in solvent	Gm. Mols. NaCl per 1000 gms. solvent
0.0	6.162	21.17	5.292
5.30	6.028	26.24	5.058
10.73	5.792	31.43	4.823
15.72	5.539		

#### SOLUBILITY OF SODIUM CHLORIDE IN PURE HYDROGEN PEROXIDE, DETERMINED BY THE FREEZING-POINT METHOD (Maass and Hatcher, 1922)

t° of f. pt.	Gms. NaCl per 100 gms. sat. sol.	f. pt.	Gms. NaCl per 100 gms. sat. sol.
- 2.37	1.08	- 10.7	11.81
- 3.62	3.14	- 10.37	15.63
- 5.07	5.42	0.0 +	17.0
- 7.67	8.61		



# Na SODIUM

## SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS HYDROCHLORIC ACID SOLUTIONS

### Results at 0°

(Armstrong and Eyre, 1910-11)		(Seidel and Fischer, 1941)		(Engel, 1888)			
Gms. HCl per liter solvent	Gms. NaCl per 100 gms. sat. sol.	Gms. per 100 gms. sat. sol.		Sp. Gr. of Solution	Gms. per 100 cc.		
		HCl	NaCl		HCl	NaCl	
	0.0	26.35	0	26.2	1.207	0.0	32.0
	9.11	25.30	22.6	1.15	1.204	0.365	31.3
	18.22	24.15	26.7	0.41	1.202	0.674	30.5
Cl	36.45	21.93	39.0	0.047	1.196	1.859	28.4
			43.9	0.034	1.185	3.38	25.7
			44.5	0.032	1.173	5.49	22.2
					1.141	11.20	13.7
					1.119	20.54	3.6

### Results at 10 - 10.5°

(Enklaar, 1901)

Gms. per 100 gms. H <sub>2</sub> O		d. of sat. sol.
HCl	NaCl	
0.0	35.77	1.2005
9.84	33.76	1.199
12.76	33.19	1.197
15.68	32.71	1.194
20.78	31.77	1.188
26.06	30.89	1.173
94.77	20.01	1.155
102.1	19.04	1.136
120.6	16.03	1.124

### Results at 18°

(Fricke and Brummer, 1935)

Gms. Mols. per 1000 gms. sat. sol.	
HCl	NaCl
0.0	4.513
0.0438	4.474
0.0870	4.433
0.1756	4.346
0.3610	4.151
0.9263	3.605
1.6677	2.889
2.6740	2.055
3.5670	1.408

### Results at 25°

(Ingham, 1928)

The author also gives the viscosities of the saturated solutions.

d. of sat. sol.	Gm. Mols. per liter sat. sol.		d. of sat. sol.	Gm. Mols. per liter sat. sol.	
	HCl	NaCl		HCl	NaCl
1.1981	0.0	5.4325	1.1200	4.500	1.333
1.1867	0.503	4.880	1.1160	5.253	0.907
1.1781	0.886	4.483	1.1158	6.101	0.544
1.1511	2.265	3.149	1.1213	7.073	0.293
1.1352	3.185	2.310	1.1302	7.976	0.158
1.1319	3.487	2.079	1.1458	9.236	0.091
1.1282	3.830	1.797	1.1970	13.41	0.017

(Cont.)

SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS HYDROCHLORIC  
ACID SOLUTIONS--Cont.

Results at 25°--Cont.

(Druzhinin and Shepelev, 1956) (Armstrong and Eyre, 1910-11) (Herz, 1911-12)

sat. sol. wt. %		d. of sat. sol.	Gms. HCl per liter of solvent	Gms. NaCl per 100 Gms. Sat. Sol.		Mols. per Liter	
NaCl	HCl					HCl	NaCl
26.41	0.0	1.1998	0	26.52( $d_{25}^4=1.2018$ )		0.607	4.850
23.52	3.94	1.1746	9.11	25.45( $d_{25}^4=1.1970$ )		1.032	4.467
17.69	11.83	1.1244	18.22	25.42( $d_{25}^4=1.1915$ )		1.590	3.782
13.33	17.83	1.1230	36.45	22.34( $d_{25}^4=1.1822$ )		2.117	3.297
8.60	24.14	1.1369	182.25	7.04( $d_{25}^4=1.1238$ )		3.283	2.343
1.13	35.59	-					
0.0	36.00	1.1791					

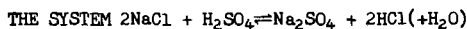
Cl

Results at 30°

(Masson, 1911)

(Schreinemakers, 1909-10)

$d_{20}^4$ of sat. sol.	Gm. Mols. per Liter		$d_{20}^4$ of sat. sol.	Gm. Mols. per Liter		Gms. per 100 Gms. Sat. Sol.	
	HCl	NaCl		HCl	NaCl	HCl	NaCl
1.2018	0	5.400	1.1427	3.052	2.463	0	26.47
1.1906	0.4575	4.932	1.1289	4.152	1.628	6.93	16.16
1.1801	0.969	4.386	1.1188	5.950	0.630	12.50	9.35
1.1633	1.786	3.589	1.1258	7.205	0.268	17.35	4.52
1.1512	2.412	2.978				35.60	0.11



Results at 25°

(Korf and Shatrobakaya, 1940)

Gms. per 100 gms. Sat. Sol.				Saturating Phases	Gms. per 100 gms. Sat. Sol.				Saturating Phases
$\text{H}_2\text{SO}_4$	$\text{Na}_2\text{SO}_4$	NaCl	HCl		$\text{H}_2\text{SO}_4$	$\text{Na}_2\text{SO}_4$	NaCl	HCl	
-	7.10	23.40	-	AB	15.00	32.50	-	-	BC
13.38	22.60	10.64	-	ABC	24.90	29.10	-	-	CE
23.03	22.86	7.14	-	ADE	29.80	26.00	-	-	EF
29.8	20.6	5.5	-	AEF	54.50	6.54	-	-	FG
51.25	-	5.85	0.88	AFG	-	-	35.70	0.87	AH
54.3	-	5.4	0.80	AGH	-	15.61	14.74	-	BJ
8.82	32.50	-	-	BJ	61.10	4.11	-	-	G

A = NaCl

B =  $\text{Na}_2\text{SO}_4$ C =  $\text{Na}_2\text{H}(\text{SO}_4)_2 \cdot \text{H}_2\text{O}$ E =  $\text{Na}_3\text{H}(\text{SO}_4)_2$ F =  $\text{NaHSO}_4 \cdot \text{H}_2\text{O}$ G =  $\text{NaHSO}_4$ 

H = HCl

J =  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ 

(Cont.)

# Na SODIUM

THE SYSTEM  $2\text{NaCl} + \text{H}_2\text{SO}_4 \rightleftharpoons \text{Na}_2\text{SO}_4 + 2\text{HCl} (+\text{H}_2\text{O})$  --Cont.

## Results at 30°

Results at 30° in air and in the presence of 1 atm. HCl are given by Sakai, Seiyama and Ikari, 1950, 1950a, 1951, and Sakai and Seiyama, 1953.

Data for equilibrium in the system sodium chloride-arsenic trioxide-water, at 30°, are given by Schreinemakers and deBaat (1915).

The system  $\text{NaCl} - \text{H}_2\text{BO}_3 - \text{H}_2\text{O}$  from -20° to +75° was reviewed by Palkin and Goloshchapov, 1949. The eutectic occurs at -21.4° with 22.9% NaCl, 1.45%  $\text{HCO}_3$ .

C1 Data for the solubility of NaCl in water saturated with  $\text{CO}_2$  from 30° to 70° and from 10 to 70 atm. pressure is given by Utida, 1940.

## SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS SOLUTIONS OF SODIUM HYDROXIDE AT VARIOUS TEMPERATURES (von Antropoff, 1924)

Constant agitation was employed and equilibrium was approached from above and from below. Silver lined apparatus was used and the determinations were made with the greatest care. The results for 16 isotherms were plotted and the dissolved sodium chloride, and specific gravities of the solutions corresponding to regular intervals of concentration of sodium hydroxide, were read from the curves. The figures in parentheses are the specific gravities of the saturated solutions.

Gms. NaOH per 100 gms. sat. sol.	Gms. NaCl dissolved per 100 gms. sat. solution at				
	-21.3°	-11.1°	0°	+10°	20°
5	20.1(1.2333)	21.0(1.229)	21.9(1.232)	22.0(1.227)	22.1(1.223)
10	16.9(1.260)	17.5(1.259)	17.8(1.254)	17.9(1.250)	18.0(1.243)
15	13.7(1.287)	13.9(1.286)	14.1(1.279)	14.2(1.276)	14.3(1.270)
20	10.3(1.318)	10.4(1.313)	10.5(1.308)	10.6(1.306)	10.7(1.298)
25	7.0(1.350)	7.1(1.342)	7.2(1.337)	7.3(1.334)	7.4(1.330)
30	-	-	4.3(1.373)	4.5(1.370)	4.7(1.368)
35	-	-	2.2(1.415)	2.5(1.412)	2.8(1.406)
40	-	-	-	1.3(1.453)	1.6(1.446)
45	-	-	-	0.9(1.501)	1.1(1.490)
50	-	-	-	-	0.8(1.540)

(Cont.)

SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS SOLUTIONS OF SODIUM HYDROXIDE  
 AT VARIOUS TEMPERATURES--Cont.

Gms. NaOH per 100 gms. sat. sol.	Gms. NaCl dissolved per 100 gms. sat. solution at				
	30°	40°	50°	60°	70°
5	22.2(1.218)	22.3(1.218)	22.4(1.213)	22.8(1.211)	23.0(1.209)
10	18.1(1.243)	18.2(1.241)	18.3(1.237)	18.7(1.236)	19.0(1.231)
15	14.4(1.271)	14.5(1.269)	14.7(1.264)	14.9(1.262)	15.0(1.258)
20	10.8(1.297)	10.9(1.296)	11.1(1.292)	11.4(1.290)	11.7(1.288)
25	7.5(1.329)	7.7(1.326)	8.0(1.323)	8.4(1.322)	8.6(1.320)
30	4.9(1.363)	5.0(1.359)	5.3(1.357)	5.8(1.360)	6.0(1.355)
35	3.0(1.400)	3.1(1.398)	3.4(1.394)	3.9(1.400)	4.1(1.393)
40	1.8(1.441)	2.0(1.438)	2.3(1.434)	2.7(1.437)	3.0(1.432)
45	1.3(1.484)	1.5(1.480)	1.8(1.474)	2.0(1.472)	2.3(1.474)
50	1.0(1.530)	1.2(1.525)	1.5(1.517)	1.7(1.515)	2.0(1.512)
55	-	1.0(1.574)	1.3(1.566)	1.7(1.563)	2.0(1.561)
60	-	-	-	1.7(1.610)	2.1(1.610)
65	-	-	-	2.2	-
70	-	-	-	2.4	-
75	-	-	-	-	-

Gms. NaOH per 100 gms. sat. sol.	Gms. NaCl dissolved per 100 gms. sat. solution at				
	80°	90°	120°	150°	180°
5	23.4(1.205)	23.7(1.200)	24.6	25.6	27.0
10	19.3(1.229)	19.6(1.224)	20.4	21.8	23.0
15	15.5(1.256)	15.8(1.254)	16.8	18.0	19.6
20	12.1(1.287)	12.4(1.284)	13.3	15.0	16.3
25	9.1(1.320)	9.5(1.318)	10.5	12.1	13.8
30	6.6(1.356)	7.1(1.352)	8.2	10.0	11.8
35	4.7(1.397)	5.2(1.390)	6.5	8.3	10.0
40	3.5(1.435)	3.9(1.428)	5.2	7.0	8.9
45	2.7(1.472)	3.0(1.465)	4.4	6.1	8.0
50	2.4(1.510)	2.7(1.508)	3.8	5.6	7.7
55	2.3(1.560)	2.6(1.558)	3.6	5.4	7.4
60	2.4(1.609)	2.7(1.608)	3.8	5.7	7.7
65	2.6	2.9(1.650)	4.1	6.0	7.9
70	2.8	3.2(1.70)	4.5	6.5	8.1
75	-	-	-	-	8.5

Results in close agreement with the above at 0°, 15°, 20°, 25°, 30°, 35°, 45° and 60° are given by Freeth, 1922; by Engel at 0°; Winteler, 1900 at 20°; Schreinemakers, 1909-10, 1910, at 30°, also von Antropoff and Sommer, 1926.

# Na SODIUM

## SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS SODIUM HYDROXIDE AT 25° (Akerlof and Short, 1937)

The solid phase is NaCl in all cases.

Cl	Gm. Mols. per 1000 gms. H <sub>2</sub> O		Gm. Mols. per 1000 gms. H <sub>2</sub> O		Gm. Mols. per 1000 gms. H <sub>2</sub> O		Gm. Mols. per 1000 gms. H <sub>2</sub> O	
	NaOH	NaCl	NaOH	NaCl	NaOH	NaCl	NaOH	NaCl
	0.920	5.613	6.688	2.635	12.35	1.074	19.30	0.451
	1.858	5.048	7.141	2.442	13.27	0.940	20.30	0.421
	2.714	4.672	8.031	2.173	14.38	0.781	21.05	0.396
	3.070	4.486	8.876	1.956	15.20	0.714	21.94	0.371
	3.812	4.048	9.824	1.558	16.25	0.580	22.82	0.356
	4.798	3.610	11.437	1.280	17.32	0.533	23.68	0.356
	5.721	3.206	11.582	1.253	17.83	0.492	23.56	0.346

## SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS SOLUTIONS OF SODIUM HYDROXIDE AT THE BOILING-POINT (von Antropoff, 1924)

t° of B. pt.	d of sat. sol.	Gms. per 100 gms. sat. sol.		t° of B. pt.	d of sat. sol.	Gms. per 100 gms. sat. sol.	
		NaCl	NaOH			NaCl	NaOH
108.8	1.172	28.9	0.0	123.0	1.346	8.7	30.0
110.0	1.195	24.8	5.0	128.7	1.381	7.4	35.0
111.5	1.222	20.9	10.0	135.0	1.416	6.5	40.0
113.3	1.250	17.1	15.0	141.7	1.452	5.9	45.0
115.4	1.279	13.8	20.0	150.0	1.487	5.6	50.0
118.4	1.312	10.8	25.0	160.5	1.522	5.9	55.0

## INVARIANT POINTS OF THE SYSTEM SODIUM CHLORIDE, SODIUM HYDROXIDE AND WATER (von Antropoff, 1924)

t°	Gms. per 100 gms. sat. sol.		Solid Phase	t°	Gms. per 100 gms. sat. sol.		Solid Phase
	NaCl	NaOH			NaCl	NaOH	
-30.15	16.55	8.87	Ice+NaCl·2H <sub>2</sub> O	20	0.78	51.07	NaCl+NaOH·H <sub>2</sub> O
-21.30	23.6	-	" + "	30	0.85	53.09	" "
-32.8	8.58	18.38	" + "NaOH·γH <sub>2</sub> O	40	0.98	55.11	" "
-29.8	4.20	20.72	" +NaOH·γH <sub>2</sub> O	50	1.28	57.58	" "
-28.25	-	19.00	" "	60	1.70	62.64	" "
-28.00	-	22.55	" "	70	2.40	70.40	" + NaOH
-21.3	6.02	26.04	NaCl+NaOH·β <sub>4</sub> H <sub>2</sub> O(?)	80	2.95	72.16	" "
-11.1	5.89	27.08	" "	90	3.45	72.73	" "
0.0	4.85	29.06	" +NaOH·3·5H <sub>2</sub> O	120	4.86	73.39	" "
10.0	3.24	33.24	" " "	150	7.02	74.10	" "
0.0	1.83	36.98	" " 3·11" *	180	8.75	76.05	" "
10.0	0.87	47.19	" +NaOH·2H <sub>2</sub> O				

\*Unstable

Phase equilibria at high temperatures in the system  $\text{NaCl} - \text{NaOH} - \text{H}_2\text{O}$  are given by Ravich, Borovaya, Luk'yanova and Elenevskaya, 1954.

Data for the mutual solubility of  $\text{NaCl} + \text{NaOH}$  in steam are given by Spillner, 1940.

SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS AMMONIA AT 30°  
(Hempel and Tedesco, 1911)

$d_{30}$ of Sat. Sol.	Gms. per 1000 cc. Sat. Sol.		$d_{30}$ of Sat. Sol.	Gms. per 1000 cc. Sat. Sol.	
	$\text{NH}_3$	$\text{NaCl}$		$\text{NH}_3$	$\text{NaCl}$
1.1735	29.535	293.38	1.1406	72.07	283.38
1.1656	40.655	292.5	1.1395	72.715	283.06
1.160	47.26	289.7	1.1301	81.855	277.49
1.1494	60.78	286.5	1.1205	97.49	270.57

Cl

Equations representing the solubility of  $\text{NaCl}$  in aq.  $\text{NH}_3$  are discussed by Nenno, 1954.

Data for the solubility of sodium chloride and of sodium chloride penta-ammoniate, in mixtures of ammonia and water at temperatures between  $-40^\circ$  and  $+25^\circ$  are given by Guyer, Bieler and Schmid, 1934. The present paper, however, contains only the diagrams drawn from the experimental results published in the dissertation of Z. Schmid E.T.H. Zurich, 1934.

The system  $\text{NaCl} - \text{NH}_4 - \text{H}_2\text{O}$  was studied by Distanov, 1953 from  $-78$  to  $+165^\circ$ .

The solubility of  $\text{NaCl}$  in  $\text{NH}_3$  and  $\text{NH}_3 + \text{CO}_2$  solutions at  $35^\circ$  and  $60^\circ$  is reported by Nenno and Drozin, 1955.

SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS SOLUTIONS OF SODIUM  
BICARBONATE SATURATED WITH  $\text{CO}_2$   
(Fedotieff 1904)

$t^\circ$	Wt. of 1 cc. Solution	Mols. per 1000 Gms. $\text{H}_2\text{O}$		Gms. per 1000 Gms. $\text{H}_2\text{O}$	
		$\text{NaHCO}_3$	$\text{NaCl}$	$\text{NaHCO}_3$	$\text{NaCl}$
0	-	0	6.09	0	356.3
"	1.208	0.09	6	7.7	350.1
15	1.203	0	6.12	0	357.6
"	1.203	0.12	6.06	10	354.6
30	1.196	0	6.16	0	360.3
"	1.199	0.17	6.12	13.9	358.1
45	1.189	0	6.24	0	365
"	1.198	0.23	6.18	19.5	361.5

## Na SODIUM

THE SYSTEM SODIUM CHLORIDE - SODIUM CHLORITE - WATER  
(Cunningham and Oey, 1955)

x = mole fraction NaCl in sat. sol.

w = moles  $H_2O$  per mole of dissolved salts

$$A = \text{NaClO}_3 \cdot 3\text{H}_2\text{O}$$
$$C = NaCl$$

	at 15°			at 25°			at 35°			Solid Phase
	x	w	sp.gr.	x	w	sp.gr.	x	w	sp.gr.	
Cl	0.1046	7.59	1.331	0.0779	6.17	1.391	0.0423	4.66	1.465	A
	0.2591	7.05	1.339	0.1579	6.07	1.391	0.0848	4.46	1.470	A
	0.3509	6.48	1.345	0.1858	5.95	1.395	0.0921	4.44	1.472	A
	0.3790	6.30	1.349	0.2571	5.57	1.400	0.1339	4.26	1.483	A, C
	0.4958	6.93	1.310	0.3717	6.31	1.349	0.3328	5.96	1.363	C
	0.6471	7.62	1.272	0.5438	7.13	1.296	0.5214	6.97	1.301	C
	0.7821	8.18	1.243	0.6156	7.49	1.278	0.6301	7.49	1.273	C
	0.8891	8.58	1.217	0.6971	7.96	1.260	0.7672	8.13	1.244	C
	1.0000	9.08	-	0.8426	8.38	1.229	0.8829	8.58	1.222	C
				1.0000	9.01	-	1.0000	8.46	-	C

THE SYSTEM SODIUM CHLORIDE - SODIUM CHLORATE - WATER

(Nallet, 1955; Nallet and Paris, 1956. 20° - DiCapua and Scaletti, 1927; for additional data see table following. Other data at 20, 40, 60, 80, and 100° are given by Billiter, 1920; at 12° and 122° by Schlosing; see also Winteler, 1900.)

I = Ice

A = NaCl

$$B = NaCl \cdot 2H_2O$$

C = NaClO<sub>4</sub>

Sat. Sol. Wt. %			Sat. Sol. Wt. %			Sat. Sol. Wt. %		
NaCl	NaClO <sub>3</sub>	Solid Phase	NaCl	NaClO <sub>3</sub>	Solid Phase	NaCl	NaClO <sub>3</sub>	Solid Phase
<u>at -26.25°</u>			<u>at -9.8°</u>			<u>at 10°</u>		
15.38	20.16	I, B, C	24.86	0	B	26.35	0	A
			22.09	7.08	B	22.42	8.83	A
<u>at -21.25°</u>			19.72	13.38	B	18.73	17.7	A
			17.68	18.95	B	16.70	22.55	A
23.19	0	I, B	16.57	22.08	B, C	14.27	28.52	A, C
			10.86	28.15	C	10.03	33.43	C
<u>at -19.2°</u>			5.30	35.0	C	6.57	37.89	C
			0	41.70	C	3.10	42.2	C
23.42	0	B	13.73	0	I	0	46.72	C
19.15	11.76	B	6.56	13.68	I			
15.91	20.92	B, C	0	26.43	I			
8.0	29.47	C				<u>at 20°</u>		
3.36	34.99	I, C				26.8	0.0	A
21.80	0	I				20.0	13.0	A
12.15	18.18	I	16.80	22.59	A, B, C	15.0	24.0	A
			16.99	22.24	B	13.0	29.5	A, C
<u>at -17.8°</u>						10.0	33.7	C
						7.5	37.5	C
0	39.74	I, C				5.0	41.5	C
			26.26	0	A, B	2.5	45.6	C
						0.0	49.6	C

(Cont.)





# Na SODIUM

## THE SYSTEM SODIUM CHLORIDE - SODIUM CHLORATE - WATER--Cont. (Results of Oey and Koopman, 1958)

x = moles  $\text{NaClO}_3$  per mole of dissolved salts  
w = moles  $\text{H}_2\text{O}$  per mole of dissolved salts

Sat. Sol.				Solid Phase	Sat. Sol.				Solid Phase
x	w	dens.			x	w	dens.		
<u>Results at 45°</u>									
Cl	0.0	8.82	1.201	NaCl	0.6158	5.47	1.398	NaCl	
	0.1042	8.29	1.226	"	0.7228	4.75	1.458	" + NaClO <sub>3</sub>	
	0.1560	8.04	1.240	"	0.7562	4.69	1.462	NaClO <sub>3</sub>	
	0.2600	7.50	1.267	"	0.8723	4.90	1.476	"	
	0.3917	6.81	1.308	"	0.9202	4.89	1.481	"	
	0.4702	6.39	1.336	"	1.000	4.90	1.491	"	

The boiling points of solutions saturated with  $\text{NaCl} + \text{NaClO}_3$  at various pressures were determined by Linari, 1939.

## THE SYSTEM $\text{NaCl}-\text{NaClO}_3-\text{H}_2\text{O}$ IN THE PRESENCE OF $\text{NH}_3$ AT 30° (Nallet, 1955)

10 gms. $\text{NH}_3$ per 100 gms. $\text{H}_2\text{O}$ added				20 gms. $\text{NH}_3$ per 100 gms. $\text{H}_2\text{O}$ added			
Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
NaCl	$\text{NaClO}_3$	$\text{NH}_3$		NaCl	$\text{NaClO}_3$	$\text{NH}_3$	
23.68	0.0	6.94	NaCl	21.86	0.0	13.02	NaCl
17.36	15.2	6.13	"	15.64	15.04	11.55	"
9.85	34.99	5.02	" + $\text{NaClO}_3$	8.66	34.5	9.47	" + $\text{NaClO}_3$
4.31	42.04	4.88	$\text{NaClO}_3$	4.16	40.07	9.29	$\text{NaClO}_3$
0.0	47.89	4.74	"	0.0	45.56	9.07	"

## THE SYSTEM SODIUM CHLORIDE - SODIUM PERCHLORATE WATER AT SEVERAL TEMPERATURES (Cornec and Dickely, 1926, 1927)

The figures in parentheses are densities.

t°	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{NaClO}_4$	NaCl	
0	23.86	15.44	NaCl
"	40.65	8.63	"
"	52.82	4.37	"
"	59.69	2.53	" + $\text{NaClO}_4 \cdot \text{H}_2\text{O}$
"	62.87	0.0	$\text{NaClO}_4 \cdot \text{H}_2\text{O}$
15(1.663)	65.63	0.0	"
25(1.683)	67.82	0.0	"
"(1.683)	66.58	1.37	" + NaCl

(Cont.)

THE SYSTEM SODIUM CHLORIDE - SODIUM PERCHLORATE  
WATER AT SEVERAL TEMPERATURES--Cont.

The figures in parentheses are densities.

t°	Gms. per 100 gms. sat. sol.		Solid Phase
	NaClO <sub>4</sub>	NaCl	
38(1.713)	70.38	0.0	NaClO <sub>4</sub>
"(1.723)	69.41	1.05	" + NaCl
50(1.749)	73.26	0	NaClO <sub>4</sub> ·H <sub>2</sub> O
"(1.749)	72.46	0.81	" + NaCl
55(1.756)	73.94	0.0	NaClO <sub>4</sub>
"(1.755)	73.00	0.78	" + NaCl
75(1.757)	75.01	0.0	NaClO <sub>4</sub>
"(1.757)	74.15	0.83	" + NaCl
100(1.758)	76.75	0.0	NaClO <sub>4</sub>
"(1.757)	75.79	0.88	" + NaCl
"(1.664)	69.32	1.44	NaCl
"(1.532)	50.33	3.06	"
"(1.567)	41.44	8.81	"

Cl

THE SYSTEM SODIUM CHLORIDE - SODIUM DICHROMATE - WATER

Results of Robertson, 1924

The mixtures of salts were dissolved in water at a temperature higher than that of the experiment and the flasks then placed in a thermostat. Constant agitation is not mentioned.

Results at 25°		Results at 50°		Results at 100°		Solid Phase at Each Temperature
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
NaCl	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	NaCl	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	NaCl	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	
24.0	5.18	24.2	5.87	25.1	6.28	NaCl
21.0	11.7	20.8	13.0	18.3	20.0	"
18.0	17.8	19.1	16.4	15.4	26.5	"
15.4	23.8	15.8	23.1	11.7	34.9	"
13.3	28.8	13.1	29.4	9.06	41.1	"
10.7	35.0	11.1	34.3	5.59	50.9	"
8.8	39.3	8.43	41.3	4.14	55.4	"
6.61	45.1	4.57	52.3	2.66	62.3	"
4.67	50.6	2.71	58.1	1.64	68.6	"
3.10	57.1	1.94	63.4	1.22	71.9	"
1.13	64.6	0.94	70.2	0.74	80.0	" + Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> ·2H <sub>2</sub> O
0.0	65.5	0.0	70.3	0.0	80.1	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> ·2H <sub>2</sub> O*

\*Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> at 100°.

(Cont.)

# Na SODIUM

## THE SYSTEM SODIUM CHLORIDE - SODIUM DICHROMATE - WATER--Cont.

Results of Gerassimow, 1930

Results at 0°		Results at 20°		Solid Phase at each Temperature
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
NaCl	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	NaCl	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	
26.00	0.0	26.43	0.0	NaCl
24.35	4.10	10.45	38.43	"
5.81	50.81	3.44	57.42	"
-	-	2.46	59.82	"
-	-	-	-	"
2.49	58.69	1.74	62.50	" + Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> · 2H <sub>2</sub> O
0.0	62.0	0.0	65.20	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> · 2H <sub>2</sub> O

Cl

<u>Results at 50°</u>		<u>Results at 75°</u>		Solid Phase at each Temperature
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
NaCl	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	NaCl	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	
26.91	0.0	27.45	0.0	NaCl
23.56	7.09	23.24	9.0	"
17.02	21.48	15.66	26.64	"
11.73	32.46	9.30	41.96	"
11.47	33.12	2.95	63.76	"
1.06	68.22	1.52	71.52	"
1.21	68.79	1.25	76.18	" + Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> · 2H <sub>2</sub> O
0.0	71.3	0.0	77.7	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> · 2H <sub>2</sub> O

Data for the system  $2\text{NaCl} + \text{K}_2\text{Cr}_2\text{O}_7 = \text{Na}_2\text{Cr}_2\text{O}_7 + 2\text{KCl} + (\text{H}_2\text{O})$  are given by Robertson, 1924.

Results for the system  $2\text{NaCl} + (\text{NH}_4)_2\text{Cr}_2\text{O}_7 = \text{Na}_2\text{Cr}_2\text{O}_7 + 2\text{NH}_4\text{Cl} + (\text{H}_2\text{O})$  are given by Gerassimow, 1930.

## THE SYSTEM SODIUM CHLORIDE - SODIUM FLUORIDE - WATER (Foote and Schairer, 1930)

t°	Gms. per 100 gms. sat. sol.		Solid Phase	t°	Gms. per 100 gms. sat. sol.		Solid Phase
	NaCl	NaF			NaCl	NaF	
25	26.40	0.0	NaCl	35	26.18	0.34	NaCl + NaF
"	26.12	0.31	" + NaF	"	26.13	0.29	"
"	26.24	0.12	" "	"	18.43	0.54	NaF
"	0.0	3.98	NaF	"	5.41	2.38	"
35	26.62	0.0	NaCl	"	0.0	4.00	"

(Cont.)

## THE SYSTEM SODIUM CHLORIDE - SODIUM FLUORIDE - WATER--Cont.

The authors also give the following results for the eutectic and transition temperatures of the above system.

t °	Gms. per 100 gms. sat. sol.		Solid Phase
	NaCl	NaI	
-21.19	23.69	0.24	Ice+NaCl·2H <sub>2</sub> O+NaF
-20.94	23.18	0.0	" +NaCl·2H <sub>2</sub> O
- 3.02	0.0	4.02	" +NaF
- 2.98	0.0	3.82	" + "
- 0.06	26.25	0.19	NaCl <sub>2</sub> ·2H <sub>2</sub> O+NaCl+NaF
- 0.08	26.39	0.0	" + "
- 0.10	26.53	0.0	" + "

Cl

THE SYSTEM SODIUM CHLORIDE - SODIUM FLUORIDE - SODIUM SULFATE - WATER  
(Foote and Schairer, 1930)Results at 25°

Gms. per 100 gms. sat. sol.			Solid Phase
Na <sub>2</sub> SO <sub>4</sub>	NaF	NaCl	
7.71	0.69	6.98	1.1
4.60	0.77	14.35	"
4.47	trace	18.41	"
4.35	0.60	21.48	"
9.72	trace	19.29	" + NaS
5.23	"	23.61	" + NaCl
14.76	"	13.78	" + NaS + NaS·10
6.98	"	22.73	" + " + NaCl
0.50	0.23	25.93	" + NaF + "
0.21	0.43	25.96	" + " + "

Results at 35°

Gms. per 100 gms. sat. sol.			Solid Phase
Na <sub>2</sub> SO <sub>4</sub>	NaF	NaCl	
1.51	trace	23.34	1.1
4.39	0.61	21.64	"
5.08	0.24	15.49	"
17.66	0.13	8.55	"
3.66	0.46	24.32	" + NaCl
6.89	trace	22.31	" + NaS
21.39	"	8.09	" + "
0.24	0.43	22.36	" + NaF
4.84	1.80	5.42	" + "
0.49	0.12	26.08	" + " + NaCl
0.17	0.31	26.18	" + " + "
6.14	trace	23.37	" + NaS + NaCl

# Na SODIUM

## THE SYSTEM SODIUM CHLORIDE - SODIUM IODIDE - WATER (Ricci and Yanick, 1936; Zhdanov and Adamenkova, 1948)

The results are in excellent agreement.

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase	
	NaCl	NaI		NaCl	NaI		
	At 0° (Z.A.)			At 25° (Z.A.)			
	-	26.40	0.0	NaCl	26.45	0.0	NaCl
	-	23.51	5.33	"	21.57	9.62	"
	-	18.86	14.71	"	20.00	16.34	"
Cl	-	14.38	23.24	"	11.58	30.07	"
	-	9.62	34.30	"	6.23	42.57	"
	-	5.72	44.50	"	2.26	54.18	"
	-	1.83	56.37	"	0.40	64.40	NaCl+NaI·2H <sub>2</sub> O
	-	0.74	60.63	NaCl+NaI·2H <sub>2</sub> O	0.0	64.72	NaI
	-	0.0	61.40	NaI·2H <sub>2</sub> O			
	At 10° (R.Y.)			At 50° (Z.A.)			
				26.90	0.0	NaCl	
	-	19.91	12.67	NaCl	15.61	20.20	"
	-	10.43	32.36	"	5.64	44.30	"
	-	3.86	48.45	"	0.96	62.28	"
	-	0.67	62.00	"	0.32	69.00	NaCl+NaI·2H <sub>2</sub> O
			" + NaI·2H <sub>2</sub> O	(0.26)	(69.00)	" + "	
				0.0	69.34	NaI·2H <sub>2</sub> O	
	At 25° (R.Y.)			At 75° (Z.A.)			
1.304	18.02	16.61	NaCl	27.46	0.0	NaCl	
1.367	14.04	24.72	"	16.01	22.18	"	
1.464	9.14	35.24	"	5.45	46.38	"	
1.593	4.59	46.48	"	0.94	66.89	"	
1.714	2.06	54.84	"	0.23	74.49	NaCl+NaI	
1.836	0.72	61.43	"	(0.18)	(74.45)	" + "	
1.887	0.45	63.97	"		(R.Y.)		
1.904	0.40	64.33	" + NaI·2H <sub>2</sub> O	0.0	74.72	NaI	
				At 100° (R.Y.)			
				16.70	22.18	NaCl	
				0.39	74.70	" + NaI	

THE SYSTEM SODIUM CHLORIDE - SODIUM IODATE - WATER  
(Foote and Vance, 1929)

D.S. =  $3\text{NaCl} \cdot 2\text{NaIO}_3 \cdot 10\text{H}_2\text{O}$ ;  $\text{NaI} \cdot 5 = \text{NaIO}_3 \cdot 5\text{H}_2\text{O}$ ;  $\text{NaI} \cdot 1 = \text{NaIO}_3 \cdot \text{H}_2\text{O}$

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{NaIO}_3$	$\text{NaCl}$	Solid Phase	$\text{NaIO}_3$	$\text{NaCl}$	Solid Phase
Results at 0°			Results at 25°		
0.0	26.34	$\text{NaCl}$	0.0	26.50	$\text{NaCl}$
0.35	26.31	" + D.S.	1.97	26.03	" + $\text{NaI} \cdot 1$
0.54	24.16	D.S.	8.66	0.0	$\text{NaI} \cdot 1$
0.73	22.66	"			
1.03	20.86	" + $\text{NaI} \cdot 5$			
0.83	16.30	$\text{NaI} \cdot 5$			
2.42	0.0	"			
Results at 15°			Results at 35°		
0.0	26.38	$\text{NaCl}$	0.0	26.66	$\text{NaCl}$
0.97	26.19	" + D.S.	1.70	26.20	"
1.29	24.64	D.S.	2.39	26.03	" + $\text{NaI} \cdot 1$
1.70	23.14	" + $\text{NaI} \cdot 1$	2.47	23.15	$\text{NaI} \cdot 1$
1.75	20.73	$\text{NaI} \cdot 1$	2.57	21.24	"
1.87	16.32	"	4.51	7.87	"
2.34	9.46	" + $\text{NaI} \cdot 5$	10.57	0.0	"

The following eutectics and transition points were also determined.

t°	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{NaIO}_3$	$\text{NaCl}$	
-21.8 Eutec.	0.36	23.28	$\text{Ice} + \text{D.S.} + \text{NaCl} \cdot 2\text{H}_2\text{O}$
-16.9 "	0.34	19.93	" + " + $\text{NaI} \cdot 5$
+ 0.04 tr. pt.	0.39	26.33	D.S. + $\text{NaCl} + \text{NaCl} \cdot 2\text{H}_2\text{O}$
6.8 "	1.66	20.76	" + $\text{NaI} \cdot 1 + \text{NaI} \cdot 5$
24.6 "	1.95	25.98	" + " + $\text{NaCl}$

Data for the system  $\text{NaCl} - \text{Na}_2\text{MoO}_4 - \text{H}_2\text{O}$  at 25° are given by Zvorykin and Perel'man, 1957. The invariant solution contains 31.71%  $\text{NaCl}$ , 18.45%  $\text{Na}_2\text{MoO}_4$ . No double salts nor solid solutions are formed.

THE SYSTEM SODIUM CHLORIDE - SODIUM NITRITE - WATER  
(Erdos and Simkova, 1957)

Results at 25°

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
$\text{NaNO}_2$	$\text{NaCl}$		$\text{NaNO}_3$	$\text{NaCl}$	
10.07	21.00	$\text{NaCl}$	32.14	10.43	$\text{NaCl}$
10.10	21.44	"	37.57	7.88	" + $\text{NaNO}_2$
21.45	15.16	"	39.80	6.03	$\text{NaNO}_2$

(Cont.)

## Na SODIUM

## THE SYSTEM SODIUM CHLORIDE - SODIUM NITRITE - WATER--Cont.

## Results at 45°

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
NaNO <sub>2</sub>	NaCl	Solid Phase	NaNO <sub>3</sub>	NaCl	Solid Phase
6.40	22.95		43.01	6.78	
24.42	14.05	"	46.81	3.00	NaCl+NaNO <sub>2</sub>
38.88	8.14	"			NaNO <sub>2</sub>

Data for the system NaCl-NaNO<sub>2</sub>-NaNO<sub>3</sub>-H<sub>2</sub>O, determined by the polythermal method are given by Simkova and Erdos, 1958 in the temperature range 10°-60°.

C1

## THE SYSTEM SODIUM CHLORIDE - SODIUM NITRATE - WATER

In addition to those tabulated below, data are given by Holzl and Crotogino, 1927 at 0°, 15°, 25°, 50°, 83° and 100°; Nikolajew, 1927 at 15°, 25°, 35°; also Nikolajew, 1929; Coppadoro, 1913 at 30°; Armstrong and Eyre, 1910-11 at 0°, 25°; Uspenskaya and Bergman, 1955 at 80°, 100°, 125°.

## Results of Cornec and Chretien, 1924

d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	NaCl	NaNO <sub>3</sub>			NaCl	NaNO <sub>3</sub>	
<u>Results at 0°</u>				<u>Results at 20°<sup>a</sup></u>			
1.209	26.4	0.0	NaCl	-	18.49	18.62	NaCl
1.251	23.2	8.0	"	-	17.34	21.30	"
1.290	20.0	15.6	"	-	13.80	30.34	" + NaNO <sub>3</sub>
1.332	17.0	23.2	" + NaNO <sub>3</sub>	-	9.56	34.85	NaNO <sub>3</sub>
1.332	12.2	28.0	NaNO <sub>3</sub>	-	7.67	37.18	"
1.333	9.48	30.9	"				
1.352	0.0	42.3	"				
<u>Results at 25°</u>				<u>Results at 50°</u>			
				1.185	26.9	0.0	NaCl
				1.259	20.5	15.3	"
1.198	26.6	0.0	NaCl	1.308	16.5	24.6	"
1.245	22.6	9.7	"	1.356	13.3	32.8	"
1.290	18.9	18.4	"	1.370	11.9	35.6	"
1.329	15.9	25.5	"	1.410	10.0	41.3	" + NaNO <sub>3</sub>
1.367	13.3	32.1	" + NaNO <sub>3</sub>	1.414	7.44	44.5	NaNO <sub>3</sub>
1.371	9.58	36.0	NaNO <sub>3</sub>	1.418	3.57	48.8	"
1.376	6.23	40.5	"	1.427	0.0	53.2	"
1.386	3.16	43.7	"				
1.392	0.0	47.8	"				

(Cont.)

<sup>a</sup>These results by Findlay and Cruickshank, 1926.

## THE SYSTEM SODIUM CHLORIDE - SODIUM NITRATE - WATER--Cont.

## Results of Cornec and Chretien, 1924--Cont.

d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	NaCl	NaNO <sub>3</sub>			NaCl	NaNO <sub>3</sub>	
<u>Results at 75°</u>				<u>Results at 100°</u>			
1.176	27.5	0.0	NaCl	1.164	28.6	0.0	NaCl
1.303	16.1	26.3	"	1.276	17.6	24.0	"
1.349	13.0	34.5	"	1.331	13.4	33.9	"
1.394	10.4	41.2	"	1.390	10.2	43.0	"
1.435	8.4	46.9	"	1.429	8.20	48.7	"
1.456	7.47	49.9	" + NaNO <sub>3</sub>	1.443	7.68	50.7	"
1.458	6.13	51.2	NaNO <sub>3</sub>	1.472	6.55	54.2	"
1.460	3.72	54.2	"	1.485	6.20	55.7	"
1.469	0.0	58.7	"	1.496	5.79	56.9	"
				1.500	5.63 <sup>b</sup>	57.4	" + NaNO <sub>3</sub>
					(6.6) <sup>b</sup>	(58.7) <sup>b</sup>	
				1.501	3.97	59.4	NaNO <sub>3</sub>
				1.502	2.82	60.6	"
				1.507	0.0	63.7	"

<sup>b</sup>This result is by Wurmser, 1922.

## Results of Leather and Mukerji, 1913

Results at 30°			Results at 40°			Solid Phase in Each Case
d <sub>30</sub> of sat. sol.	Gms. per 100 gms. H <sub>2</sub> O		d <sub>40</sub> of sat. sol.	Gms. per 100 gms. H <sub>2</sub> O		
	NaNO <sub>3</sub>	NaCl		NaNO <sub>3</sub>	NaCl	
1.202	0	36.3	1.197	0	36.53	NaCl
1.276	24.21	31.16	1.284	27.31	30.53	"
1.343	48.15	26.35	1.323	54.82	26.50	"
1.379	63.08	23.50	1.409	73.96	21.87	"
1.388	63.40	23.40	1.397	74.01	21.71	" + NaNO <sub>3</sub>
1.381	67.91	19.69	1.396	75.29	21.61	" NaNO <sub>3</sub>
1.394	81.46	9.76	1.410	89.90	10.80	"
1.406	95.90	0	1.421	105.2	0	"

## Results at 91°

d <sub>91</sub> of sat. sol.	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
	NaNO <sub>3</sub>	NaCl	
1.189	0	38.72	NaCl
1.296	37.43	30.21	"
1.381	79.65	23.17	"
1.487	127.2	17.05	"
1.519	141.4	15.93	" + NaNO <sub>3</sub>
1.518	141.3	15.83	" NaNO <sub>3</sub>
1.504	149.5	9.03	"
1.521	160.8	0	"

(Cont.)





## SYSTEM SODIUM CHLORIDE, SODIUM NITRATE, SODIUM SULFATE AND WATER

(Chretien, 1926, 1927, 1929; See also Guillier, 1927 and Pfeiffenberger and Leimbach, 1928)

The author gives in this very exhaustive paper the complete numerical and diagrammatical results (with densities) for binary, ternary and quaternary equilibrium in this system at very frequent temperature intervals between  $-24.4^{\circ}$  and  $+121.7^{\circ}$ . The following are the values given for the quaternary equilibrium at  $25^{\circ}$ .

d. of sat. sol.	Gms. per 100 gms. sat. sol.			Solid Phase	
	NaNO <sub>3</sub>	NaCl	Na <sub>2</sub> SO <sub>4</sub>		
1.281	7.08	9.98	14.9	Na <sub>2</sub> SO <sub>4</sub> +Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	Cl
-	12.40	6.42	15.0	" + "	
1.325	18.50	3.15	15.0	" + "	
1.291	11.7	18.6	5.34	" +NaCl	
1.322	18.2	16.6	4.50	" + " +D	
1.319	20.0	13.0	5.92	" +D	
1.325	22.0	8.68	8.19	" +"	
1.333	23.9	4.32	10.8	" +"	
-	22.6	15.3	3.30	NaCl +"	
1.357	26.5	14.0	2.45	" +"	
1.378	31.2	12.7	1.88	" +"+NaNO <sub>3</sub>	
1.387	37.7	6.41	2.51	NaNO <sub>3</sub> +D	
1.396	41.0	3.43	2.8	" +"	

D = Darapskite, NaNO<sub>3</sub>·Na<sub>2</sub>SO<sub>4</sub>·H<sub>2</sub>O.

Solubility studies made over a period of some ten years by many investigators including Cornec and his students have established the diagrams representing the equilibrium in aqueous solutions of the chloride, nitrate and sulfate of sodium at various temperatures. Using these results Graziadei, 1935, 1936, has worked out a graphic method of calculating the yield of nitrate obtained by cooling solutions of two and three salts. A simple formula of practical application has been deduced.

Data for the system  $2\text{NaCl} + \text{Ba}(\text{NO}_3)_2 \rightleftharpoons 2\text{NaNO}_3 + \text{BaCl}_2 + (\text{H}_2\text{O})$  at  $0^{\circ}$  and  $50^{\circ}$  are given by Speranskaya, 1954.

## THE SYSTEM SODIUM CHLORIDE - SODIUM PHOSPHATE - WATER

(Obukhoff and Michailova, 1935)

Results at  $25^{\circ}$ 

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
Na <sub>3</sub> PO <sub>4</sub>	NaCl		Na <sub>3</sub> PO <sub>4</sub>	NaCl	
13.40	0.0	Na <sub>3</sub> PO <sub>4</sub> ·12H <sub>2</sub> O	3.07	12.50	Na <sub>3</sub> PO <sub>4</sub> ·12H <sub>2</sub> O
9.51	2.00	"	2.32	17.05	"
7.24	3.48	"	1.96	21.92	"
5.14	6.12	"	1.90	25.26	NaCl+Na <sub>3</sub> PO <sub>4</sub> ·12H <sub>2</sub> O
4.70	7.45	"	0.95	25.76	NaCl
4.28	10.44	"	0.0	26.40	"

(Cont.)

# Na SODIUM

## THE SYSTEM SODIUM CHLORIDE - SODIUM PHOSPHATE - WATER--Cont.

### Results at 105°

	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	Na <sub>3</sub> PO <sub>4</sub>	NaCl		Na <sub>3</sub> PO <sub>4</sub>	NaCl	
	49.71	0.0	Na <sub>3</sub> PO <sub>4</sub>	33.89	10.30	NaCl
	44.50	2.56	"	21.72	16.27	"
	43.35	3.15	"	14.60	20.08	"
	39.70	6.67	"	10.78	22.23	"
	37.33	7.75	"	3.30	26.51	"
	35.75	8.40	"	1.31	27.65	"
Cl	34.62	9.95	Na <sub>3</sub> PO <sub>4</sub> + NaCl	0.0	28.25	"

## THE SYSTEM SODIUM CHLORIDE - DISODIUM PHOSPHATE - WATER AT 25° (Makin, 1957)

	Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
	Na <sub>2</sub> HPO <sub>4</sub>	NaCl		Na <sub>2</sub> HPO <sub>4</sub>	NaCl	
	10.32	0.0	Na <sub>2</sub> HPO <sub>4</sub> ·12H <sub>2</sub> O	9.37	20.32	Na <sub>2</sub> HPO <sub>4</sub> ·12H <sub>2</sub> O+NaCl
	9.26	5.09	"	9.12	20.54	"
	9.32	9.48	"	8.69	19.67	"
	9.51	15.72	"	5.31	22.24	NaCl
	8.50	19.96	" + NaCl	3.01	23.46	"
	9.67	20.47	" + "	0.0	26.42	"
	9.50	20.99	" + "			

## THE SYSTEM SODIUM CHLORIDE - SODIUM BISULFIDE - WATER AT 20° (Bezuglyi and Kutsakov, 1939)

### Gms. per 100 gms. Sat. Sol.

NaCl	NaSH	Solid Phase
2.06	35.8	NaCl+NaSH

## THE SYSTEM SODIUM CHLORIDE - SODIUM SULFITE - WATER

### Results of Kobe and Hellwig, 1955

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
NaCl	Na <sub>2</sub> SO <sub>3</sub>	Solid Phase	NaCl	Na <sub>2</sub> SO <sub>3</sub>	Solid Phase
Results at 0°			Results at 25°		
0.00	11.7	Na <sub>2</sub> SO <sub>3</sub> ·7H <sub>2</sub> O	0.00	23.5	Na <sub>2</sub> SO <sub>3</sub> ·7H <sub>2</sub> O
6.2	7.85	"	2.79	20.7	"
18.1	3.87	"	6.65	17.7	"
24.5	2.83	Na <sub>2</sub> SO <sub>3</sub> ·7H <sub>2</sub> O + NaCl	10.6	15.0	"
26.2	0.00	NaCl	12.5	13.7	"

(Cont.)

## THE SYSTEM SODIUM CHLORIDE - SODIUM SULFITE - WATER--Cont.

Results of Kobe and Hellwig, 1955--Cont.

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
NaCl	Na <sub>2</sub> SO <sub>3</sub>	Solid Phase	NaCl	Na <sub>2</sub> SO <sub>3</sub>	Solid Phase
Results at 25°, Cont.			Results at 60°		
15.6	11.9	Na <sub>2</sub> SO <sub>3</sub> ·7H <sub>2</sub> O	0.00	23.8	Na <sub>2</sub> SO <sub>3</sub>
18.9	10.6	"	10.3	12.9	"
19.3	11.8	Na <sub>2</sub> SO <sub>3</sub> ·7H <sub>2</sub> O + NaCl	15.8	8.45	"
20.2	10.8	"	25.2	3.14	Na <sub>2</sub> SO <sub>3</sub> + NaCl
20.5	10.1	"	25.6	2.44	NaCl
20.9	9.31	NaCl	26.1	1.65	"
22.3	7.07	"	27.1	0.00	"
23.0	5.96	"			
23.9	4.34	"	Results at 80°		
24.5	3.38	"			
25.1	2.36	"	0.00	21.9	Na <sub>2</sub> SO <sub>3</sub>
25.7	1.27	"	10.3	11.9	"
26.5	0.00	"	20.5	4.56	"
			26.1	2.45	Na <sub>2</sub> SO <sub>3</sub> + NaCl
			26.8	1.25	NaCl
			27.6	0.00	"
Results at 40°			Results at 100°		
0.00	26.3	Na <sub>2</sub> SO <sub>3</sub>			
5.00	20.5	"			
9.83	15.8	"	0.00	20.8	Na <sub>2</sub> SO <sub>3</sub>
15.5	10.4	"	10.6	10.6	"
23.2	5.86	Na <sub>2</sub> SO <sub>3</sub> + NaCl	20.7	4.04	"
24.0	4.51	"	27.0	2.08	Na <sub>2</sub> SO <sub>3</sub> + NaCl
25.2	2.39	NaCl	27.9	0.44	NaCl
26.7	0.00	"	28.2	0.00	"

Results of Labash and Lusby, 1955

Results at 20°				Results at 60°			
Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
NaCl	Na <sub>2</sub> SO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>		NaCl	Na <sub>2</sub> SO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	
26.36	0.0	-	NaCl	27.03	0.0	-	NaCl "
24.22	3.26	0.22	"	25.77	1.89	0.30	NaCl?+Na <sub>2</sub> SO <sub>3</sub>
23.68	4.35	0.21	"	25.14	3.04	0.16	" ?+ "
21.10	7.41	1.24	"	(24.23) <sup>a</sup>	(2.36)	"	NaCl+Na <sub>2</sub> SO <sub>3</sub>
21.19	7.61	1.23	"	18.85	5.98	0.93	NaSO <sub>3</sub>
16.73	9.13	1.14	Na <sub>2</sub> SO <sub>3</sub> ·7H <sub>2</sub> O	14.03	9.57	0.70	"
16.89	9.20	0.71	"	12.75	10.64	1.05	"
10.27	12.46	1.04	"	11.69	11.46	2.40	"
6.76	14.87	0.86	"	10.88	11.27	1.06	"
0.0	20.58	0.77	"	7.55	15.80	2.04	"
				4.45	18.90	1.32	"
				2.98	21.90	1.02	"
aZilberman and Ivanov, 1941				1.29	22.50	0.65	"
				0.0	22.86	0.67	"

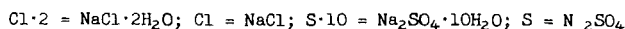
THE SYSTEM SODIUM CHLORIDE - SODIUM SULFATE - WATER.

In addition to the results listed below, data for this system are given by Seshadri and Loba, 1957, at  $-5^{\circ}$ ,  $0^{\circ}$ ,  $+5^{\circ}$ ,  $10^{\circ}$ ; Kournakov and Zemcnznyi, 1924, at  $0^{\circ}$ ,  $25^{\circ}$ ; Levina, 1938, at  $25^{\circ}$ ; Bogoyaulenskii and Sukmanskaya, 1955, at  $25^{\circ}$ , Ravich and Borovaya, 1949, and Ravich, Borovaya and Ketkovich, 1953, from  $200^{\circ}$  to  $650^{\circ}$ ; Makarov and Krasnikov at about  $105^{\circ}$ ; Schroeder, Gabriel and Partridge, 1935, and Schroeder, Berk and Gabriel, 1937, from  $150^{\circ}$  to  $350^{\circ}$ ; Ravich and Borovaya, 1957, up to  $600^{\circ}$ . 200 atmospheres.

## Results of Chretien, 1926, 1929

(Also see tables following)

c1



density	Gms. per 100 gms. sat. sol.		Solid Phase	density	Gms. per 100 gms. sat. sol.		Solid Phase
	NaCl	Na <sub>2</sub> SO <sub>4</sub>			NaCl	Na <sub>2</sub> SO <sub>4</sub>	
<u>Results below 0°</u>				<u>Results at 17.9°</u>			
(-21.7°)	22.8	0.12	Ice+Cl <sub>2</sub> +S·10	-	22.3	7.57	S·10+S+Cl
(-21.32°)	23.43	0.31(1)	" + " + "				
(-21.6°)	22.9	0.0	" + Cl <sub>2</sub>				
(-20.94°)	23.18	0.0(1)	" + "				
(- 1.2°)	0.0	3.79	" +S·10	(1.207)	7.66	16.0	S·10
(- 0.1°)	25.3	1.39	Cl <sub>2</sub> +S·10+Cl	-	14.5	14.5	" +S
( 0.0°)	25.79	1.32(1)	" + " + "	-	14.12	14.93(1)	" +S
				-	14.02	15.22(5)	" +S
				-	13.61	15.18(3)	" +Cl
				(1.239)	18.4	10.4	S
(1.102)	8.78	4.07	S·10	(1.249)	22.7	7.06	" +Cl
(1.159)	17.2	3.26	"	-	22.77	6.02(1)	" + "
(1.224)	24.3	3.39	" +Cl	-	22.98	6.80(3)	" + "
				(1.2453)	23.1	6.89(4)	" + "
				-	23.23	7.20(5)	" + "
				(1.216)	24.6	3.35	Cl
<u>Results at 10.2°</u>				<u>Results at 30°</u>			
-	5.42	7.86(4)	S·10				
-	11.51	5.87(4)	"				
-	15.97	5.23(4)	"				
-	21.03	5.26(4)	"	(1.283)	3.35	26.0	S·10
-	23.39	5.64(4)	" +Cl	(1.291)	5.68	25.0	" +S
(1.236)	23.2	5.41	" + "	-	12.2	16.2	S
-	25.21	2.26(4)	Cl	-	18.0	9.70	"
				1.237	23.0	6.68	" +Cl
<u>Results at 17.5°</u>							
(1.339)	8.12	8.51	S·10				
(1.190)	16.9	6.8	"				
(1.247)	22.3	7.31	" +Cl				

(Cont.)

(Cont.)

- (1) Foote and Schairer, 1930
- (2) Pelling, 1925
- (3) Takejima, 1920, 1921
- (4) Schreinmakers and deBaat, 1909
- (5) Bogoyavlenskii and Sukmanskaya, 1955

## THE SYSTEM SODIUM CHLORIDE - SODIUM SULFATE - WATER--Cont.

Results of Chretien, 1926, 1929--Cont.

Cl·2 = NaCl·2H<sub>2</sub>O; Cl = NaCl; S·10 = Na<sub>2</sub>SO<sub>4</sub>·10H<sub>2</sub>O; S = Na<sub>2</sub>SO<sub>4</sub>

Gms. per 100 gms. sat. sol.				Gms. per 100 gms. sat. sol.			
density	NaCl	Na <sub>2</sub> SO <sub>4</sub>	Solid Phase	density	NaCl	Na <sub>2</sub> SO <sub>4</sub>	Solid Phase
<u>Results at 38° (5)</u>				<u>Results at 75°</u>			
-	0.0	33.06	S	-	7.76	19.7	S
-	1.90	30.21	"	-	16.5	10.2	"
-	3.71	27.68	"	(1.207)	25.3	4.95	" + Cl
-	8.19	21.68	"	(1.189)	26.4	2.14	Cl
-	12.27	16.43	"	<u>Results at 94.5 (2)</u>			
-	14.32	14.09	"	-	23.2	26.3	S
-	15.42	13.10	"	-	15.56	10.8	"
-	15.70	12.60	"	-	25.8	4.42	" + Cl
-	17.51	10.90	"	-	27.15	2.43	Cl
-	17.90	10.70	"	<u>Results at 100°</u>			
-	18.17	10.22	"	-	7.67	18.6	S
-	20.64	8.13	"	-	18.4	8.75	"
-	20.92	7.96	"	(1.194)	25.9	4.51	" + Cl
-	23.60	5.97	" + Cl	(1.777)	27.2	1.84	Cl
-	23.98	4.93	Cl	<u>Results at 109.1° (b. pt.)</u>			
-	24.83	3.47	"	-	26.4	5.01	S + Cl
-	25.59	1.97	"				
-	25.85	1.34	"				
-	26.69	0.0	"				

<u>Results at 50°</u>				(1) Foote and Schairer, 1930
(1.247)	7.85	20.8	S	(2) Pelling, 1925
(1.216)	16.1	11.3	"	(3) Takejani, 1920, 1921
(1.223)	24.1	5.54	" + Cl	(4) Schreinemakers and deBaas, 1909
(1.203)	25.4	2.56	Cl	(5) Bogoyaulenskii and Sukmanskaya, 1955

Results of Seidell, 1902

(See also tables preceding and following)

Gms. per 100 gms. H <sub>2</sub> O			Gms. per 100 gms. H <sub>2</sub> O			Gms. per 100 gms. H <sub>2</sub> O		
d.	NaCl	Na <sub>2</sub> SO <sub>4</sub>	d.	NaCl	Na <sub>2</sub> SO <sub>4</sub>	d.	NaCl	Na <sub>2</sub> SO <sub>4</sub>
<u>Results at 10°</u>			<u>Results at 25°*</u>			<u>Results at 30°</u>		
1.080	0.0	9.14	1.2173	2.96	26.60	1.281	0.0	39.70
1.083	4.28	6.42	1.2162	5.79	24.32	1.282	2.45	38.25
1.102	9.60	4.76	1.2150	9.90	21.41	1.284	5.61	36.50
1.150	15.65	3.99	1.2275	13.43	19.62	1.290	7.91	35.96
1.164	21.82	3.97	1.2385	15.82	19.64	1.276	10.61	31.64
1.192	28.13	4.15	1.2571	19.13	20.73 <sup>a</sup>	1.270	12.36	29.87
1.207	30.11	4.34	1.2476	23.22	16.28	1.258	15.65	25.02
1.217	32.27	4.59	1.2429	26.54	12.64	1.249	18.44	21.30
1.223	33.76	4.75	1.2438	31.06	9.98	1.244	20.66	19.06
			1.2451	32.41	9.93			
			1.2453	33.00	9.84 <sup>b</sup>			
			1.2309	33.81	6.66	<sup>a</sup> Solid phase: Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub>		
(1) Cameron, Bell and Robinson, 1907			1.2162	34.60	3.38	<sup>b</sup> Solid phase: Na <sub>2</sub> SO <sub>4</sub> + NaCl		
			1.2002	35.80	0.0			

# Na SODIUM

## THE SYSTEM SODIUM CHLORIDE - SODIUM SULFATE - WATER--Cont.

Results of Seidell, 1902--Cont.

Cl	Gms. per 100 gms. H <sub>2</sub> O			Gms. per 100 gms. H <sub>2</sub> O			Gms. per 100 gms. H <sub>2</sub> O		
	d.	NaCl	Na <sub>2</sub> SO <sub>4</sub>	d.	NaCl	Na <sub>2</sub> SO <sub>4</sub>	d.	NaCl	Na <sub>2</sub> SO <sub>4</sub>
	Results at 21.5°			Results at 27°			Results at 33°--Cont.		
	1.164	0.0	21.33	1.228	0.0	31.10	1.315	2.64	44.09
	1.169	9.05	15.48	1.230	2.66	28.73	1.309	3.47	42.61
	1.199	17.48	13.73	1.230	5.29	27.17	1.265	12.14	29.32
	1.214	20.41	13.62	1.235	7.90	26.02	1.237	21.87	16.83
	1.243	26.01	15.05	1.259	16.13	24.83	1.234	32.84	8.76
	1.244	26.53	14.44	1.253	18.91	21.39	1.217	33.99	4.63
	1.244	27.74	13.39	1.249	19.64	20.11	1.208	34.77	2.75
	1.244	31.25	10.64	1.245	20.77	19.29			
	1.243	31.80	10.28	1.238	32.33	9.53	Results at 35°		
	1.245	32.10	8.43	Results at 33°			1.324	0.0	47.94
	1.219	33.69	4.73	1.329	0.0	48.48	1.314	2.14	43.75
	1.212	34.08	2.77	1.323	1.22	46.49	1.256	13.57	26.26
	1.197	35.46	0.00	1.318	1.99	45.16	1.238	18.78	19.74
							1.231	31.91	8.28
							1.193	35.63	0.00

Compositions of Invariant Solutions from -10° to +35°  
(Pel'sh, 1949)

(Also see preceeding tables)

Sat. Sol. Wt. %			Sat. Sol. Wt. %			Sat. Sol. Wt. %		
t °	NaCl	Na <sub>2</sub> SO <sub>4</sub>	t °	NaCl	Na <sub>2</sub> SO <sub>4</sub>	t °	NaCl	Na <sub>2</sub> SO <sub>4</sub>
<u>Solid Phase</u>			<u>Solid Phase</u>			<u>Solid Phase</u>		
<u>NaCl+Na<sub>2</sub>SO<sub>4</sub></u>			<u>Na<sub>2</sub>SO<sub>4</sub>+Na<sub>2</sub>SO<sub>4</sub>·10H<sub>2</sub>O</u>			<u>NaCl+Na<sub>2</sub>SO<sub>4</sub>·10H<sub>2</sub>O</u>		
35	23.46	6.06	32.38	0.0	33.20	17	22.70	7.00
34	23.40	6.13	32	0.91	31.90	16	23.07	6.26
33	23.35	6.21	31	3.08	28.60	15	23.38	5.60
32	23.38	6.29	30	5.17	25.60	14	23.65	5.00
31	23.23	6.37	29	7.17	22.90	13	23.90	4.51
30	23.17	6.45	28	9.07	20.50	12	24.14	4.07
29	23.11	6.53	27	10.86	18.39	11	24.34	3.66
28	23.05	6.62	26	12.53	16.54	10	24.52	3.34
27	22.98	6.71	25	14.08	14.92	9	24.70	3.00
26	22.92	6.80	24	15.51	13.50	8	24.85	2.71
25	22.85	6.89	23	16.82	12.25	7	24.98	2.45
24	22.78	6.98	22	18.02	11.14	6	25.10	2.22
23	22.72	7.09	21	19.13	10.15	5	25.22	2.00
22	22.65	7.19	20	20.18	9.27	4	25.32	1.81
21	22.58	7.30	19	21.21	8.49	3	25.41	1.63
20	22.50	7.41				2	25.50	1.48
19	22.43	7.55				1	25.58	1.33
17.9	22.34	7.70 <sup>a</sup>				0.1	25.64	1.22 <sup>b</sup>

<sup>a</sup>Solid phase NaCl+Na<sub>2</sub>SO<sub>4</sub>+Na<sub>2</sub>SO<sub>4</sub>·10H<sub>2</sub>O

<sup>b</sup>Solid phase NaCl+NaCl·2H<sub>2</sub>O+Na<sub>2</sub>SO<sub>4</sub>·10H<sub>2</sub>O

(Cont.)

## THE SYSTEM SODIUM CHLORIDE - SODIUM SULFATE - WATER--Cont.

Compositions of Invariant Solutions from  $-10^{\circ}$  to  $+35^{\circ}$ --Cont.  
(Pel'sh, 1949)

t°	Sat. Sol. Wt. %	
	NaCl	Na <sub>2</sub> SO <sub>4</sub>
	Solid Phase NaCl·2H <sub>2</sub> O+Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	
0	25.63	1.21
-1	25.57	1.07
-2	25.47	0.96
-3	25.36	0.87
-4	25.24	0.79
-5	25.13	0.71
-6	25.00	0.64
-7	24.88	0.58
-8	24.76	0.52
-9	24.65	0.47
-10	24.53	0.43

C1

Data for the system  $\text{Na}_2\text{SO}_4 + \text{NaCl} + \text{C}_2\text{H}_5\text{OH} + \text{H}_2\text{O}$  at  $15^{\circ}$ ,  $25^{\circ}$  and  $35^{\circ}$  are given by Schreinemakers and de Baat (1909), and Schreinemakers (1910).

The solubility of NaCl+Na<sub>2</sub>SO<sub>4</sub> in solutions of NH<sub>3</sub> and NH<sub>3</sub>+CO<sub>2</sub> at  $35^{\circ}$  and  $60^{\circ}$  is given by Nenno and Drozin, 1955.

## Multicomponent Systems

NaCl-Na <sub>2</sub> SO <sub>4</sub> -CaSO <sub>4</sub> -H <sub>2</sub> O	25°	(Cameron, Bell and Robinsor, 1907)
NaCl-Na <sub>2</sub> SO <sub>4</sub> -NaNO <sub>3</sub> -H <sub>2</sub> O	-24.4° to +121.7°	(Chretien, 1926, 1929)
	25°	(Rode, 1947 much detail; Levina, 1938)
2NaCl+MgSO <sub>4</sub> = Na <sub>2</sub> SO <sub>4</sub> +MgCl <sub>2</sub> (+H <sub>2</sub> O)	-5° to -20°	(Iljinski and Sagaidotschny, 1931)
NaCl-Na <sub>2</sub> SO <sub>4</sub> -NaOH-H <sub>2</sub> O	25°	(Itkina and Kokhova, 1953)
NaCl-Na <sub>2</sub> SO <sub>4</sub> -NaOH-H <sub>2</sub> O	150° to 350°	(Ravich and Elenevskaya, 1957)
		(Schroeder, Gabriel and Partridge, 1935)
		(Schmoeder, Berk and Gabriel, 1937)
NaCl-Na <sub>2</sub> SO <sub>4</sub> -NaOH-H <sub>2</sub> O	high temp.	(Ravich and Borovaya, 1957)
NaCl-Na <sub>2</sub> SO <sub>4</sub> -Na <sub>2</sub> CO <sub>3</sub> -NaOH-H <sub>2</sub> O	25°	(Itkina and Kokhova, 1953)



# Na SODIUM

## THE SYSTEM SODIUM CHLORIDE - SODIUM THIOSULFATE - WATER AT 25° (Radicev, 1928)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	NaCl		Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	NaCl	
0	26.45	NaCl	32.98	9.86	NaCl+Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O
4.54	24.11	"	33.80	9.03	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O
9.80	21.62	"	35.48	7.31	"
16.66	18.00	"	39.52	3.37	"
25.67	13.37	"	43.10	0.0	"

## C1 THE SYSTEM SODIUM CHLORIDE - SODIUM SULFAMATE - WATER AT 25° (Ricci and Selikson, 1952)

Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
d.	NaSO <sub>3</sub> NH <sub>2</sub>	NaCl		d.	NaSO <sub>3</sub> NH <sub>2</sub>	NaCl	
1.427	55.25	0.0	Na <sub>2</sub> SO <sub>3</sub> NH <sub>2</sub> ·H <sub>2</sub> O	1.459	43.03	11.21	Na <sub>2</sub> SO <sub>3</sub> NH <sub>2</sub> ·H <sub>2</sub> O
-	52.14	2.75	"				+NaCl
1.459	49.99	4.34	"	1.412	37.26	13.09	NaCl
1.452	46.24	7.79	"	1.336	25.21	17.27	"
1.495	47.69	9.69 <sup>m</sup>	"	1.260	12.24	21.97	"
				1.196	0.0	26.47	"

<sup>m</sup>metastable

## THE SYSTEM SODIUM CHLORIDE - SODIUM PYROVANADATE - WATER AT 35° (V. V. Andreev, 1957)

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
NaCl	Na <sub>4</sub> V <sub>2</sub> O <sub>7</sub>		NaCl	Na <sub>4</sub> V <sub>2</sub> O <sub>7</sub>	
36.20	0.0	NaCl	23.87	35.04	NaCl
31.79	5.35	"	11.63	69.23	" + Na <sub>4</sub> V <sub>2</sub> O <sub>7</sub>
27.26	21.30	"	0.0	63.29	Na <sub>4</sub> V <sub>2</sub> O <sub>7</sub>

## THE SYSTEM 2NaCl + PbSO<sub>4</sub> = PbCl<sub>2</sub> + Na<sub>2</sub>SO<sub>4</sub> (+H<sub>2</sub>O) (Gromov, 1940)

<u>Results at 25°</u>			<u>Results at 50°</u>			<u>Results at 100°</u>			Solid Phase
Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.			
NaCl	Na <sub>2</sub> SO <sub>4</sub>	PbCl <sub>2</sub>	NaCl	Na <sub>2</sub> SO <sub>4</sub>	PbCl <sub>2</sub>	NaCl	Na <sub>2</sub> SO <sub>4</sub>	PbCl <sub>2</sub>	
25.7	0.0	2.53	26.0	0.0	4.92	26.9	0.0	12.81	A+B
23.4	3.40	2.34	25.0	2.04	4.49	25.9	1.08	12.7	A+B+C
22.3	7.1	0.60	24.2	5.37	0.62	26.3	4.76	1.43	A+C+D
0.0	0.0	0.99	0.0	Trace	1.76	-	-	-	B+C
A = NaCl			B = PbCl <sub>2</sub>		C = PbSO <sub>4</sub>	D = Na <sub>2</sub> SO <sub>4</sub>		E = Na <sub>2</sub> SO <sub>4</sub> · 10H <sub>2</sub> O	

A = NaCl

B = PbCl<sub>2</sub>

C = PbSO<sub>4</sub>

D = Na<sub>2</sub>SO<sub>4</sub>

E = Na<sub>2</sub>SO<sub>4</sub>·10H<sub>2</sub>O

(Cont.)

THE SYSTEM  $2\text{NaCl} + \text{PbSO}_4 \rightleftharpoons \text{PbCl}_2 + \text{Na}_2\text{SO}_4(+\text{H}_2\text{O})$ --Cont.

<u>Results at 25°</u>			<u>Results at 50°</u>			<u>Results at 100°</u>			Solid Phase
Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.			
NaCl	Na <sub>2</sub> SO <sub>4</sub>	PbCl <sub>2</sub>	NaCl	Na <sub>2</sub> SO <sub>4</sub>	PbCl <sub>2</sub>	NaCl	Na <sub>2</sub> SO <sub>4</sub>	PbCl <sub>2</sub>	
14.4	15.0	0.0	-	-	-	-	-	-	D+E
23.2	6.85	0.0	23.5	5.49	0.0	25.0	4.59	0.0	A+D
0	21.6	0	0.0	32.0	0.0	0.0	29.6	0.0	C+E
									C+D

A = NaCl      B = PbCl<sub>2</sub>      C = PbSO<sub>4</sub>      D = Na<sub>2</sub>SO<sub>4</sub>      E = Na<sub>2</sub>SO<sub>4</sub> · 10H<sub>2</sub>O

A = NaCl      B = PbCl<sub>2</sub>      C = PbSO<sub>4</sub>      D = Na<sub>2</sub>SO<sub>4</sub>      E = Na<sub>2</sub>SO<sub>4</sub>·10H<sub>2</sub>O

Cl

THE SYSTEM SODIUM CHLORIDE - BERYLLIUM CHLORIDE - WATER AT 25°  
(Bliden, 1956)

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
NaCl	BeCl <sub>2</sub>		NaCl	BeCl <sub>2</sub>	
26.50	0.0	NaCl	2.96	19.87	NaCl
21.37	3.74	"	1.75	22.52	"
15.64	7.86	"	1.05	25.84	"
12.42	10.29	"	-	28.85	"
8.15	14.28	"	0.0	41.72	BeCl <sub>2</sub> ·4H <sub>2</sub> O
4.09	18.49	"			

SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS CALCIUM CHLORIDE SOLUTIONS  
AT 25°  
(Mills and Wells, 1918)Additional data are given under CaCl<sub>2</sub>. See also Mun and Darer, 1956 and Druzhinin and Shepelev, 1956.

d <sub>25</sub> of Sat. Sol.	Gms. per 100 gms. sat. sol.		d <sub>25</sub> of Sat. Sol.	Gms. per 100 gms. sat. sol.	
	CaCl <sub>2</sub>	NaCl		CaCl <sub>2</sub>	NaCl
1.207	1.103	25.30	1.225	9.50	17.55
1.210	2.160	24.32	1.233	11.48	15.91
1.209	3.220	23.37	1.241	17.77	10.54
1.216	5.451	20.43	1.257	21.00	8.05
1.220	7.398	19.17	1.276	24.58	5.63

# Na SODIUM

## THE SYSTEM NaCl - CaCl<sub>2</sub> - HCl - H<sub>2</sub>O AT 25° (Druzhinin and Shepelev, 1956)

Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
CaCl <sub>2</sub>	HCl	NaCl		CaCl <sub>2</sub>	HCl	NaCl	
45.09	4.13	0.37	Ca·6+NaCl+αCa·4	29.77	20.06	0.24	NaCl+βCa·4+Ca·2
43.25	5.51	0.22	NaCl+αCa·4	18.05	22.03	0.18	NaCl+Ca·2
35.33	14.38	0.22	" + "	27.81	21.83	0.0	Ca·2
31.23	18.86	0.23	" + "	28.59	22.05	0.35	NaCl+αCa·4+βCa·4
43.52	0.0	1.03	" + Ca·6	28.49	20.56	0.0	αCa·4+βCa·4
0.0	35.59	1.13	NaCl	28.57	21.30	0.0	βCa·4+Ca·2
44.72	3.20	0.0	Ca·6+αCa·4				

Cl Ca·2 = CaCl<sub>2</sub>·2H<sub>2</sub>O      α, βCa·4 = α, βCaCl<sub>2</sub>·4H<sub>2</sub>O      Ca·6 = CaCl<sub>2</sub>·6H<sub>2</sub>O

## THE SYSTEM SODIUM CHLORIDE - CESIUM CHLORIDE - WATER (Flyushchev, Tulinova, Kuznetsova, Korovin and Shipetina, 1957)

Gms. per 100 gms. sat. sol.		dens. sat. sol.	Gms. per 100 gms. wet residue		Solid Phase
NaCl	CsCl		NaCl	CsCl	
<u>Results at 25°</u>					
26.58	-	1.199			NaCl
21.77	8.31	1.306	90.05	1.25	"
16.78	27.98	1.476	80.09	7.60	"
12.37	41.76	1.640	-	-	"
11.95	42.33	1.642	71.64	13.10	"
11.95	42.28	1.644	29.76	50.97	NaCl + Solid Solution
			27.71	56.71	" + "
8.37	49.26	1.710	12.90	73.99	Solid Solution
2.98	57.32	1.861	5.74	83.64	"
1.60	62.94	1.900	1.48	96.68	"
0.97	64.16	1.903	0.76	97.57	"
0.62	64.85	1.915	0.31	92.74	"
-	65.77	1.924			CsCl
<u>Results at 50°</u>					
26.78	-	1.188			NaCl
23.78	7.88	1.270	-	-	"
22.16	12.82	1.285	82.33	3.50	"
17.33	26.21	1.411	75.00	8.20	"
12.75	40.30	1.571	66.57	15.75	"
9.27	50.97	1.730	72.75	15.52	"
8.65	53.17	1.774	73.16	21.41	NaCl + Solid Solution
			45.02	53.55	" + "
6.22	57.00	-	18.41	72.00	Solid Solution
5.06	59.53	1.855	9.99	70.69	"
3.51	62.49	1.900	4.51	77.96	"
1.95	65.66	1.945	2.35	85.99	"
1.30	66.40	-	1.08	92.00	"
-	68.61	1.991			CsCl

(Cont.)

## THE SYSTEM SODIUM CHLORIDE - CESIUM CHLORIDE - WATER--Cont.

Gms. per 100 gms. sat. sol.		dens. sat. sol.	Gms. per 100 gms. wet residue		Solid Phase
NaCl	CsCl		NaCl	CsCl	
<u>Results at 75°</u>					
27.24	-	1.181			NaCl
23.01	11.69	1.266	98.42	0.45	"
20.24	17.20	1.330	91.14	1.76	"
17.66	26.85	1.379	95.75	1.23	"
13.30	36.10	1.512	93.07	3.28	"
10.86	45.55	1.688	92.72	2.09	"
7.20	57.99	1.844	91.05	5.24	"
6.75	59.62	1.889	44.01	43.98	NaCl + Solid Solution
			10.74	47.47	" + "
5.14	62.45	1.919	8.39	77.69	Solid Solution
2.90	66.19	1.942	4.77	81.39	"
0.43	69.47	-	0.47	93.05	"
-	70.62	2.039			CsCl

Cl

THE SYSTEM SODIUM CHLORIDE - MAGNESIUM CHLORIDE - WATER  
(Achowmow and Wassilijew, 1932)

(See also under magnesium chloride. Additional data are given by Pozner and Biryukova, 1954)

t°	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	t°	Gms. per 1000 gms. H <sub>2</sub> O		Solid Phase
	MgCl <sub>2</sub>	NaCl			MgCl <sub>2</sub>	NaCl	
100	100	282	NaCl	175	100	330	NaCl
"	300	106	"	"	300	156	"
"	500	12	"	"	500	52	"
"(1.384)	718	8	" + MgCl <sub>2</sub>	"	900	13	"
125	100	298	NaCl	"(1.442)	1220	trace	" + MgCl <sub>2</sub>
"	300	120	"	200	100	354	NaCl
"	500	20	"	"	300	176	"
"(1.411)	902	5	" + MgCl <sub>2</sub>	"	500	60	"
150	100	312	NaCl	"	700	28	"
"	300	138	"	"	900	20	"
"	500	34	"	"(1.462)	1315	trace	" + MgCl <sub>2</sub>
"(1.428)	1072	2	" + MgCl <sub>2</sub>				

The figures in parentheses are densities.

# Na SODIUM

## THE SYSTEM SODIUM CHLORIDE - LEAD CHLORIDE - WATER AT 25° (Deacon, 1927)

	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
	NaCl	PbCl <sub>2</sub>		NaCl	PbCl <sub>2</sub>	
Cl	35.96	0.0	NaCl	10.00	0.214	PbCl <sub>2</sub>
	36.30	0.82	"	8.00	0.188	"
	36.70	2.01	"	6.00	0.175	"
	36.99	3.48	" + PbCl <sub>2</sub>	5.00	0.167	"
	32.0	2.15	PbCl <sub>2</sub>	4.00	0.172	"
	28.0	1.38	"	2.00	0.209	"
	24.0	0.89	"	1.56	0.252	"
	20.0	0.60	"	0.50	0.720	"
	14.30	0.352	"	0.0	1.098	"

## THE SYSTEM SODIUM CHLORIDE - PLATINUM CHLORIDE - WATER (Kurnakov and Nikitina, 1940)

Data for the system NaCl - PtCl<sub>4</sub> - H<sub>2</sub>O at 25° are given by Kumakov and Genke, 1924, and the general nature of the system is similar to that indicated below. The freezing points of some mixtures in the system were determined by Kurnakov and Ravich, 1932.

Gms. per 100 gms. Sat. Sol.			Solid Phase	Gms. per 100 gms. Sat. Sol.			Solid Phase
NaCl	PtCl <sub>4</sub>			NaCl	PtCl <sub>4</sub>		
Results at 40°				Results at 60°			
0.0	62.38	P.5		0.0	74.75	P.4	
0.11	61.47	P.5+D.6		1.71	72.35	"	
2.91	60.43	D.6		3.84	69.25	"	
4.35	59.05	"		4.75	68.11	P.4+D.6	
5.28	56.33	"		5.15	66.54	D.6	
6.19	53.60	"		5.98	65.41	"	
7.43	50.03	"		6.55	61.96	"	
16.93	42.79	"		7.75	59.67	"	
11.11	40.31	"		8.91	56.09	"	
13.14	37.89	"		10.64	51.80	"	
14.66	33.60	"		11.95	48.30	"	
20.69	30.57	"		15.23	43.90	"	
20.18	29.26	"		16.19	40.98	"	
23.80	25.54	"		18.64	38.04	"	
23.33	24.36	"		21.30	34.56	"	
29.71	20.37	D.6+N		23.69	35.13	"	
29.05	19.79	"		25.49	33.87	"	
28.83	18.76	N		29.04	32.48	"	
28.50	17.48	N		30.97	31.93	"	
24.44	19.75	N		31.87	31.73	"	
28.14	1.78	N		33.44	31.13	D.6+N	
27.04	0.0	N		32.35	29.95	N	
				31.30	25.37	N	
				29.27	20.79	N	
				29.02	11.73	N	
				26.95	5.89	N	
				27.15	0.0	N	
							(Cont.)

P.5 = PtCl<sub>4</sub>·5H<sub>2</sub>O  
P.4 = PtCl<sub>4</sub>·4H<sub>2</sub>O  
P.3 = PtCl<sub>4</sub>·3H<sub>2</sub>O  
D.6 = Na<sub>2</sub>PtCl<sub>6</sub>·6H<sub>2</sub>O  
N = NaCl

## THE SYSTEM SODIUM CHLORIDE - PLATINUM CHLORIDE - WATER--Cont.

Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
NaCl	PtCl <sub>4</sub>		NaCl	PtCl <sub>4</sub>	
Results at 90°			Results at 98°		
0.0	82.50	P.3	0.0	85.11	P.3
1.85	76.55	"	1.36	82.64	"
3.58	76.34	"	2.69	80.52	"
4.83	75.66	"	3.33	78.89	"
6.36	72.75	P.3+D-6	4.37	78.15	"
7.50	70.21	D-6	4.60	77.29	"
8.54	66.18	"	5.83	76.27	P.3+D-6
10.44	63.48	"	7.24	72.86	D-6
13.25	57.66	"	9.57	68.15	"
17.52	50.58	"	12.13	63.49	"
14.12	46.22	"	17.26	57.02	"
24.43	41.35	"	18.52	53.39	"
36.48	32.11	D-6+N	21.87	47.19	"
35.67	29.44	N	25.34	43.60	"
35.61	25.69	N	30.57	41.99	"
35.17	22.12	N	38.20	32.34	"
34.48	15.70	N	43.73	32.10	D-6+N
33.03	8.93	N	42.65	27.42	N
31.24	3.79	N	39.61	23.14	N
28.01	0.0	N	38.38	18.60	N
			35.26	12.01	N
			31.40	1.44	N
			28.40	0.0	N

Cl

P.5 = PtCl<sub>4</sub>·5H<sub>2</sub>OP.4 = PtCl<sub>4</sub>·4H<sub>2</sub>OP.3 = PtCl<sub>4</sub>·3H<sub>2</sub>OD.6 = Na<sub>2</sub>PtCl<sub>6</sub>·6H<sub>2</sub>O

N = NaCl

SODIUM PLATINUM CHLORIDE Na<sub>2</sub>PtCl<sub>6</sub>SOLUBILITY OF SODIUM CHLOROPLATINATE IN WATER  
(Kurnakov and Nikitina, 1940)

t°	Gms. Na <sub>2</sub> PtCl <sub>6</sub> per 100 gms. Sat. Sol.	Mole % Na <sub>2</sub> PtCl <sub>6</sub>	Solid Phase
0	38.70	2.44	Na <sub>2</sub> PtCl <sub>6</sub> ·6H <sub>2</sub> O
25	44.91	3.13	"
30	47.87	3.51	"
35	49.04	3.67	"
40	50.67	3.79	"
60	57.07	5.01	"
70	59.12	5.42	"
80	65.25	6.93	"
90	68.10	7.81	"
98	71.91	9.21	"

# Na SODIUM

## THE SYSTEM SODIUM CHLORIDE - STRONTIUM CHLORIDE - WATER (Assarsson, 1953)

Na = NaCl

Sr2 =  $\text{SrCl}_2 \cdot 2\text{H}_2\text{O}$

Sr6 =  $\text{SrCl}_2 \cdot 6\text{H}_2\text{O}$

Isothermally invariant compositions are given at many temperatures between 18° and 114°.

	At 18°			At 60°			At 100°		
	Sat.Sol.Wt.%		Solid Phase	Sat.Sol.Wt.%		Solid Phase	Sat.Sol.Wt.%		Solid Phase
	$\text{SrCl}_2$	NaCl		$\text{SrCl}_2$	NaCl		$\text{SrCl}_2$	NaCl	
Cl	0.0	26.0	Na	0.0	27.0	Na	0.0	28.5	Na
	9.0	20.1	"	8.9	21.2	"	8.8	22.5	"
	18.0	14.2	"	17.8	15.2	"	17.5	17.2	"
	24.3	10.1	"	24.0	11.6	"	23.6	13.1	"
	26.7	8.7	"	36.9	5.1	"	36.4	6.6	"
	27.1	8.6	Na, Sr6	44.0	3.0	"	48.0	3.8	"
	28.0	7.2	Sr6	44.3	2.9	Na, Sr2	48.2	3.6	Na, Sr2
	29.6	5.5	"	44.8	2.2	Sr2	48.7	3.5	Sr2
	34.3	0.0	"	45.8	0.9	"	50.8	0.0	"
				46.1	0.5	Sr6			
				46.2	0.0	"			

Assarsson, 1953 gives data for the system  $\text{NaCl} - \text{SrCl}_2 - \text{KCl} - \text{H}_2\text{O}$  between 18° and 114°.

## SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS SOLUTIONS OF: (Herz and Hiebenthal, 1929)

Potassium Chromate		Potassium Dichromate		Potassium Permanganate	
Gm. Mol. per liter sat. sol.		Gm. Mol. per liter sat. sol.		Gm. Mol. per liter sat. sol.	
$\text{K}_2\text{CrO}_4/6$	NaCl	$\text{K}_2\text{Cr}_2\text{O}_7/6$	NaCl	$\text{KMnO}_4/5$	NaCl
0.71	5.25	0.16	5.29	0.0	5.38
0.93	5.18	0.40	5.28	0.02	5.29
1.31	5.12	0.79	5.25	0.49	5.24
1.86	5.04	1.29	5.16	1.26	5.09
3.57	4.65	1.57	5.11	+1.53	5.15
+4.49	4.25	+2.06	5.03		

## SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS POTASSIUM NITRATE AT 25° (Ritzel, 1911)

Gms. per 100 cc. Sat. Sol.		Gms. per 100 cc. Sat. Sol.	
$\text{KNO}_3$	NaCl	$\text{KNO}_3$	NaCl
0	31.80	12	30.86
4	32.26	16	30.45
8	31.85	20	30.10

Data for the solubility of NaCl in aqueous  $\text{MgCl}_2$  solutions are given by Feit and Przibylla (1909).

SOLUBILITY OF SODIUM CHLORIDE IN AMMONIUM NITRATE SOLUTIONS  
(Rengade, 1917, 1922)

Equimolecular mixtures of  $\text{NH}_4\text{NO}_3 + \text{NaCl}$  or of  $\text{NaNO}_3 + \text{NH}_4\text{Cl}$  were evaporated at gradually increasing temperatures and the solutions analyzed after the separation of  $\text{NaCl}$  and before the appearance of  $\text{NH}_4\text{Cl}$ , which could be easily distinguished by its crystalline form. The four ions were determined and the results arbitrarily expressed in terms of  $\text{NH}_4\text{NO}_3 + \text{NaCl}$ .

t°	Gms. per 100 gms. H <sub>2</sub> O		t°	Gms. per 100 gms. H <sub>2</sub> O		t°	Gms. per 100 gms. H <sub>2</sub> O		NaNO <sub>3</sub>	Cl
	NH <sub>4</sub> NO <sub>3</sub>	NaCl		NH <sub>4</sub> NO <sub>3</sub>	NaCl		NH <sub>4</sub> NO <sub>3</sub>	NaCl		
80*	81	46	108*	435	100	118	750	140	0	
98*	128	56	111	464	101	124	2,015	320	35	
100*	139	59	115	683	137	129	3,500	427	29	

\*These solutions prepared from equimolecular mixtures of  $\text{NaNO}_3 + \text{NH}_4\text{Cl}$ , and the others from equimolecular mixtures of  $\text{NH}_4\text{NO}_3 + \text{NaCl}$ . The results were intended for use in the industrial preparation of  $\text{NH}_4\text{NO}_3$ .

The specific volumes and heat capacities of solutions of  $\text{NaCl}$  in aqueous ammonium nitrate were determined by Rutskov, 1948.

SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS SOLUTIONS SIMULTANEOUSLY  
SATURATED WITH OTHER SALTS

The various papers of J. H. van't Hoff and collaborators on this subject were collected by H. Precht and E. Cohn in a volume entitled "Untersuchungen über die Bildungsverhältnisse der Ozeanischen Salzablagerungen," Leipzig, 1912, p. 374. By far the larger part of the "new" data in these papers is for solutions simultaneously saturated with three or more salts. The various systems are described in detail and diagrams are given. A table summarizing much of the data (van't Hoff (1905)) is given below.

Mols. per 1000 Mols. H <sub>2</sub> O					Solution Saturated with Respect to NaCl and:
Na <sub>2</sub> Cl <sub>2</sub>	K <sub>2</sub> Cl <sub>2</sub>	MgCl <sub>2</sub>	MgSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	
1	0.5	105	-	-	MgCl <sub>2</sub> ·6H <sub>2</sub> O + Carnallite
2	5.5	70.5	-	-	KCl + Carnallite
44	20	-	-	4.5	" + Glaserite
44	10.5	-	-	14.5	Na <sub>2</sub> SO <sub>4</sub> + Glaserite
46	-	-	16.5	3.0	" + Astrakanite
26	-	7	34	-	MgSO <sub>4</sub> ·7H <sub>2</sub> O + Astrakanite
4	-	67.5	12	-	" + MgSO <sub>4</sub> ·6H <sub>2</sub> O
2.5	-	79	9.5	-	Kieserite + "
1	-	101	5	-	" + MgCl <sub>2</sub> ·6H <sub>2</sub> O
23	14	21.5	14	-	KCl + Glaserite + Schönite
19.5	14.5	25.5	14.5	-	" + Leonite + Schönite
9.5	9.5	47	14.5	-	" + " + Kainite
2.5	6	68	5	-	" + Carnallite + Kainite

Carnallite =  $\text{KMgCl}_3 \cdot 6\text{H}_2\text{O}$ , Glaserite =  $\text{K}_3\text{Na}(\text{SO}_4)_2$ , Astrakanite =  $\text{Na}_2\text{Mg}(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O}$ , Kieserite =  $\text{MgSO}_4 \cdot \text{H}_2\text{O}$ , Leonite =  $\text{MgK}_2(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O}$ , Schönite =  $\text{MgK}_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ , Kainite =  $\text{MgSO}_4 \cdot \text{KCl} \cdot 3\text{H}_2\text{O}$ .

(Cont.)



# Na SODIUM

## SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS SOLUTIONS SIMULTANEOUSLY SATURATED WITH OTHER SALTS--Cont.

Mols. per 1000 Mols. H <sub>2</sub> O					Solution Saturated with Respect to NaCl and:
Na <sub>2</sub> Cl <sub>2</sub>	K <sub>2</sub> Cl <sub>2</sub>	MgCl <sub>2</sub>	MgSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	
1	1	85.5	8	-	Kieserite+Carnallite+Kainite
42	8	-	16	6	Na <sub>2</sub> SO <sub>4</sub> +Glaserite+Astrakanite
27.5	10.5	16.5	18.5	-	Schönite+Glaserite+Astrakanite
22	10.5	23	19	-	Leonite+Glaserite+Astrakanite
10.5	7.5	42	19	-	" + MgSO <sub>4</sub> ·7H <sub>2</sub> O+Astrakanite
9	7.5	45	19.5	-	" + " + Kainite
3.5	4	65.5	13	-	MgSO <sub>4</sub> ·6H <sub>2</sub> O+MgSO <sub>4</sub> ·7H <sub>2</sub> O+Kainite
1.5	2	77	10	-	MgSO <sub>4</sub> ·6H <sub>2</sub> O+Kieserite+Kainite
1	0.5	100	5	-	Carnallite+MgCl <sub>2</sub> ·6H <sub>2</sub> O+Kainite
1	0.5	105	-	-	MgCl <sub>2</sub> ·6H <sub>2</sub> O+Carnallite
2	5.5	70.5	-	-	KCl+Carnallite
			CaCl <sub>2</sub>		
1	-	51.5	90.5	-	MgCl <sub>2</sub> ·6H <sub>2</sub> O+Tachhydrite
1	11	-	146	-	KCl+CaCl <sub>2</sub> ·6H <sub>2</sub> O
1	-	35.5	121.5	-	Tachhydrite+CaCl <sub>2</sub> ·6H <sub>2</sub> O
1	1.5	50.5	90.5	-	MgCl <sub>2</sub> ·6H <sub>2</sub> O+Tachhydrite+Carnallite
1	9.5	5	141.5	-	CaCl <sub>2</sub> ·6H <sub>2</sub> O+KCl+Carnallite
1	2	34.5	121.5	-	CaCl <sub>2</sub> ·6H <sub>2</sub> O+Tachhydrite+Carnallite

Carnallite =  $\text{KMgCl}_3 \cdot 6\text{H}_2\text{O}$ , Glaserite =  $\text{K}_3\text{Na}(\text{SO}_4)_2$ , Astrakanite =  $\text{Na}_2\text{Mg}(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O}$ , Kieserite =  $\text{MgSO}_4 \cdot \text{H}_2\text{O}$ , Leonite =  $\text{MgK}_2(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O}$ , Schönite =  $\text{MgK}_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ , Kainite =  $\text{MgSO}_4 \cdot \text{KCl} \cdot 3\text{H}_2\text{O}$ .

Results for the solubility of NaCl in Dead Sea brines at 27.5° and 50° are given by Schnerb and Yaron, 1952.

## SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS METHYL ALCOHOL (Armstrong and Eyre, 1910-11)

Results at 0°		Results at 25°	
Solvent, Gms. CH <sub>3</sub> OH per 1000 Gms. H <sub>2</sub> O	Gms. NaCl per 100 Gms. Sat. Sol.	Solvent, Gms. CH <sub>3</sub> OH per 1000 Gms. H <sub>2</sub> O	Gms. NaCl per 100 Gms. Sat. Sol.
0	26.35	8.01	26.29
8.01	26.05	16.02	26.02
16.02	25.79	32.04	25.50
32.04	29.19	96.12	23.50

## SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS SOLUTIONS OF METHYL ALCOHOL AT 25° (Akerlof and Turck, 1935)

Wt. % CH <sub>3</sub> OH in solvent	Gm. Mols. NaCl per 1000 gms. solvent	Wt. % CH <sub>3</sub> OH in solvent	Gm. Mols. NaCl per 1000 gms. solvent
0.0	6.162	60.10	1.328
10.59	5.038	70.83	0.8656
20.49	4.096	80.45	0.5544
30.16	3.273	89.29	0.3685
39.80	2.552	100.00	0.2367
50.65	1.896		

## SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS SOLUTIONS OF ETHYL ALCOHOL

0°, 25°	Armstrong and Eyre, 1910-11	30°, 40°	Taylor, 1897
11.5°, 13°	Bodlander, 1891	16°, 25°, 35°	Ferner and Mellon, 1934
28°	Fontein, 1910	4°-60°	Gerardin, 1856

[Check each table]

(Armstrong and Eyre, 1910-11)

Results at 0°		Results at 25°		Cl	
Solvent Gms. C <sub>2</sub> H <sub>5</sub> OH per 1000 Gms. H <sub>2</sub> O	Gms. NaCl per 100 Gms. Sat. Sol.	D <sub>25</sub> of Sat. Sol.	Solvent Gms. C <sub>2</sub> H <sub>5</sub> OH per 1000 Gms. H <sub>2</sub> O		Gms. NaCl per 100 Gms. Sat. Sol.
0	26.46	1.202	0	26.55	
11.51	25.97	1.196	11.51	26.06	
23.03	25.48	1.190	23.03	25.63	
46.06	24.41	1.179	46.06	24.75	
138.18	20.95	1.159	92.12	23.29	
		1.1115	230.3	19.35	

(Bodlander, 1891)

Results at 11.5°				Results at 13°			
Sp. Gr. of Solutions	Gms. per 100 cc. Solution			Sp. Gr. of Solutions	Gms. per 100 cc. Solution		
	C <sub>2</sub> H <sub>5</sub> OH	H <sub>2</sub> O	NaCl		C <sub>2</sub> H <sub>5</sub> OH	H <sub>2</sub> O	NaCl
1.2035	0	86.62	31.73	1.2030	0	88.70	31.60
1.1865	2.86	86.14	29.66	1.1348	11.81	78.41	23.26
1.1710	5.41	83.93	27.77	1.1144	15.99	74.64	20.81
1.1548	7.93	81.50	26.05	1.0970	19.39	71.45	18.86
1.1350	10.84	78.78	24.28	1.0698	24.95	65.80	16.23
1.1390	11.22	78.62	23.65	1.0295	32.33	57.96	12.66
1.1088	16.85	73.40	20.63	0.9880	40.33	49.34	9.13
				0.9445	49.28	38.54	5.93
				0.9075	57.91	29.37	3.47
				0.8700	63.86	21.62	1.52
				0.8400	72.26	11.24	0.50

(Fontein, 1910)

Results at 28°					
Gms. per 100	Gms. Sat. Sol.		Gms. per 100	Gms. Sat. Sol.	
C <sub>2</sub> H <sub>5</sub> OH	H <sub>2</sub> O	NaCl	C <sub>2</sub> H <sub>5</sub> OH	H <sub>2</sub> O	NaCl
0	73.53	26.47	45.35	45.35	9.3
3.8	71.6	24.6	56.2	37.5	6.3
7.7	69.7	22.6	67.4	28.9	3.7
16.1	64.6	19.3	78.8	19.7	1.5
25.3	58.9	15.8	89.6	10.0	0.4
35.0	52.5	12.5			

(Cont.)

# Na SODIUM

## SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS SOLUTIONS OF ETHYL ALCOHOL--Cont.

(Taylor, 1897)

Cl	Wt. per cent Alcohol in Solvent	Results at 30°		Results at 40°	
		Gms. NaCl per 100 Gms.		Gms. NaCl per 100 Gms.	
		Solution	Water	Solution	Water
	0	26.50	36.05	26.68	36.38
	5	24.59	34.29	24.79	34.69
	10	22.66	32.57	22.90	33.00
	20	19.05	29.40	19.46	30.20
	30	15.67	26.53	16.02	27.25
	40	12.45	23.70	12.75	24.37
	50	9.34	20.60	9.67	21.42
	60	6.36	16.96	6.65	17.82
	70	3.36	12.75	3.87	13.10
	80	1.56	7.95	1.69	8.68
	90	0.43	4.30	0.50	5.10

## SOLUBILITY OF SODIUM CHLORIDE IN CONCENTRATED AQUEOUS ETHYL ALCOHOL (Ferner and Mellon, 1934)

Wt. Percent C <sub>2</sub> H <sub>5</sub> OH in solvent	Gms. NaCl per 100 gms. solvent at:				
	16°	20°	25°	35°	100°
20.4	-	-	22.86 <sup>b</sup>	-	-
42.5	-	-	12.84 <sup>b</sup>	-	-
50.0	-	9.8 <sup>a</sup>	-	-	12.1 <sup>a</sup>
69.7	-	-	4.07 <sup>b</sup>	-	-
86.4	0.5767	-	0.6417	0.6586	-
89.6	0.3711	-	0.4181	0.4345	-
92.3	0.2358	-	0.2670	0.2706	-
96.9	0.1183	-	0.1220	0.1335	-
100.0	0.0657	-	0.0657	0.0667	-

<sup>a</sup>Wright, 1927

<sup>b</sup>Flatt and Jordan, 1933

(Gerardin, 1856)

100 gms. alcohol of 0.9282 Sp. Gr. = 45.0% by wt. dissolve at

4°	10°	13°	23°	32°	33°	44°	51°	60°
10.9	11.1	11.43	11.9	12.3	12.5	13.1	13.8	14.1
								gms. NaCl

Additional data for the solubility of NaCl in aqueous ethanol are given by Barkan, 1953.

100 gms. of a mixture of equal parts of 96% alcohol and 98% ether dissolve 0.11 gm. NaCl. (Mayer, Liebig's Ann. 98, 205, '56)

SOLUBILITY OF SODIUM CHLORIDE AT 20° IN AQUEOUS 30 PER CENT  
ETHYL ALCOHOL CONTAINING INCREASING AMOUNTS OF BENZENE  
(Wright, 1926; See also Grinberg and Zemlyakova, 1948)

Per cent $C_6H_6$ in aq. 50% alcohol	0.0	1.91	4.10	5.34	7.95
Gms. NaCl per 100 gms. sat. sol.	9.80	9.86	9.95	10.10	10.35

Results are given by Fontein, 1910 showing the solubility of sodium chloride in mixtures of ethyl alcohol, amyl alcohol and water at 28°, both when one liquid phase is present and when conjugated liquid layers are formed.

THE SYSTEM SODIUM CHLORIDE, NORMAL PROPYL ALCOHOL AND WATER AT 23°-25°  
(Frankforter and Frary, 1913)

C1

The authors determined the binodal curve and quadruple points of the system but did not locate tie lines.

Gms. per 100 Gms. Homogeneous Liquid			Gms. per 100 Gms. Homogeneous Liquid		
NaCl	$C_3H_7OH$	$H_2O$	NaCl	$C_3H_7OH$	$H_2O$
0.55	87.7	11.75	14.38	5.39	80.23
2.23	51.57	46.20	15.42	5.11	79.47
3.55	18.99	77.46	16.38	4.47	79.14
3.90	14.78	81.32	18.08	3.83	78.09
5.27	12.77	81.96	20.12	3.27	76.61
8.04	9.49	82.47	22.35	2.64	75.01
10.49	7.79	81.72	24.50	2.13	73.37
12.20	6.57	81.23	24.9	2.3	72.8*

\*Quad. pt.

The effect of temperature upon the equilibrium in the above system was greater than observed in any of the other systems investigated and additional data, illustrating the extent of the temperature influence, are given.

SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS PROPYL ALCOHOL  
(Armstrong and Eyre, 1910-11)

Aqueous propyl alcohol containing 15.01 gms.  $C_3H_7OH$  per 1000 cc.  $H_2O$  dissolves 25.71 gms. NaCl per 100 gms. sat. solution at 0° and 25.95 gms. at 25°.

Aqueous propyl alcohol containing 30.02 gms.  $C_3H_7OH$  per 1000 cc.  $H_2O$  dissolves 25.12 gms. NaCl per 100 gms. sat. solution at 0° and 25.37 gms. at 25°.

100 gms. sat. sol. of NaCl in 99.6 per cent  $C_3H_7OH$  contain 0.04 gm. NaCl at 25°. (Frankforter and Frary, 1913)

# Na SODIUM

## THE SYSTEM SODIUM CHLORIDE - ISO PROPYL ALCOHOL - WATER AT 25° (Ginninge and Chen, 1931)

Points on the binodal curve of this system were determined by observing the appearance or disappearance of clouding in a mixture of weighed amounts of NaCl and one of the liquids, upon addition of weighed amounts of the other. Tie lines, \*, were located by determination of NaCl in two liquid layers in contact with each other and the plait point, PP, was found by plotting.

	Gms. per 100 gms. of the three constituents		Gms. per 100 gms. of the three constituents	
	NaCl	CH <sub>3</sub> CH <sub>2</sub> OHCH <sub>3</sub>	NaCl	CH <sub>3</sub> CH <sub>2</sub> OHCH <sub>3</sub>
C1	1.70	75.20*	10.62	23.90
	2.95	64.35	13.70	15.70
	5.20	49.50PP	21.10	5.9*
	10.17	25.45		

## SOLUBILITY OF SODIUM CHLORIDE IN CONCENTRATED SOLUTIONS OF 2-PROPANOL (ISO PROPYL ALCOHOL) IN WATER (Ferner and Mellon, 1934)

Wt. Percent CH <sub>3</sub> CH <sub>2</sub> OHCH <sub>3</sub> in solvent	Gms. NaCl per 100 gms. solvent at:		
	16°	25°	35°
87.7	0.2650	0.2812	0.2968
92.6	0.0647	0.0630	0.0701
96.5	0.0169	0.0161	0.0183
100.0	0.0040	0.0041	0.0030

## SOLUBILITY OF SODIUM CHLORIDE IN ISO PROPYL ALCOHOL CONTAINING SMALL AMOUNTS OF WATER AT 25° (Kraus and Seward, 1928)

d. of solvent	% H <sub>2</sub> O in solvent	Gm. mols. NaCl per liter solvent	d. of solvent	% H <sub>2</sub> O in solvent	Gm. mols. NaCl per liter solvent
0.7849	0.0	0.0004246	0.7885	1.39	0.0008025
0.7854	0.084	0.0004399	0.7900	2.02	0.001100
0.7868	0.815	0.0006034	0.7985	5.88	0.004138

## THE SYSTEM SODIUM CHLORIDE - ALLYL ALCOHOL - WATER AT 20° (Frankforter and Temple, 1915)

Gms. per 100 Gms. Alcohol + Water			Gms. per 100 Gms. Alcohol + Water		
NaCl	Alcohol	Water	NaCl	Alcohol	Water
3.509	69.867	30.133	8.776	47.132	52.868
4.452	64.858	33.142	10.650	40.392	59.608
5.079	60.821	39.179	12.535	33.224	66.776
6.712	54.683	45.317	14.925	27.261	72.739
			18.557	19.705	80.295

(Cont.)

## THE SYSTEM SODIUM CHLORIDE - ALLYL ALCOHOL - WATER AT 20°--Cont.

The binodal curve for the System Sodium Chloride, Allyl Alcohol and Water at 25° has been determined by Ginnings and Dees, 1935, but the authors do not give their experimental results but only the values of a series of arbitrary constants calculated by means of an empirical equation. From these the conclusion is drawn that allyl alcohol seems to be more difficult to salt out than either normal or iso propyl alcohol.

The effect of the addition of 0.02-0.08 molar sodium chloride on the mutual solubility of n-butyl alcohol and water is reported by Reber, McNabb, and Lucasse, 1942.

THE SYSTEM NaCl - ISOBUTANOL - WATER AT 25°  
(Fritzschke and Stockton, 1946)

C1

Sat. Sol. Wt. %		Sat. Sol. Wt. %	
i-butanol	NaCl	i-butanol	NaCl
0.0	26.0	6.6	1.5
1.2	22.0 <sup>a</sup>	85.1	0.2
2.6	11.8	96.5	0.4 <sup>a</sup>
5.6	3.3		

<sup>a</sup>Triple points - 2 liquids + NaCl in equilibrium.

THE SYSTEM SODIUM CHLORIDE - TERTIARY BUTYL ALCOHOL - WATER AT 30°  
(Ginnings and Robbins, 1930)

The determinations were made as noted above.

Gms. per 100 gms. of the three constituents		Gms. per 100 gms. of the three constituents		Gms. per 100 gms. of the three constituents	
NaCl	(CH <sub>3</sub> ) <sub>3</sub> COH	NaCl	(CH <sub>3</sub> ) <sub>3</sub> COH	NaCl	(CH <sub>3</sub> ) <sub>3</sub> COH
0.0	84.0	4.3	27.7	10.7	- *
0.3	83.8	4.5	26.0	11.2	8.5
-	60.0*	4.6	23.0 <sup>PP</sup>	12.5	7.5
1.5	57.3	5.1	19.0	13.9	-
-	48.0*	6.7	14.5	14.1	6.7
2.4	44.4	9.0	11.5	15.6	5.8
3.2	36.4	10.0	10.0	18.4	4.2
				22.4	-*

The plait point PP, at 25° was found by Ginnings, Herring and Webb, 1933, to have the composition -3.7 percent NaCl + 36.7 percent (CH<sub>3</sub>)<sub>3</sub>COH + 59.6 percent H<sub>2</sub>O. The original results for the remaining points on the binodal curve are not given but only the values of arbitrary constants derived by empirical equations.

# Na SODIUM

## SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS GLYCEROL SOLUTIONS

### Results at 20°

(Holm, 1921, 1922)

100 gms. 86.5% glycerol (d = 1.2326) dissolve 10.37 gms. NaCl at 20°  
 " 98.5% " " (d = 1.2645) " 8.28 gms. " "

### Results at 25°

(Herz and Knoch, 1905)

C1	Wt. Per cent Glycerol in Solvent	NaCl per 100 cc. Solution		Sp. Gr. of Solution
		Millimols.	Gms.	
	0	545.6	31.93	1.1960
	13.28	501.1	29.31	1.2048
	25.98	448.4	26.23	1.2133
	45.36	370.2	21.66	1.2283
	54.23	333.9	19.54	1.2381
	83.84	220.8	12.91	1.2666
	100*	167.1	9.78	1.2964

\*Sp. Gr. of Glycerol, 1.2592. Impurities about 1.5%.

100 gms. 95% formic acid dissolve 5.8 gms. NaCl at 19.7°.  
 (Aschan, 1913)

## THE SYSTEM SODIUM CHLORIDE - BUTYRIC ACID - WATER AT 25°

(Bury and Mends, 1939)

The mixtures separate into two liquid layers at concentrations of butyric acid between 1.47 and 85.25 percent.

Results for Solutions  
in contact with NaCl

Results for mixtures yielding two liquid layers

Upper Layer

Lower Layer

Gms. per 100 gms.  
sat. sol.

Gms. per 100 gms.  
sat. sol.

Gms. per 100 gms.  
sat. sol.

C<sub>4</sub>H<sub>8</sub>O<sub>2</sub>      NaCl

C<sub>4</sub>H<sub>8</sub>O<sub>2</sub>      NaCl

C<sub>4</sub>H<sub>8</sub>O<sub>2</sub>      NaCl

0.0      26.45  
 0.22      26.30  
 0.68      26.05  
 1.30      25.76  
 1.47      25.68  
 89.25      0.12  
 90.37      0.11  
 93.27      0.07  
 94.06      0.06  
 97.44      0.03  
 99.98      0.02

34.86      1.90  
 36.50      1.69  
 38.73      1.58  
 41.50      1.49  
 44.78      1.42  
 50.78      1.35  
 60.42      0.9  
 70.20      0.85  
 76.38      0.65  
 85.65      0.50  
 88.12      0.31(tr.pt.)

32.70      2.0  
 31.75      2.07  
 28.90      2.20  
 27.10      2.26  
 22.76      2.50  
 18.64      3.20  
 12.62      4.44  
 7.76      10.15  
 5.65      14.05  
 3.00      21.15  
 1.77      25.48

THE SYSTEM SODIUM CHLORIDE - ISO BUTYRIC ACID - WATER AT 25°  
(Bury and Mends, 1939)

Results for  
solutions in  
contact with NaCl

Results for mixtures yielding  
two liquid layers

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
iso C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>	NaCl	iso C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>	NaCl	iso C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>	NaCl
0.24	26.31	57.26	0.0	24.10	0.0
0.73	26.11	69.34	0.10	15.80	1.25
1.17	25.88	78.40	0.11	10.80	3.95
95.53	0.06	86.86	0.14	5.59	10.63
96.24	0.04	90.10	0.14	3.67	15.54
98.24	0.03	94.13	0.14	2.43	20.88
99.99	0.01	94.78	0.14(tr.pt.)	1.40	25.77

Cl

THE SYSTEM SODIUM CHLORIDE - ACETONE - WATER AT 20°  
(Frankforter and Cohen, 1914;  
additional data are given by Herz and Knoch, 1904)

Gms. per 100 Gms. Sat. Sol.			Gms. per 100 Gms. Sat. Sol.		
NaCl	H <sub>2</sub> O	(CH <sub>3</sub> ) <sub>2</sub> CO	NaCl	H <sub>2</sub> O	(CH <sub>3</sub> ) <sub>2</sub> CO
25.9	73.06	1.04	16.55	61.59	21.86*
24.19	71.18	4.03	0.45	13.75	85.8*
20.85	66.78	12.37	0.32	13.92	85.76
18.32	63.16	18.52	0.19	10.82	88.99
17.89	62.21	19.90	0.12	8.94	90.94

\*Quad pt.

Between the concentration 21.86 and 85.8 per cent acetone, two layers are formed. The binodal curve corresponding to this range of concentration was determined and it is stated by the authors that tie lines were located but the analytical data for them are not given. The results for the binodal curve are as follows:

Gms. per 100 Gms. Homogeneous Liquid			Gms. per 100 Gms. Homogeneous Liquid		
NaCl	H <sub>2</sub> O	(CH <sub>3</sub> ) <sub>2</sub> CO	NaCl	H <sub>2</sub> O	(CH <sub>3</sub> ) <sub>2</sub> CO
0.59	15.46	83.95	5.87	40.19	53.94
0.79	17.58	81.63	6.45	42.12	51.43
0.93	18.83	80.24	7.53	46.12	46.35
1.27	22.19	76.54	8.87	49.39	41.74
1.57	23.89	74.54	9.47	50.92	39.61
2.31	27.27	70.42	10.35	53.06	36.59
4.87	36.79	58.34	15.87	59.71	24.42

Additional data, showing the effect of temperature on the above system, are also given.



# Na SODIUM

## THE SYSTEM SODIUM CHLORIDE - METHYL ETHYL KETONE - WATER AT 25° (BINODAL CURVE) (Frankforter and Cohen, 1916)

Gms. per 100 Gms. Homogeneous Liquid			Gms. per 100 Gms. Homogeneous Liquid		
NaCl	CH <sub>3</sub> ·CO·C <sub>2</sub> H <sub>5</sub>	H <sub>2</sub> O	NaCl	CH <sub>3</sub> ·CO·C <sub>2</sub> H <sub>5</sub>	H <sub>2</sub> O
0.35	20.13	79.52	6.75	10.80	82.45
0.55	19.75	79.70	10.07	7.65	82.28
1.42	16.52	82.06	14.32	5.36	80.32
1.80	17.70	80.50	14.65	3.82	81.52
2.47	16.24	81.29	23.15	2.08	74.77
4.11	13.34	82.55	24.14	0.94	74.92

C1

100 cc. of a mixture of equal volumes of ethyl ether and water saturated with HCl at 0° will dissolve 0.0012 gms. of NaCl. (Fischer and Seidel, 1941).

## THE SYSTEM SODIUM CHLORIDE - DIOXANE - WATER AT 25° (Herz and Lorentz, 1929)

Vol. percent C <sub>4</sub> H <sub>8</sub> O <sub>2</sub> in solvent	Gm. Mol. NaCl per liter of solution
10	4.70
20	4.00
30	3.68

Between 23 and 85 Vol. percent dioxane the mixtures separate into two liquid layers. The lower, H<sub>2</sub>O rich layer, contains 3.28 gm. mol. NaCl per liter and the upper, dioxane rich layer, contains 0.01 gm. mol. NaCl per liter.

## SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS SOLUTIONS OF TARTARIC ACID AT 25° (Herz and Hiebenthal, 1929)

Gms. per liter		Solid Phase	Gms. per liter		Solid Phase
C <sub>4</sub> H <sub>6</sub> O <sub>6</sub>	NaCl		C <sub>4</sub> H <sub>6</sub> O <sub>6</sub>	NaCl	
0.0	314.5	NaCl	242.0	283.5	NaCl
92.0	308.7	"	630.0	229.7	"
161.0	298.1	"	733.0	216.3	" + C <sub>4</sub> H <sub>6</sub> O <sub>6</sub>

EQUILIBRIUM IN THE SYSTEM SODIUM CHLORIDE ETHYL URETHAN AND WATER AT 25°  
(Palitzsch, 1928, 1929)

Gm. Mols. per 1000 gms. H <sub>2</sub> O			Gm. Mols. per 1000 gms. H <sub>2</sub> O		
NaCl	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>	Solid Phase	NaCl	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>	Solid Phase
6.12	0.0	NaCl	2.20	21.78	Upper liq. layer
6.12	0.1123	"	4.65	1.785	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>
5.96	0.5612	"	3.55	3.581	"
5.86	1.119	" + NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>	1.0	39.0	"
3.21	5.187	Lower liq. layer	0.0	53.09	"

## SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS UREA SOLUTIONS

C1

## Results of Ritzel at 25°

Gms. CO(NH <sub>2</sub> ) <sub>2</sub> per 100 cc. Solution	Gms. NaCl per 100 cc. Solution
0	31.80
5	30.63
9.6	29.05
13	28.46
18	27.65
23	27.24
28	26.56

## Results of Fastert, 1912

Gms. CO(NH <sub>2</sub> ) <sub>2</sub> per 100 cc. Solution	Gms. NaCl per 100 cc. Solution
10	31.92
20	32.17
30	32.51
40	32.93
50	33.40

THE SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS THIOUREA SOLUTIONS AT 29.93°  
(Taft and Anderson, 1950)

The invariant solution contains 23.5 wt. % NaCl, 7.8 wt. % thiourea.

Salt/Thiourea ratio	Soly. NaCl Gms. per 100 gms. H <sub>2</sub> O	Salt/Thiourea ratio	Soly. Thiourea g./100 g. H <sub>2</sub> O
10:0	36.05	7:3	12.7
9:1	35.3	6:4	14.7
8:2	35.1	5:5	16.0
		4:6	17.4
		3:7	19.1
		2:8	20.0
		1:9	20.8
		0:10	21.1

## Na SODIUM

### SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS FORMAMIDE SOLUTIONS AT 25° (Ritzel, 1911)

Gms. HCO-NH <sub>2</sub> per 100 cc. Solution	Gms. NaCl per 100 cc. Solution	Gms. HCO-NH <sub>2</sub> per 100 cc. Solution	Gms. NaCl per 100 cc. Solution
0	31.80	11	29.11
2.3	30.98	15	28.52
5.3	30.86	18.8	27.76
8	30.40		

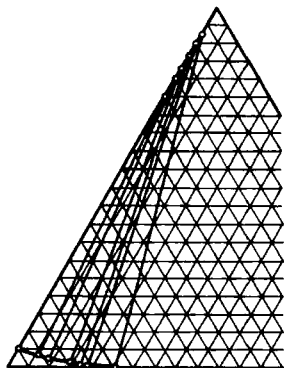
Data for equilibrium in the system sodium chloride-succinonitrile-water are given by Timmermans (1907).

C1

### THE SYSTEM SODIUM CHLORIDE - PYRIDINE - WATER

Arakawa, Kawaguchi and Kato, 1958 give results for the system at 30°, 50° and 60° in graphic form. The binodal curve and plait point of the system at 25° has been determined by Ginnings, Webb and Hinohara, 1933, but the authors do not give their experimental results but only the values of a series of constants calculated by means of empirical equations.

### THE SYSTEM NaCl - DIPROPYLAMINE - WATER AT 20° (Ishiguro, Kametani and Oka, 1956)



For results in the system NaCl - heptylamine - water at 30° see Arakawa and Kawaguchi, 1958.

IN THE SYSTEM SODIUM CHLORIDE - GLUCOSE - WATER AT 24°  
(Matsuura, 1927)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>	NaCl		C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>	NaCl	
0.0	26.46	NaCl	36.90	14.50	1.2.1
2.84	25.87	"	38.67	13.61	"
5.21	25.28	"	41.62	11.92	"
9.90	24.10	"	44.05	10.95	"
13.09	23.38	"	47.35	9.57	" + C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> · H <sub>2</sub> O
19.77	21.90	"	47.23	8.28	C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> · H <sub>2</sub> O
23.87	20.83	"	47.73	7.65	"
27.81	19.87	"	47.74	6.97	"
29.47	19.50	" + 1.2.1	48.08	5.60	"
31.70	18.10	1.2.1	48.12	4.04	"
33.74	16.87	"	48.55	2.49	"
34.92	15.98	"	48.68	0.00	"

Cl

1.2.1 = NaCl · 2 C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> · H<sub>2</sub>O

SOLUBILITY OF GLUCOSE SODIUM CHLORIDE DOUBLE SALT IN WATER  
(Lebedev, Lubin and Khai, 1950)

t°	Sat. Sol. Wt. %		Solid Phase Wt. %	
	C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>	NaCl	C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>	NaCl
-10	16.1	14.8	89.8	1.57
- 2.5	20.2	16.0	-	-
+ 2.5	22.4	14.2	66.0	5.1
5	26.8	12.7	62.5	5.5
10	29.6	12.5	73.2	5.4
15	35.8	11.8	64.9	5.4
20	44.1	10.8	77.1	2.8
25	49.3	9.3	74.6	10.1
30	53.6	9.3	74.6	12.8
35	54.9	8.9	70.7	12.3
40	57.0	9.7	75.6	12.9

SOLUBILITY OF DEXTROSE (GLUCOSE) SODIUM CHLORIDE IN  
HYDROCHLORIC ACID SOLUTIONS AT 30°  
(Ough and Peckham, 1946)

The solubility of the double salt in pure water was found to be 61.4 gms. (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>)<sub>2</sub> · NaCl per 100 gms. sat. sol. at 30° (compare with above).

Mixtures of the pure double salt, water, and concentrated hydrochloric acid were weighed into flasks which were held at 30° for 1/2 hour with intermittent shaking. The solutions and wet residues were analyzed for NaCl, dextrose, and HCl, and the solid was identified under the microscope.

(Cont.)

# Na SODIUM

## SOLUBILITY OF DEXTROSE (GLUCOSE) SODIUM CHLORIDE IN HYDROCHLORIC ACID SOLUTIONS AT 30°--Cont.

Saturated Solution Wt. %			Solid Phase	Saturated Solution Wt. %			Solid Phase
$C_6H_{12}O_6$	NaCl	HCl		$C_6H_{12}O_6$	NaCl	HCl	
42.9	7.4	7.3	D.S.	24.7	1.4	19.3	NaCl
42.6	7.4	6.7	"	29.7	4.0	13.5	"
42.7	7.2	6.1	"	37.2	5.5	10.1	"
37.1	4.5	11.4	D.S.+NaCl	39.4	6.2	9.2	"
36.6	4.4	11.6	"	42.1	6.7	8.1	"

D.S. =  $(C_6H_{12}O_6)_2 \cdot NaCl \cdot H_2O$

C1

## THE SYSTEM SODIUM CHLORIDE - SUCROSE - WATER AT 25° (Schoorl, 1923)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
NaCl	$C_{12}H_{22}O_{11}$		NaCl	$C_{12}H_{22}O_{11}$	
23.3	12.7	NaCl	8.6	62.2	$1.1.2 + C_{12}H_{22}O_{11}$
17.5	36.7	"	11.5	61.7	NaCl + "
16.2	43.0	" + 1.1.2	6.15	63.0	$C_{12}H_{22}O_{11}$
9.75	57.0	1.1.2	1.62	66.0	"

1.1.2 =  $NaCl \cdot C_{12}H_{22}O_{11} \cdot 2H_2O$

The author also gives very complete vapor tension data for this system.

100 gms.  $H_2O$  dissolve 236.3 gms. sugar + 42.3 gms. NaCl at 31.25°, or 100 gms. sat. aq. solution contain 62.17 gms. sugar + 11.13 gms. NaCl. (Köhler, 1897)

## SOLUBILITY OF SODIUM CHLORIDE IN AQUEOUS ETHYL ALCOHOL SOLUTIONS OF HYDROCHLORIC ACID AT 25° (Akerlof, Teare and Turek, 1937)

Gm. Mols. HCl per 1000 gms. solvent	Gm. Mols. NaCl per 1000 gms. solvent containing:					
	0% $C_2H_5OH$	10% $C_2H_5OH$	20% $C_2H_5OH$	30% $C_2H_5OH$	40% $C_2H_5OH$	50% $C_2H_5OH$
0.0	6.162	5.104	4.133	3.282	2.543	1.892
0.1	6.058	4.983	4.039	3.221	2.474	1.811
0.2	5.951	4.866	3.959	3.112	2.383	1.727
0.3	5.846	4.767	3.856	3.032	2.295	1.666
0.5	5.631	4.574	3.702	2.858	2.144	1.535
0.75	5.361	4.325	3.435	2.645	1.957	1.376
1.0	5.096	4.082	3.213	2.454	1.780	1.222
1.5	4.567	3.616	2.800	2.070	1.477	0.9267
2.0	4.054	3.146	2.397	1.730	1.165	0.7005
2.5	3.569	2.741	2.041	1.404	0.9079	0.5266
3.0	3.100	2.318	1.683	1.129	0.6878	0.3850
3.5	2.660	1.931	1.406	0.8801	0.5208	0.2706
4.0	2.261	1.605	1.112	0.6639	0.3757	0.1902

RECIPROCAL SOLUBILITY OF SODIUM CHLORIDE AND OF SODIUM NITRATE IN  
AQUEOUS SOLUTIONS OF ETHYL ALCOHOL AT 25°  
(Hering, 1926)

Gms. per 100 gms. H <sub>2</sub> O			Solid Phase	Gms. per 100 gms. H <sub>2</sub> O			Solid Phase
C <sub>2</sub> H <sub>5</sub> OH	NaNO <sub>3</sub>	NaCl		C <sub>2</sub> H <sub>5</sub> OH	NaNO <sub>3</sub>	NaCl	
25	0.0	28.8	NaCl	72.3	49.2	0.0	NaNO <sub>3</sub>
25	16.1	25.4	"	150	0.0	16.0	NaCl
25	32.2	22.5	"	150	26.9	11.9	" + NaNO <sub>3</sub>
25	47.0	20.3	" + NaNO <sub>3</sub>	150	33.3	0.0	NaNO <sub>3</sub>
25	57.2	10.2	NaNO <sub>3</sub>	255	0.0	10.1	NaCl
25	69.7	0.0	"	255	19.3	8.1	" + NaNO <sub>3</sub>
72.3	0.0	22.4	NaCl	255	22.7	0.0	NaNO <sub>3</sub>
72.3	18.2	19.0	"	396	0.0	6.7	NaCl
72.3	36.3	16.3	" + NaNO <sub>3</sub>	396	13.8	5.2	" + NaNO <sub>3</sub>
72.3	42.2	8.0	NaNO <sub>3</sub>	396	15.4	0.0	NaNO <sub>3</sub>

Data for the system NaCl-acetic acid-benzene-water at 25° are given  
by Jodra, Otero and Sole, 1955.

SOLUBILITY OF SODIUM CHLORIDE IN SEVERAL ALCOHOLS AT 25°

[See table following for other temperatures]

(Larson and Hunt, 1939)

Alcohol	Formula	d. of sat. sol.	Gms. NaCl per 100 gms. solvent	
Methanol	CH <sub>3</sub> OH	0.7977	1.401	(1.31) <sup>a</sup> (1.40) <sup>b</sup>
Ethanol	C <sub>2</sub> H <sub>5</sub> OH	0.7857	0.0649	(0.065) <sup>a</sup>
1-Propanol	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> OH	0.8000	0.0124	(0.012) <sup>a</sup>
1-Butanol	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>2</sub> CH <sub>2</sub> OH	0.8058	0.0050	(0.014) <sup>e</sup>
2-Propanol (iso)	CH <sub>3</sub> CHOHCH <sub>3</sub>	0.7809	0.0027	(0.0024) <sup>d</sup>
2-Methyl-1-propanol (iso butyl)	(CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>2</sub> OH	0.7980	0.0020	
1-Pentanol	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>3</sub> CH <sub>2</sub> OH	0.0899	0.00177	
2-Butanol (Secondary)	CH <sub>3</sub> CH <sub>2</sub> CHOHCH <sub>3</sub>	0.8022	0.00047	
Amyl alcohol	C <sub>5</sub> H <sub>11</sub> OH	-	-	(0.002) <sup>a</sup>
Iso amyl alcohol	i-C <sub>5</sub> H <sub>11</sub> OH	-	-	(0.0016) <sup>c</sup>
m-Hexanol	C <sub>6</sub> H <sub>13</sub> OH	-	-	(0.0008) <sup>c</sup>
n-Ethyl hexanol	-	-	-	(0.0001) <sup>c</sup>

<sup>a</sup>Turner and Bissett, 1913

<sup>b</sup>Pavlopoulos and Strehlow, 1954 (at 18° these authors found 1.44 gms.,  
d. = 0.802; 25° density was 0.798)

<sup>c</sup>Caley and Axilrod, 1942 in gms. per 100 ml. of solvent.

<sup>d</sup>Kraus and Swar, 1918

<sup>e</sup>Willard and Smith, 1922, 1923

# Na SODIUM

## SOLUBILITY OF SODIUM CHLORIDE IN SEVERAL ALCOHOLS AT DIFFERENT TEMPERATURES (Kirm and Dunlap, 1931)

Alcohol	Gm. Mols. NaCl per 100 gms. mols. alcohol at:					
	20°	30°	35°	40°	45°	50°
Methanol	0.778	0.758	0.744	0.734	0.720	0.711
Ethanol	0.1147	0.1197	0.1242	0.1258	0.1293	0.1142
Propanol	0.00446	0.00434	0.00421	0.00417	0.00384	0.0037
Iso propanol	0.096	0.100	0.108	0.102	0.102	0.093
Butanol	0.00695	0.00710	-	0.00762	-	0.00774
Iso butanol	0.00280	0.00292	-	0.00341	-	0.00356

- C1 Data for the solubility of very finely divided NaCl in absolute ethanol, as a function of particle size and surface energy are reported by Van Zeggeren and Benson, 1957.

## SOLUBILITY OF SODIUM CHLORIDE IN ORGANIC SOLVENTS

Solvent	t°	Solubility	Reference
methyl acetate	20	0.00399 gms./100 cc solvent	1
ethyl acetate	19	0.00025 "	1
diethyl acetate	19	0.00371 "	1
butylic acid	20	0.00102 "	1
acetonitrile	18	0.00015 gms./100 gms. solvent	2
"	25	0.00025 "	2
formic acid	18	5.21 " (d.=1.256)	2
"	25	5.21 " (d.=1.251)	2
acetone	18	0.000032 gms./100 cc sat. sol.	3
"	37	0.000035 "	3
ethylene glycol	14.8	31.7 gms./100 gms. sat. sol.	4
"	25	7.15 gms./100 gms. solvent	5
furfural	25	0.08 gms./100 gms. sat. sol.	6
ethylene diamine	25	0.33 gms./100 gms. solvent	7
monoethanolamine	25	1.86 "	7
ethyl urethan	60	0.132 gms./100 cc sat. sol.	8
acetic acid	30	0.076 mols. per 100 mols. sat. sol.	9
"	41	0.081 "	9
"	45	0.085 "	9
"	54	0.097 "	9
"	60	0.105 "	9
"	68	0.115 "	9
"	76	0.130 "	9
"	84	0.145 "	9
"	92	0.166 "	9

<sup>1</sup>Kato and Hagiwara, 1950

<sup>2</sup>Pavlopoulos and Strehlow, 1954

<sup>3</sup>Lanning, 1932

<sup>4</sup>de Coninck, 1905

<sup>5</sup>Isbin and Kobe, 1945

<sup>6</sup>Trimble, 1941

<sup>7</sup>Isbin and Kobe, 1945

<sup>8</sup>Stuckgold, 1917

<sup>9</sup>Davidson and Chappell, 1938

Data for the effect of small amounts of NaCl on the miscibility temperature of methanol and cyclohexane are reported by Eckfeldt and Lucasse, 1943.

SOLUBILITY OF SODIUM CHLORIDE IN ISO PROPYL ALCOHOL CONTAINING  
INCREASING AMOUNTS OF SODIUM NITRATE AT 25°  
(Kraus and Seward, 1927, 1928)

Gm. Mols. per liter		Gm. Mols. per liter		Gm. Mols. per liter	
NaNO <sub>3</sub>	NaCl	NaNO <sub>3</sub>	NaCl	NaNO <sub>3</sub>	NaCl
0.00	0.0004246	0.0005907	0.0003625	0.0015574	0.0003244
0.00008	0.0004159	0.0005984	0.0003640	0.001959	0.0003074
0.0001672	0.0004050	0.0008539	0.0003480	0.002824	0.0002903
0.0004013	0.0003817	0.0013097	0.0003242		

The authors also give results for the Solubility of Sodium Chloride in Iso propyl Alcohol containing 2.02 percent H<sub>2</sub>O and increasing amounts of Sodium Nitrate at 25°.

C1

SOLUBILITY OF SODIUM CHLORIDE IN ISO PROPYL ALCOHOL  
CONTAINING INCREASING AMOUNTS OF AMMONIUM NITRATE AT 25°  
(Kraus and Seward, 1927, 1928)

Gm. Mols. per liter		Gm. Mols. per liter	
NH <sub>4</sub> NO <sub>3</sub>	NaCl	NH <sub>4</sub> NO <sub>3</sub>	NaCl
0.000	0.000455	0.0003537	0.000547
0.0000985	0.000481	0.0006938	0.000617
0.0001839	0.000503	0.0014024	0.000734

SOLUBILITY OF SODIUM CHLORIDE IN LIQUID AMMONIA  
(Patscheke, 1933)

The authors results were plotted and the following values taken from the curve. The results of Johnson and Kromboltz, 1933; Scherer, Jr., 1931; Abe and Hara, 1933; Abe, Sigatomi, and Hara, 1935; Schattenstein and Viktorov, 1936; Linhard and Stephan, 1933, 1934; and Portinow and Rawdine, 1937, agree in general with those of Patscheke. The results of Hunt, 1932, at 25° are apparently too low.

t°	Gms. NaCl per 100 gms. sat. sol.	Solid Phase	t°	Gms. NaCl per 100 gms. sat. sol.	Solid Phase
-76.3	0.0	NH <sub>3</sub>	- 8.5	16.3*	NaCl·5NH <sub>3</sub>
-76.6	0.28	" + NaCl·5NH <sub>3</sub>	- 9.5	15.4	"
-70.0	0.4	NaCl·5NH <sub>3</sub>	-11.5	16.3*	" + NaCl
-60.0	0.55	"	- 5.0	13.4	NaCl
-50	1.15	"	0	11.5	"
-40	2.10	"	+10	7.85	"
-30	4.0	"	20	5.3	"
-20	7.5	"	25	4.2 <sup>a</sup>	"
-15	10.6	"	30	3.2	"
-12.5	12.6	"	40	2.0	"
-10	14.5	"	45	1.0	"

\*Metastable

<sup>a</sup>Watt, Jenkins and Robertson, 1950

(Cont.)



# Na SODIUM

## SOLUBILITY OF SODIUM CHLORIDE IN LIQUID AMMONIA--Cont.

Data for the isotherms of the System  $\text{NaCl} + \text{NH}_4\text{Cl} + \text{NH}_3$  at  $-10^\circ$ ,  $0^\circ$  and  $+10^\circ$  are given by Patscheke and Tanne, 1935. They also give results for the solution temperatures of mixtures in various ratios of  $\text{NaCl}$  and  $\text{NH}_4\text{Cl}$  as compared with the solution temperature of each salt separately.

## THE SYSTEM SODIUM CHLORIDE - SODIUM NITRATE - LIQUID AMMONIA

### Results at $0^\circ$

(Portnow and Rawdine, 1937)

Cl	Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
	NaCl	$\text{NaNO}_3$	$\text{NH}_3$		NaCl	$\text{NaNO}_3$	$\text{NH}_3$	
	11.60	0.0	88.40	NaCl	4.32	31.07	64.61	NaCl
	10.76	3.51	85.73	"	2.21	41.60	56.19	"
	9.34	11.30	79.30	"	0.95	49.64	49.41	"
	7.41	18.77	73.82	"	0.92	50.70	48.38	"
	6.79	21.96	21.25	"	0.83	55.12	44.05	"
	6.43	22.80	20.77	"	0.0	56.04	43.95	"

### Results at $25^\circ$

(Hunt and Boncyk, 1933)

0.25 gm. of the less soluble salt was mixed with variable amounts of the more soluble salt and ammonia added in excess. Ammonia was then allowed to escape from the solution until a single crystal of salt separated from solution. Identical results were obtained by approaching the saturation point from opposite sides.

Gm. Mols. per 100 gms. Mols. $\text{NH}_3$		Gm. MoIs. per 100 gms. Mols. $\text{NH}_3$	
NaCl	$\text{NaNO}_3$	NaCl	$\text{NaNO}_3$
0.088	0.0	0.0686	1.694
0.098	0.46	0.0590	1.787
0.0746	1.232	0.0524	1.80
0.0700	1.482	0.0	1.95

## SOLUBILITY OF SODIUM CHLORIDE IN LIQUID AMMONIA CONTAINING INCREASING AMOUNTS OF SODIUM NITRATE (Guyer, Bieler and Schmid, 1934)

The results are presented only in the form of a diagram from which the following approximate values were read.

(Cont.)

SOLUBILITY OF SODIUM CHLORIDE IN LIQUID AMMONIA CONTAINING  
INCREASING AMOUNTS OF SODIUM NITRATE--Cont.

t°	Gms. NaCl per 100 gms. sat. solution in Liquid Ammonia Containing:				
	0% NaNO <sub>3</sub>	10% NaNO <sub>3</sub>	20% NaNO <sub>3</sub>	30% NaNO <sub>3</sub>	40% NaNO <sub>3</sub>
-30	4.3	4.2	4.1	3.5	3.0
-20	8.0	7.5	7.2	6.0	4.5(-21°)
-9.5	15.4	12.0(-10°)	9.5(-11°)	7.2(-13°)	3.0
0	11.2	9.0	7.0	4.5	2.0
+10	7.5	6.5	4.5	3.5	2.0
20	5.0	4.2	3.0	3.0	2.0

Cl

SOLUBILITY OF SODIUM CHLORIDE IN INORGANIC SOLVENTS

Solvent	t°	Solubility	Reference
Sulfur dioxide (liq)	0	0.016 gm./100 gms. SO <sub>2</sub>	1
"	25	0.00040 gm./100 gms. sat. sol.	2
Hydrazine	Room	8 gms./100 cc N <sub>2</sub> H <sub>4</sub>	3
Hydroxylamine	17.5	14.7 gms./100 gms. NH <sub>2</sub> OH	4
Selenium oxychloride	25	0.57 gms./100 gms. sat. sol.	5

<sup>1</sup>Jander and Wickert, 1936; Jander and Ruppolt, 1937<sup>2</sup>Schatenstein and Viktorov, 1937<sup>3</sup>Welsh and Broderson, 1915<sup>4</sup>de Bruyn, 1892<sup>5</sup>Wise, 1923

Melting points have been determined for:

NaCl+Na <sub>2</sub> CrO <sub>4</sub>	(Sackur, 1911-12; Rassonskaya and Bergman, 1943; Gromakov, 1951)
" +NaF	(Ruff and Plato, 1903; Walters, 1910; Plato, 1907; Volkov and Bergman, 1940a; Rassonskaya and Bergman, 1943; Banashek and Bergman, 1947, 1950; Doucet, Bizouard and Netzer, 1956; Sauerwald and Dombois, 1954; Bergman and Banasher, 1953)
" +NaOH	(Scarpa, 1915)
" +NaI	(Ruff and Plato, 1903; Amadori, 1912a)
" +NaNO <sub>2</sub>	(Meneghini, 1912)
" +Na <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	(LeChatilier, 1894)
" +Na <sub>2</sub> SO <sub>4</sub>	(Ruff and Plato, 1903; Jänecke, 1908; Wolters, 1910; Speranskaya, 1938; Akopov and Bergman, 1954c; Sackur, 1911-12; Bergman and Bakutskaya, 1955; Flood, Forland and Nesland, 1951)
" +SrCl <sub>2</sub>	(Vortisch, 1914; Sackur, 1911-12; Scholich, 1920)
" +SrCO <sub>3</sub>	(Sackur, 1911-12)
" +TiCl <sub>3</sub>	(Sandonini, 1911, 1914)
" +NaNO <sub>3</sub>	(Blidin, 1940)
" +NaVO <sub>3</sub>	(Schmitz-Dumont and Schmitz, 1944)
" +ZnCl <sub>2</sub>	(Nikonova, Pavlenko, and Bergman, 1941)

(Cont.)

## Na SODIUM

### SOLUBILITY OF SODIUM CHLORIDE IN INORGANIC SOLVENTS--Cont.

Melting points have been determined for:  
(Cont.)

NaCl+MgCl <sub>2</sub>	(Markov and Panchenko, 1955)
" +SrSO <sub>4</sub>	(Bye and Holder, 1953)
" +CsCl	(Sumarokova, 1957)
" +ZnSO <sub>4</sub>	(Luzhnaya and Vereshemina, 1949)
" +ZrCl <sub>4</sub>	(Howell, Sommer and Kellogg, 1957; Morozov and Korshunov, 1956; Belozersky and Kucherenko, 1940)
" +CoCl <sub>2</sub>	(Bol'shapov, Federov and Agashkina, 1957)
" +NiCl <sub>2</sub>	(Bol'shapov, Federov and Agashkina, 1957)
Cl " +BaCl <sub>2</sub>	(Bergman and Banashek, 1953)
" +TaCl <sub>5</sub>	(Morozov, Korshunov and Simonich, 1956)
NaCl+TaCl <sub>5</sub> +AlCl <sub>3</sub>	(Morozov, Korshunov and Simonich, 1956)
NaCl+NaF+Na <sub>2</sub> CrO <sub>4</sub>	(Rassonskaya and Bergman, 1943)
NaCl+NbCl <sub>5</sub>	(Morozov, Korshunov and Simonich, 1956; Morozov and Korshunov, 1956)
NaCl+NbCl <sub>5</sub> +AlCl <sub>3</sub>	(Morozov, Korshunov and Simonich, 1956)
NaCl+NaF+Na <sub>2</sub> SO <sub>4</sub>	(Mukimov, 1940)
NaCl+NdCl <sub>3</sub>	(Morozov, Shevtsova and Klyukina, 1957)
NaCl+NdCl <sub>3</sub> +CaCl <sub>2</sub>	(Morozov, Shevtsova and Klyukina, 1957)
NaCl+NaF+K <sub>2</sub> CrO <sub>4</sub>	(Rassonskaya and Bergman, 1953)
2NaCl+PbI <sub>2</sub> = 2NaI+PbCl <sub>2</sub>	(Il'yasov and Bostandzhian, 1956)
2NaCl+ZnSO <sub>4</sub> = Na <sub>2</sub> SO <sub>4</sub> +ZnCl <sub>2</sub>	(Evseeva and Bergman, 1952)
2NaCl+SrF <sub>2</sub> = 2NaF+SrCl <sub>2</sub>	(Bergman(?), 1955)
2NaCl+CdI <sub>2</sub> = 2NaI+CdCl <sub>2</sub>	(Il'yasov and Bergman, 1956)
NaCl+RbNO <sub>3</sub> = NaNO <sub>3</sub> +RbCl	(Blidin, 1941)
2NaCl+BaF <sub>2</sub> = 2NaF+BaCl <sub>2</sub>	(Bergman and Banashek, 1953)

For data on the cryoscopy of various salts and oxides in molten NaCl see Harrison, 1955, 1955a; Harrison, Petit and Plancel, 1955; and Petit and Bourlange, 1953.

Reactions of the salts below the melting points were studied with X-rays by Link and Wood, 1940 for the following salt pairs:

NaCl+KF

NaCl+RbF

NaCl+CsF

## ClO SODIUM HYPOCHLORITE NaClO

### SOLUBILITY OF SODIUM HYPOCHLORITE IN WATER, DETERMINED BY THE FREEZING-POINT METHOD (Sanfourche and Gardnet, 1924)

t°	Gms. NaClO per 100 gms. sat. sol.	Solid Phase
- 2.6	5.0	Ice
- 7.0	10.0	"
-12.0	15.0	"
-16.0	19.2	Ice+NaClO·5H <sub>2</sub> O
-12.0	20.0	NaClO·5H <sub>2</sub> O

(Cont.)

SOLUBILITY OF SODIUM HYPOCHLORITE IN WATER, DETERMINED BY THE  
FREEZING-POINT METHOD--Cont.

t°	Gms. NaClO per 100 gms. sat. sol.	Solid Phase
0	22.7	NaClO·5H <sub>2</sub> O
+10.0	26.7	"
15.0	30.6	"
20.0	34.8	"
23.0	39.0	"
24.0	42.0	"
24.5m.pt.	44.0	"
24.0	46.0	"
23.0tr.pt.	48.5	NaClO·5H <sub>2</sub> O+NaClO·2,5H <sub>2</sub> O
30.0	50.0	NaClO·2,5H <sub>2</sub> O
40.0	52.5	"
50.0	56.5	"
56.0	61.2	"

SODIUM CHLORITE NaClO<sub>2</sub>

ClO

## SOLUBILITY IN WATER

(5°, 17°, 30°, 45°, 60° - Taylor, White, Vincent, and Cunningham, 1940)  
(15°, 25°, 35°, 45° - Cunningham and Oey, 1955, 1955a)

t°	moles NaClO <sub>2</sub> per mole H <sub>2</sub> O	gms. NaClO <sub>2</sub> per 100 gms. sat. sol.	Solid Phase
5	9.8	33.9	NaClO <sub>2</sub> ·3H <sub>2</sub> O
15	8.18	38.1	"
17	7.8	39.2	"
25	6.51	43.6	"
30	5.8	46.4	"
35	4.94	50.4	"
37.4	-	-	" + NaClO <sub>2</sub>
45	4.28(C.O.)	54.0	NaClO <sub>2</sub>
	4.5 (TWVC)	53.0	"
60	4.1	55.0	"

densities: 15°, 1.331; 25°, 1.391; 35°, 1.465; 45°, 1.501 (C.O.)

# Na SODIUM

## THE SYSTEM SODIUM CHLORITE - SODIUM CHLORATE - WATER (Cunningham and Oey, 1955a)

x = moles  $\text{NaClO}_3$  per mole of dissolved salts

w = moles  $\text{H}_2\text{O}$  per mole of dissolved salts

Saturated Solution				Saturated Solution					
	x	w	Sp. gr.	Solid Phase		x	w	Sp. gr.	Solid Phase
<u>Results at 15°</u>					<u>Results at 35°</u>				
ClO	0.0	8.18	1.327	NaClO <sub>2</sub> ·3H <sub>2</sub> O	0.0	4.95	1.406	NaClO <sub>2</sub> ·3H <sub>2</sub> O	
	0.1422	7.23	1.361	"	0.0464	4.54	1.478	"	
	0.2142	6.55	1.383	"	0.1202	4.06	1.515	"	
	0.2537	6.30	1.394	"	0.2276	3.56	1.563	"	
	0.4066	5.12	1.457	"	0.2918	3.42	1.571	"	
	0.4448	4.78	1.482	" + NaClO <sub>3</sub>	0.3177	3.15	1.595	" + NaClO <sub>3</sub>	
	0.5063	4.78	1.483	NaClO <sub>3</sub>	0.3171	3.13	1.595	" + "	
	0.5273	5.09	1.460	"	0.4475	3.82	1.540	NaClO <sub>3</sub>	
	0.7051	5.55	1.439	"	0.5411	4.17	1.516	"	
	0.8574	5.86	1.424	"	0.7103	4.55	1.490	"	
1.000	6.49	1.409	"	0.8657	4.89	1.473	"		
				1.000	5.06	1.467	"		
<u>Results at 25°</u>					<u>Results at 45° -</u>				
	0.0	6.50	1.375	NaClO <sub>2</sub> ·3H <sub>2</sub> O					
	0.0426	6.22	1.394	"	0.0	4.28	1.501	NaClO <sub>2</sub>	
	0.0598	5.98	1.391	"	0.1482	3.64	1.543	"	
	0.0788	5.97	1.402	"	0.2550	3.25	1.586	"	
	0.1374	5.58	1.421	"	0.3524	2.85	1.621	" + NaClO <sub>3</sub>	
	0.1692	5.41	1.463	"	0.4112	3.16	1.590	NaClO <sub>3</sub>	
	0.2351	4.88	1.461	"	0.5141	3.54	1.558	"	
	0.2594	4.72	1.474	"	0.6397	3.97	1.529	"	
	0.3241	4.22	1.508	"	0.7745	4.18	1.510	"	
	0.3652	3.86	1.535	" + NaClO <sub>3</sub>	1.000	4.41	-	"	
	0.3941	4.22	1.520	NaClO <sub>3</sub>					
	0.5004	4.56	1.498	"					
	0.6278	4.87	1.472	"					
	0.7269	5.07	1.461	"					
	0.8053	5.24	1.456	"					
	0.8486	5.30	1.450	"					
	0.9046	5.50	1.446	"					
	1.000	5.88	1.444	"					

### ClO SODIUM CHLORATE $\text{NaClO}_3$

#### SOLUBILITY IN WATER

Values read from the average curve drawn through the very closely agreeing results of LeBlanc and Schmandt, 1911; Osaka, 1903-8; Bell, 1923; Ricci and Weltman, 1942; Ricci and Yanick, 1937; Nallet, 1955. The older values of Carlson, 1910 are too high. Other results are given by Billiter, 1920. The values below lie on a straight line. The solid phase is  $\text{NaClO}_3$  in all cases; values in parentheses are densities.

(Cont.)

## SOLUBILITY IN WATER --Cont.

t°	gms. NaClO <sub>3</sub> per 100 gms. sat. sol.	t°	gms. NaClO <sub>3</sub> per 100 gms. sat. sol.	t°	gms. NaClO <sub>3</sub> per 100 gms. sat. sol.
- 9.8	26.43(1.215) <sup>a</sup>	20	48.9	60	57.9
-17.8	39.74(1.355) <sup>b</sup>	25	50.0(1.424)	70	60.1
-10	41.7	30	51.2	75	61.3
0	44.3	35	52.3	80	62.4
5	45.5	40	53.4	90	64.6
10	46.7	45	54.5	100	66.8
15	47.8(1.406)	50	55.6		

<sup>a</sup>Solid phase = ice<sup>b</sup>Solid phase = ice+NaClO<sub>3</sub>

ClO

THE SYSTEM SODIUM CHLORATE - SODIUM HYDROXIDE - WATER AT 18°  
(Windmeisser and Stockl, 1951)

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
NaOH	NaClO <sub>3</sub>		NaOH	NaClO <sub>3</sub>	
0.0	48.86	NaClO <sub>3</sub>	41.58	3.98	NaClO <sub>3</sub>
6.55	37.86	"	44.56	3.65	"
15.25	25.10	"	46.90	3.56	"
19.93	19.45	"	48.73	3.46	" + NaOH·H <sub>2</sub> O
33.34	7.90	"	51.43	0.0	NaOH·H <sub>2</sub> O

THE SYSTEM SODIUM CHLORATE - SODIUM CHROMATE - WATER  
(Ricci and Weltman, 1942)

Results at 19°			Results at 25°			Results at 50°		
Gms. per 100 gms. Sat.Sol.		Solid	Gms. per 100 gms. Sat.Sol.		Solid	Gms. per 100 gms. Sat.Sol.		Solid
NaClO <sub>3</sub>	Na <sub>2</sub> CrO <sub>4</sub>		NaClO <sub>3</sub>	Na <sub>2</sub> CrO <sub>4</sub>		NaClO <sub>3</sub>	Na <sub>2</sub> CrO <sub>4</sub>	
48.28	0.0	A	50.06	0.0	A	55.49	0.0	A
41.91	6.43	A	43.88	5.95	A	48.49	6.36	A
33.59	14.56	A	37.06	12.45	A	36.71	18.37	A
21.57	27.00	A	29.30	20.42	A	23.55	31.45	A
15.02	35.04	A,B	21.50	28.51	A	15.81	40.80	A
10.70	37.26	B	15.65	35.18	A	13.86	43.14	A,B
5.14	40.60	B	14.43	36.43	A,B	11.54	44.21	B
2.31	42.26	B	9.82	39.47	B	6.20	47.32	B
0.0	43.63	B	7.34	41.04	B	0.0	50.66	B
			0.0	45.59				

A = NaClO<sub>3</sub>B = Na<sub>2</sub>CrO<sub>4</sub>·4H<sub>2</sub>O

# Na SODIUM

## THE SYSTEM SODIUM CHLORATE - SODIUM IODIDE - WATER AT 25° (Ricci, 1944)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
NaClO <sub>3</sub>	NaI		NaClO <sub>3</sub>	NaI	
50.10	0.0	NaClO <sub>3</sub>	5.44	58.56	NaClO <sub>3</sub>
38.72	12.40	"	4.32	61.68	NaClO <sub>3</sub> +NaI·2H <sub>2</sub> O
27.62	25.23	"	2.83	62.65	NaI·2H <sub>2</sub> O
18.67	36.53	"	1.43	63.67	"
10.28	48.78	"	1.22	64.00	"
7.11	54.63	"	0.0	64.80	"

C10

## THE SYSTEM SODIUM CHLORATE - SODIUM IODATE - WATER (Ricci, 1938)

Results at 25°				Results at 50°		
d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	NaIO <sub>3</sub>	NaClO <sub>3</sub>		NaIO <sub>3</sub>	NaClO <sub>3</sub>	
-	0.0	50.14	NaClO <sub>3</sub>	0.0	55.74	NaClO <sub>3</sub>
1.444	1.16	49.52	"	1.26	54.98	"
1.444	1.29	49.38	" + NaIO <sub>3</sub> ·H <sub>2</sub> O	1.69	54.71	" + NaIO <sub>3</sub>
1.440	1.30	49.19	NaIO <sub>3</sub> ·H <sub>2</sub> O	1.75	53.83	NaIO <sub>3</sub>
1.425	1.33	48.13	"	2.14	47.86	"
1.404	1.39	46.27	"	2.2	45.0	" + NaIO <sub>3</sub> ·H <sub>2</sub> O
1.396	1.46	44.56	"	2.50	43.4 <sup>m</sup>	"
-	1.52	42.99	"	1.87	54.59	NaClO <sub>3</sub> +H <sub>2</sub> O
1.332	1.69	38.66	"	1.92	53.20 <sup>m</sup>	NaIO <sub>3</sub> ·H <sub>2</sub> O
1.273	1.97	32.57	"	2.12	48.95 <sup>m</sup>	"
1.204	2.43	24.67	"	2.41	43.71	"
1.146	3.14	16.50	"	3.23	33.33	"
1.098	4.51	8.36	"	5.69	16.56	"
1.075	8.57	0.0	"	7.67	10.02	"
				13.49	0.0	"

m = metastable

## THE SYSTEM SODIUM CHLORATE - SODIUM NITRATE - WATER AT 25° (Ricci, 1944)

Gms. per 100 gms. Sat. Sol.		Density	Solid	Gms. per 100 gms. Sat. Sol.		Density	Solid
NaClO <sub>3</sub>	NaNO <sub>3</sub>			NaClO <sub>3</sub>	NaNO <sub>3</sub>		
50.10	0.0	1.432	C	32.15	27.09	1.548	N
43.98	9.26	1.481	C	27.34	29.72	1.505	N
38.82	17.47	1.517	C	20.96	33.94	1.468	N
35.72	22.65	1.528	C	13.85	38.66	1.440	N
34.28	25.94	1.553	C, N	6.93	43.27	-	N
				0.0	47.87	1.389	N

C = NaClO<sub>3</sub>

N = NaNO<sub>3</sub>

THE SYSTEM SODIUM CHLORATE - SODIUM SULFATE - WATER  
(Ricci and Yanick, 1937)

Results for this system at 0°, 20° and 40° are given by Babaew, 1936, but the author failed to find the double salt,  $\text{NaClO}_3 \cdot 3\text{Na}_2\text{SO}_4$ , or trace the metastable portions of the curves.

sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	NaClO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>		NaClO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	
<u>Results at 15°</u>				<u>Results at 45°</u>		
1.406	47.91	0.0	NaClO <sub>3</sub>	54.59	0.0	NaClO <sub>3</sub>
1.423	45.86	2.19	"	53.10	1.77	"
1.422	44.34	3.83	"	50.22	2.40	1.3
-	42.66	5.59*	"	40.14	5.85*	"
1.424	41.85	6.44*	" + Na	28.23	12.66*	"
1.393	35.93	8.91*	Na	20.10	18.68*	"
1.422	44.12	4.06	NaClO <sub>3</sub> + Na · 10	51.46	2.38*	Na
-	43.07	3.89	Na · 10	49.71	2.57	" + 1.3
1.372	39.37	4.02	"	45.88	3.55	"
1.323	34.75	4.06	"	36.12	6.87	"
1.200	19.86	5.52	"	17.88	17.52	"
1.106	0.0	11.60	"	0.0	32.08	"
<u>Results at 25°</u>				<u>Results at 75°</u>		
	50.14	0.0	NaClO <sub>3</sub>	61.40	0.0	NaClO <sub>3</sub>
	47.62	2.80	"	60.73	1.0	" + 1.3
	46.64	3.86*	" + Na	58.34	1.37	1.3
	46.62	3.87	" + 1.3	56.25	1.62	"
	44.10	4.76*	1.3	52.84	1.94*	"
	39.75	6.70*	"	46.82	3.27*	"
	34.36	9.61*	"	41.42	5.11*	"
	30.80	11.90*	"	57.81	1.61*	Na
	25.26	15.72*	"	55.71	1.52	" + 1.3
	46.31	4.01	" + Na	51.85	2.09	"
	44.76	4.60	Na	45.51	3.19	"
	38.07	7.21	"	27.19	10.56	"
	32.47	9.86	"	6.26	24.70	"
	28.02	12.53*	"	0.0	30.33	"
	17.09	19.89*	"			
	6.03	28.62*	"			
	0.0	33.97*	"			
	29.90	12.26*	1.3 + Na · 10			
	29.52	12.20*	Na · 10			
	28.90	12.12	" + Na			
	27.36	12.06	Na · 10			
	23.45	12.64	"			
	18.05	13.90	"			
	12.30	15.77	"			
	6.58	18.20	"			
	0.0	21.78	"			

\* = Metastable; Na =  $\text{Na}_2\text{SO}_4$ ; Na · 10 =  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ ; 1.3 =  $\text{NaClO}_3 \cdot 3\text{Na}_2\text{SO}_4$



# Na SODIUM

## SOLUBILITY OF SODIUM CHLORATE IN AQUEOUS ETHYL ALCOHOL (Carlson, 1910)

t°	Gms. NaClO <sub>3</sub> per liter of sat. sol. in aqueous alcohol of:		
	50%	75%	90%
20	313.3	110.8	16.1
40	321.8	133.5	22.9
60	326.8	155.8	29
70	-	161.3	-

100 gms. alcohol of 77 Wt. per cent dissolve 2.9 gms. NaClO<sub>3</sub> at  
 C10 16°. (Wittstein)  
 100 gms. alcohol dissolve 1 gm. NaClO<sub>3</sub> at 25°, and 2.5 gms. at  
 b.pt. (Ossendowski, 1907)

## SOLUBILITY OF SODIUM CHLORATE IN OTHER SOLVENTS

Solvent	t°	Solubility	Reference
glycerol	15.5	20 gms. NaClO <sub>3</sub> per 100 gms. glycerol	1
ethylene glycol	25	16.0 gms. NaClO <sub>3</sub> per 100 gms. glycol	2
ethylene diamine	25	52.8 gms. NaClO <sub>3</sub> per 100 gms. ethylene diamine	2
monoethanol amine	25	19.7 gms. NaClO <sub>3</sub> per 100 gms. monoethanolamine	2
hydrazine	room	66 gms. NaClO <sub>3</sub> per 100 cc hydrazine	3

<sup>1</sup>Ossendowski, 1907

<sup>2</sup>Isbin and Kobe, 1945

<sup>3</sup>Welsh and Broderson, 1915

## SODIUM PERCHLORATE NaClO<sub>4</sub>

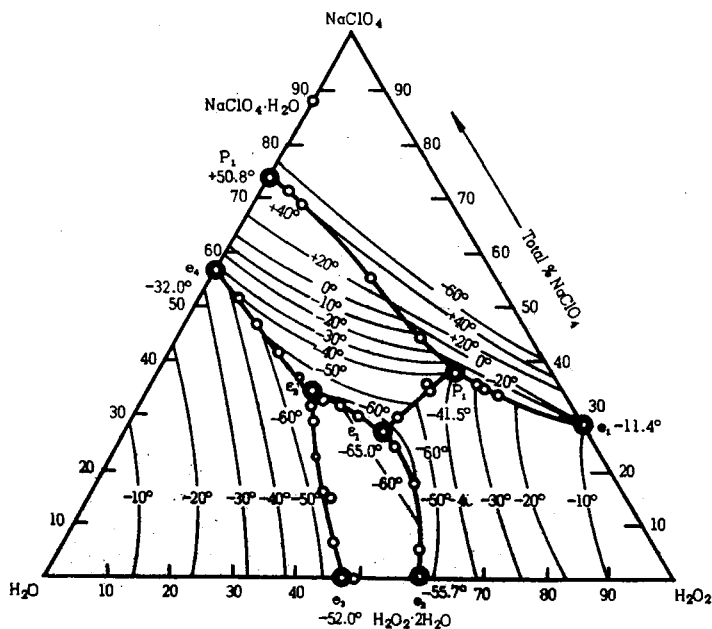
### THE SYSTEM SODIUM PERCHLORATE - WATER

Results of Freeth, 1924			Results of Cornec and Dickely, 1927			
t°	Gms. NaClO <sub>4</sub> per 100 gms. sat. sol.	Solid Phase	t°	d. of sat. sol.	Gms. NaClO <sub>4</sub> per 100 gms. sat. sol.	Solid Phase
- 3.0	10.00	Ice	0	-	62.87	NaClO <sub>4</sub> ·H <sub>2</sub> O
- 6.8	20.00	"	15	1.663	65.63	"
-11.1	30.00	"	25	1.683	67.82	"
-17.8	40.00	"	38	1.713	70.38	"
-22.0	45.00	"	50	1.749	73.26	"
-32.0	56.00	Ice+NaClO <sub>4</sub> ·H <sub>2</sub> O	15	1.758	71.68 <sup>m</sup>	NaClO <sub>4</sub>
0.0	62.64	NaClO <sub>4</sub> ·H <sub>2</sub> O	25	1.757	73.21 <sup>m</sup>	"
15.0	65.51	"	38	1.757	72.83 <sup>m</sup>	"
30.0	68.71	"	55	1.756	73.94	"
40.0	70.88	"	75	1.757	75.01	"
50.0	73.16	"	100	1.758	76.75	"
50.8	73.3	" + NaClO <sub>4</sub>	143	1.789	79.03 <sup>a</sup>	"
60.0	74.3	NaClO <sub>4</sub>				
75.0	75.0	"				

<sup>m</sup>Metastable

<sup>a</sup>Carlson, 1910. (The results of this author at 15° and 50° are considered too low, however.)

THE SYSTEM SODIUM PERCHLORATE - HYDROGEN PEROXIDE - WATER AT  
(Mironov, Pronina and Tokareva, 1958)



ClO

Point	t°	Sat. Sol. Wt. %		Solid Phases
		NaClO <sub>4</sub>	H <sub>2</sub> O <sub>2</sub>	
P <sub>1</sub>	-41.5	38	46	H <sub>2</sub> O <sub>2</sub> +NaClO <sub>4</sub> +NaClO <sub>4</sub> ·H <sub>2</sub> O
E <sub>1</sub>	-65	27	41	H <sub>2</sub> O <sub>2</sub> +NaClO <sub>4</sub> ·H <sub>2</sub> O+H <sub>2</sub> O <sub>2</sub> ·2H <sub>2</sub> O
E <sub>2</sub>	-60	33	27	Ice+H <sub>2</sub> O <sub>2</sub> ·2H <sub>2</sub> O+NaClO <sub>4</sub> ·H <sub>2</sub> O

THE SYSTEM SODIUM CHLORATE - HYDROGEN PEROXIDE

Wt. % NaClO <sub>3</sub>	t°	Solid Phase	Wt. % NaClO <sub>3</sub>	t°	Solid Phase
0.0	-0.4	H <sub>2</sub> O <sub>2</sub>	20.5	- 7.0	H <sub>2</sub> O <sub>2</sub>
1.5	-1.0	"	22.7	- 8.0	"
5.0	-2.5	"	26.5	-10.0	"
7.3	-3.0	"	31.3	+19.0	NaClO <sub>3</sub>
12.3	-4.0	"	33.5	+31.5	"
15.5	-5.5	"	36.1	+40.0	"

# Na SODIUM

## THE SYSTEM SODIUM PERCHLORATE - SODIUM NITRATE - WATER AT 25° (Karnaukhov, 1954)

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
NaNO <sub>3</sub>	NaClO <sub>4</sub>	Solid Phase	NaNO <sub>3</sub>	NaClO <sub>4</sub>	Solid Phase
0.0	67.56	NaClO <sub>4</sub> ·H <sub>2</sub> O	17.66	52.34	NaClO <sub>4</sub> ·H <sub>2</sub> O+NaNO <sub>3</sub>
2.31	65.22	"	17.82	52.30	NaNO <sub>3</sub>
5.75	60.57	"	21.92	38.52	"
11.60	57.20	Solid Solution(?) <sup>a</sup>	28.65	30.00	"
17.15	52.27	NaClO <sub>4</sub> ·H <sub>2</sub> O+NaNO <sub>3</sub>	36.04	18.23	"
17.76	52.37	"	40.80	9.60	"
17.79	52.50	"	47.29	0.0	"

<sup>a</sup> Solid phase 15.14% NaNO<sub>3</sub>, 83.34% NaClO<sub>4</sub>(?); all other mixtures are in equilibrium with the pure phases.

## THE SYSTEM SODIUM PERCHLORATE - SODIUM SULFATE - WATER (Freeth, 1924)

Results at 25°			Results at 60°		
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
NaClO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>		NaClO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	
67.60	0.0	NaClO <sub>4</sub> ·H <sub>2</sub> O	74.30	0.0	NaClO <sub>4</sub>
67.67	0.26	" + Na <sub>2</sub> SO <sub>4</sub>	74.40	0.29	" + Na <sub>2</sub> SO <sub>4</sub>
53.58	1.24	Na <sub>2</sub> SO <sub>4</sub>	64.65	0.37	Na <sub>2</sub> SO <sub>4</sub>
41.68	4.28	"	52.47	1.11	"
31.24	9.07	Na <sub>2</sub> SO <sub>4</sub> + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	31.55	6.95	"
18.72	12.56	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	17.70	14.90	"
5.79	18.15	"	0.0	31.20	"
0.0	21.71	"			

The author also gives complete data for the quaternary equilibria in the system NaClO<sub>4</sub> + (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> + NH<sub>4</sub>ClO<sub>4</sub> + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O at 25° and at 60°.

## SOLUBILITY OF SODIUM PERCHLORATE IN ALCOHOLS AT 25°

Alcohol	(Willard and Smith, 1923)		(Smith, 1925)
	density sat. sol.	Gms. NaClO <sub>4</sub> per 100 gms. sat. sol.	Gms. NaClO <sub>4</sub> per 100 gms. sat. sol.
Methanol	1.0561	33.93	34.33
Ethanol	0.8685	12.82	12.87
n-propanol	0.8308	4.66	-
n-butanol	0.8167	1.83	2.19-4.27
iso butanol	0.8031	0.78	-

SOLUBILITY OF SODIUM PERCHLORATE IN NORMAL BUTYL ALCOHOL CONTAINING  
PERCHLORIC ACID  
(Smith, 1923a)

The results are given only in the form of a diagram, from which the following approximate values were read.

Gms. $\text{HClO}_4 \cdot 2\text{H}_2\text{O}$ per 100 gms. solvent	Gms. $\text{NaClO}_4$ per 100 gms. sat. sol. at $25^\circ \pm 3^\circ \cdot 0$ b.pt.		Gms. $\text{HClO}_4 \cdot 2\text{H}_2\text{O}$ per 100 gms. solvent	Gms. $\text{NaClO}_4$ per 100 gms. sat. sol. at $25^\circ \pm 3^\circ \cdot 0$ b.pt.	
0.0 (=n butyl alc.)	2.8	7.5	0.6	3.05	8.2
0.2	2.9	7.8	0.8	3.0	8.35
0.4	3.0	8.0	1.0	2.8	9.0

ClO

SOLUBILITY OF ANHYDROUS SODIUM PERCHLORATE IN MIXTURES OF ETHYL ACETATE  
AND ALCOHOLS AT  $25^\circ \pm 0.1^\circ$   
(Smith, 1925)

Volume % alcohol in solvent	Gms. $\text{NaClO}_4$ per 100 gms. sat. sol. in solvent composed of ethyl acetate and					
	Methyl alcohol	Ethyl alcohol	93% Ethyl alcohol	n Butyl alcohol	n Butyl* alcohol	Ethyl** alcohol
0.0 <sup>a</sup>	8.8	8.8	8.8	8.8	8.8	26.32
5.0	-	13.83	14.12	-	11.97	-
10.0	19.39	16.05	16.92	12.34	13.00	29.32
20.0	23.37	18.55	20.00	13.16	14.32	31.16
30.0	25.85	19.66	21.75	-	14.75	32.44
40.0	27.81	20.08	22.79	12.82	14.71	33.26
50.0	29.38	20.07	23.30	11.99	13.98	33.63
60.0	30.50	19.67	23.39	10.54	13.09	33.61
70.0	31.61	18.78	22.73	-	11.66	33.20
80.0	32.56	17.53	21.92	6.70	9.85	32.56
90.0	33.44	15.82	20.96	4.35	7.87	31.56
95.0	-	14.80	21.31	-	6.97	31.10
100.0	34.33	12.87	20.60	2.19	4.27	29.80

\*A different sample of n Butyl alcohol of  $d_{4}^{25} = 0.8065$  and b.pt.  $112^\circ - 118^\circ$ .

\*\*The solid phase in this case was  $\text{NaClO}_4 \cdot \text{H}_2\text{O}$  instead of the anhydrous salt.

SOLUBILITY OF  $\text{NaClO}_4$  IN OTHER SOLVENTS AT  $25^\circ$

Solvent	Solubility	Reference
Acetone	34.10 gms. $\text{NaClO}_4$ per 100 gms. sat. sol. ( $d=1.0732$ )	1
Ethyl acetate	8.80 gms. $\text{NaClO}_4$ per 100 gms. sat. sol. ( $d=0.9574$ )	1
Ethylene diamine	30.1 gms. $\text{NaClO}_4$ per 100 gms. solvent	2
Monoeethanol amine	90.8 gms. $\text{NaClO}_4$ per 100 gms. solvent	2
Ethylene glycol	75.5 gms. $\text{NaClO}_4$ per 100 gms. solvent	2
Willard and Smith, 1923	Isbin and Kobe, 1945	

Melting points in the system  $\text{NaClO}_4 - \text{Ba}(\text{ClO}_4)_2$  are given by Zinovev, Chudinova and Smolina, 1956.

# Na SODIUM

## CrO SODIUM CHROMATE $\text{Na}_2\text{CrO}_4$

### SOLUBILITY IN WATER

(Mylius and Funk, 1900; Salkowski, 1901; Richards and Kelley, 1911; Hartford, 1949; Cadbury, 1945; above 100°, Benrath, 1942)

I = ice      0 =  $\text{Na}_2\text{CrO}_4$       4 =  $\text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O}$   
6 =  $\text{Na}_2\text{CrO}_4 \cdot 6\text{H}_2\text{O}$       10 =  $\text{Na}_2\text{CrO}_4 \cdot 10\text{H}_2\text{O}$

t°	Sat. Sol.		t°	Sat. Sol.		t°	Sat. Sol.	
	wt. % $\text{Na}_2\text{CrO}_4$	Solid Phase		wt. % $\text{Na}_2\text{CrO}_4$	Solid Phase		wt. % $\text{Na}_2\text{CrO}_4$	Solid Phase
-5	18.81	10+1	45	50.2	4	210	59	0
0	24.2	10	50	51.0	4	225	60	0
8	30.5	10	55	52.4	4	245	61	0
10	32.1	10	55.7	(51.93) <sup>a</sup>	4	260	62	0
15	37.7	10	60	53.5	4	270	63	0
17.7	43.6	10	65	55.2	0	280	64	0
19.5	44.2	10+6	70	55.2	0	296	66	0
20	44.3	6	80	55.5	0	305	67	0
25	45.8	6	90	55.8	0	315	68	0
25.9	46.3	6+4	100	56.1	0	335	70	0
30	46.8	4	140	56	0	350	73	0
36	48.0	4	165	57	0	372	76	0
40	48.9	4	190	58	0			

<sup>a</sup>Ryss and Zhukov, 1954

### THE SYSTEM $\text{Na}_2\text{O} - \text{CrO}_3 - \text{H}_2\text{O}$ AT 30° (Schreinemakers, 1906)

Sat. Sol. Wt. %		Wet Residue Wt. %		Solid Phase
$\text{CrO}_3$	$\text{Na}_2\text{O}$	$\text{CrO}_3$	$\text{Na}_2\text{O}$	
0	±42	-	-	$\text{NaOH} \cdot \text{H}_2\text{O}$
2.00	41.44	5.83	42.64	$\text{NaOH} \cdot \text{H}_2\text{O} + \text{Na}_2\text{CrO}_4$
2.04	40.89	-	-	$\text{Na}_2\text{CrO}_4$
4.23	35.51	27.52	36.57	"
6.64	32.34	27.72	34.60	"
15.19	27.06	37.07	32.20	"
10.22	29.39	15.48	28.41	$\text{Na}_2\text{CrO}_4 + \text{Na}_4\text{CrO}_5 \cdot 13\text{H}_2\text{O}$
8.93	28.49	18.09	26.89	$\text{Na}_4\text{CrO}_5 \cdot 13\text{H}_2\text{O}$
8.62	26.91	-	-	"
13.12	23.91	18.57	25.92	"
18.44	22.86	-	-	"
19.26	22.98	21.54	25.31	$\text{Na}_4\text{CrO}_5 \cdot 13\text{H}_2\text{O} + \text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O}$
17.84	24.21	26.24	24.98	$\text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O}$
28.82	17.88	31.97	23.47	"
38.93	16.30	40.70	20.83	"
48.70	16.49	47.49	19.75	$\text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O} + \text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$
50.68	15.72	-	-	$\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$
58.08	13.89	62.76	17.38	"
66.13	13.70	69.48	16.06	$\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O} + \text{Na}_2\text{Cr}_3\text{O}_{10} \cdot \text{H}_2\text{O}$
65.98	14.15	69.46	15.15	$\text{Na}_2\text{Cr}_3\text{O}_{10} \cdot \text{H}_2\text{O}$
68.46	10.95	73.88	13.38	$\text{Na}_2\text{Cr}_3\text{O}_{10} \cdot \text{H}_2\text{O} + \text{Na}_2\text{Cr}_4\text{O}_{13} \cdot 4\text{H}_2\text{O}$

(Cont.)

THE SYSTEM  $\text{Na}_2\text{O} - \text{CrO}_3 - \text{H}_2\text{O}$  AT  $30^\circ$ --Cont.

Sat. Sol. Wt. %		Wet Residue Wt. %		Solid Phase
$\text{CrO}_3$	$\text{Na}_2\text{O}$	$\text{CrO}_3$	$\text{Na}_2\text{O}$	
66.88	9.85	71.27	10.67	$\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 4\text{H}_2\text{O}$
70.06	11.85	83.95	9.57	" (?)
69.04	11.04	81.80	6.43	$\text{CrO}_3$
67.84	9.81	82.85	5.42	"
64.48	4.51	79.49	2.71	"
62.28	0.0	-	-	

THE SYSTEM SODIUM CHROMATE - SODIUM NITRATE - WATER  
(Ravich, 1943)

CrO

t°	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{NaNO}_3$	$\text{Na}_2\text{CrO}_4$	
0	24.40	19.80 <sup>m</sup>	$\text{NaNO}_3$
	15.73	29.90 <sup>m</sup>	"
	12.26	34.52 <sup>m</sup>	"
25	30.70	18.13	"
	18.04	33.00	"
	11.72	43.28	$\text{NaNO}_3 + \text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O}$
	7.08	44.73	$\text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O}$
50	19.70	36.35	$\text{NaNO}_3$
	15.56	43.56	"
	13.30	46.19	"
	11.83	47.62	$\text{NaNO}_3 + \text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O}$
	4.12	50.90	$\text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O}$
98.5	47.30	19.34	$\text{NaNO}_3$
	37.04	30.51	"
	32.2	33.9	$\text{NaNO}_3 + \text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O}$
	24.40	42.96	$\text{Na}_2\text{CrO}_4$
	7.75	52.43	"
- 5.0	0.0	18.81	$\text{Na}_2\text{CrO}_4 \cdot 10\text{H}_2\text{O} + \text{Ice}$
+19.7	0.0	45.05	$\text{Na}_2\text{CrO}_4 \cdot 10\text{H}_2\text{O} + \text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O}$
57.2	13.97	46.81	$\text{NaNO}_3 + \text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O} + \text{Na}_2\text{CrO}_4$
74.0	19.68	42.57	$\text{NaNO}_3 + \text{Na}_2\text{CrO}_4$
98.5	32.17	34.41	"
50.0	11.83	47.62	$\text{NaNO}_3 + \text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O}$
25.0	11.72	43.28	"
14.8	12.58	36.35	$\text{NaNO}_3 + \text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O} + \text{Na}_2\text{CrO}_4 \cdot 10\text{H}_2\text{O}$
9.0	21.70	24.30	$\text{NaNO}_3 + \text{Na}_2\text{CrO}_4 \cdot 10\text{H}_2\text{O}$
- 8.0	10.70	12.00	$\text{Na}_2\text{CrO}_4 \cdot 10\text{H}_2\text{O} + \text{Ice}$
-10.0	34.10	7.11	$\text{Na}_2\text{CrO}_4 \cdot 10\text{H}_2\text{O} + \text{NaNO}_3$
-18.5	34.70	3.51	$\text{NaNO}_3 + \text{Na}_2\text{CrO}_4 \cdot 10\text{H}_2\text{O} + \text{Ice}$

<sup>m</sup>Metastable

# Na SODIUM

## THE SYSTEM SODIUM CHROMATE - SODIUM MOLYBDATE - WATER (Cadbury, 1945)

Sat. Sol. Wt. %		Wet Residue Wt. %		Hydration of Solid Solution
$\text{Na}_2\text{CrO}_4$	$\text{Na}_2\text{MoO}_4$	$\text{Na}_2\text{CrO}_4$	$\text{Na}_2\text{MoO}_4$	
<u>Results at 0°</u>				
23.50	0.0	-	-	10
18.73	7.31	42.30	4.94	10
11.24	19.24	30.40	17.69	10
8.83	23.30	22.47	26.49	10
8.35	23.86	14.01	35.75	10
5.04	26.81	7.24	44.08	10
CrO 0.0	30.35	-	-	10
<u>Results at 8°</u>				
30.50	0.0	-	-	10
25.49	7.16	41.49	4.64	10
22.44	11.56	38.12	7.92	10
19.36	16.45	35.12	12.06	10
13.07	25.35	23.76	23.64	10
20.59	19.64	23.91	23.09	10
15.22	24.27	15.55	31.37	10
9.44	29.25	10.94	37.44	10
3.21	33.97	3.63	47.18	10
0.0	36.83	-	-	10
<u>Results at 15°</u>				
37.78	0.0	-	-	10
33.57	5.80	45.73	1.67	10
25.97	16.50	36.74	11.60	10
21.23	20.66	11.13	54.52	2
10.62	29.54	1.84	78.61	2
0.0	39.15	-	-	2
<u>Results at 19°</u>				
43.09	0.0	-	-	10
40.85	3.20	45.65	2.37	10
38.55	6.45	44.21	4.30	10
43.82	0.0	-	-	6
41.92	2.14	58.22	1.42	6
37.76	6.80	56.49	4.12	6
44.80	0.35	67.28	0.68	4
43.68	1.37	63.88	3.20	4
42.42	2.82	61.60	5.49	4
38.00	6.96	17.63	55.58	2
24.71	17.31	4.08	78.22	2
0.0	29.28	-	-	2

(Cont.)

## THE SYSTEM SODIUM CHROMATE - SODIUM MOLYBDATE - WATER--Cont.

Sat. Sol. Wt. %		Wet Residue Wt. %		Hydration of Solid Solution
$\text{Na}_2\text{CrO}_4$	$\text{Na}_2\text{MoO}_4$	$\text{Na}_2\text{CrO}_4$	$\text{Na}_2\text{MoO}_4$	
<u>Results at 22°</u>				
44.98	0.0	-	-	6
42.98	2.07	58.15	1.32	6
40.42	5.10	55.76	3.53	6
40.64	5.08	56.91	10.97	4
40.15	5.70	53.50	12.22	4
40.18	5.95	53.10	15.23	4
<u>Results at 25°</u>				CrO
45.85	0.0	-	-	6
45.38	0.60	59.55	0.05	6
44.55	1.40	59.37	0.31	6
44.53	1.33	64.90	2.80	4
42.85	3.09	61.00	6.01	4
40.30	5.89	53.55	16.07	4
41.12	4.89	24.10	53.97	2
20.20	21.93	10.91	54.41	2
0.0	39.56	-	-	2

CrO

THE SYSTEM SODIUM CHROMATE - SODIUM SULFATE - WATER  
(Results of Takeuchi, 1915)

The mixtures were rotated at constant temperature until attainment of equilibrium and both the saturated solutions and the undissolved residues were analyzed.

The decahydrates of sodium and chromium are isomorphous and the results show that these two salts are mutually miscible in all proportions at 15°. At 25° the solubility curve consists of three branches. The solutions of the first branch are in equilibrium with decahydrated mixed crystals, those of the second branch with anhydrous sulfate and those of the third with hexahydrated sodium chromate.

Sat. Sol. Wt. %		Wet Residue Wt. %		Sat. Sol. Wt. %		Wet Residue Wt. %	
$\text{Na}_2\text{CrO}_4$	$\text{Na}_2\text{SO}_4$	$\text{Na}_2\text{CrO}_4$	$\text{Na}_2\text{SO}_4$	$\text{Na}_2\text{CrO}_4$	$\text{Na}_2\text{SO}_4$	$\text{Na}_2\text{CrO}_4$	$\text{Na}_2\text{SO}_4$
<u>Results at 15°</u>							
0	11.70	0	44.08	24.21	4.23	15.94	29.04
2.42	10.58	0.66	42.29	26.06	3.78	18.78	25.77
3.92	10.08	1.25	41.90	28.49	3.18	22.89	22.37
6.72	9.24	1.95	40.89	31.34	2.32	29.03	16.39
8.91	8.35	2.68	40.97	33.34	1.55	35.48	10.71
11.51	7.57	3.96	39.41	33.90	1.31	38.62	7.49
14.90	6.41	6.12	37.71	36.44	0.47	43.66	2.96
15.14	6.43	6.63	37.15	37.17	0.24	46.06	1.06
20.03	5.05	10.96	33.15	37.45	0	47.35	0
22.83	4.33	13.60	30.72				

(Cont.)



# Na SODIUM

## THE SYSTEM SODIUM CHROMATE - SODIUM SULFATE - WATER--Cont. (Results of Takeuchi, 1915)

Sat. Sol. Wt. %		Wet Residue Wt. %		Sat. Sol. Wt. %		Wet Residue Wt. %	
$\text{Na}_2\text{CrO}_4$	$\text{Na}_2\text{SO}_4$	$\text{Na}_2\text{CrO}_4$	$\text{Na}_2\text{SO}_4$	$\text{Na}_2\text{CrO}_4$	$\text{Na}_2\text{SO}_4$	$\text{Na}_2\text{CrO}_4$	$\text{Na}_2\text{SO}_4$
Results at 25°							
0	21.90	0	44.08	32.34	8.03	5.71	85.81
1.56	20.76	0.55	42.85	34.75	6.75	5.94	84.35
2.53	20.12	0.82	43.48	38.59	4.44	5.70	86.94
4.02	18.96	1.22	42.03	39.22	4.38	8.83	79.22
4.95	18.62	1.29	42.09	42.48	2.79	13.27	72.66
9.66	16.49	2.91	41.07	43.80	2.20	25.50	56.72
CrO 14.19	14.71	4.49	39.56	43.83	2.29	48.54	18.21
14.85	13.87	4.18	39.36	43.26	2.44	58.18	3.45
16.22	13.91	5.72	38.46	43.57	2.18	53.85	10.59
23.72	10.69	9.22	37.00	43.69	2.12	53.89	8.78
26.13	10.02	12.51	32.35	43.49	2.24	57.93	2.10
31.70	8.32	16.11	30.01	43.53	2.20	58.50	1.47
31.43	8.49	15.59	34.08	44.61	1.08	59.17	0.38
31.84	8.63	12.86	54.14	45.76	0	59.75	0

### (Results of Marakov and Druzhinin, 1937 at 25°)

0.0	21.92	0.0 <sup>a</sup>	44.10	32.34	8.03	1.30 <sup>c</sup>	98.70
1.56	20.76	0.50 <sup>a</sup>	43.05	34.75	6.75	- <sup>c</sup>	-
2.53	20.12	.80 <sup>a</sup>	43.66	38.59	4.44	0.75 <sup>c</sup>	99.25
4.02	18.96	1.10 <sup>a</sup>	43.40	39.22	4.38	- <sup>c</sup>	-
4.95	18.62	1.30 <sup>a</sup>	43.25	42.48	2.79	2.25 <sup>c</sup>	97.75
9.66	16.49	2.60 <sup>a</sup>	43.35	43.80	2.20	25.25 <sup>d</sup>	58.60
14.19	14.71	3.60 <sup>a</sup>	41.60	43.83	2.29	48.70 <sup>d</sup>	18.00
14.85	13.87	3.25 <sup>a</sup>	41.90	43.26	2.44	58.30 <sup>d</sup>	3.50
16.22	13.91	4.50 <sup>a</sup>	40.95	43.57	2.18	53.70 <sup>d</sup>	10.30
23.72	10.69	8.80 <sup>a</sup>	37.95	43.69	2.12	56.00 <sup>d</sup>	8.90
26.13	10.02	9.50 <sup>a</sup>	37.30	43.49	2.24	58.75 <sup>d</sup>	2.25
31.70	8.32	15.50 <sup>b</sup>	31.00	43.33	2.20	59.00 <sup>d</sup>	0.60
31.43	8.49	- <sup>b</sup>	-	44.61	1.08	60.00 <sup>e</sup>	0.0
31.84	8.68	- <sup>b</sup>	-	45.76	0.0	60.00 <sup>e</sup>	0.0

Solid phases: a = Solid Solution of  $\text{Na}_2\text{CrO}_4 \cdot 6\text{H}_2\text{O}$  in  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$

b =  $\text{a} + \text{Na}_2\text{SO}_4$

c =  $\text{Na}_2\text{SO}_4 + \text{Na}_2\text{CrO}_4 \cdot 6\text{H}_2\text{O}$

d =  $\text{Na}_2\text{CrO}_4 \cdot 6\text{H}_2\text{O}$

Additional data are given by Osaka and Yoshida, 1922 for the isotherms at 28°, 31° and 33°. The results are, however, expressed in accordance with the formula  $100 \text{ m H}_2\text{O}, x \text{ Na}_2\text{CrO}_4(100 - x) \text{ Na}_2\text{SO}_4$ , and the tables show only numerical values corresponding to x and m.

### (Results of Ryss and Zhukov, 1954 at 55.7°)

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
$\text{Na}_2\text{CrO}_4$	$\text{Na}_2\text{SO}_4$		$\text{Na}_2\text{CrO}_4$	$\text{Na}_2\text{SO}_4$	
0	31.40	$\text{Na}_2\text{SO}_4$	30.40	8.669	$\text{Na}_2\text{SO}_4$
10.17	22.91	"	40.89	3.308	"
19.79	15.59	"	47.49	1.448	" + $\text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O}$
			51.93	0.0	$\text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O}$

100 gms. absolute methyl alcohol dissolve 0.345 gms.  $\text{Na}_2\text{CrO}_4$  at 25°.  
(de Bruyn, 1892)

SOLUBILITY OF SODIUM DICHROMATE IN ETHANOL AT 19.4°  
(Reinitzer, 1913)

An excess of  $\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$  was shaken with absolute alcohol for 10 minutes and the mixture filtered. The filtrate contained 5.132 gms.  $\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$  per 100 cc. and its  $d_{19.4}$  was 0.8374. The solution decomposed within a few minutes with production of a brown precipitate and evolution of an aldehyde odor. The results are, therefore, only approximately correct.

SOLUBILITY OF SODIUM CHROMATE IN MIXTURES OF BENZENE AND ACETIC ACID  
(Anders, 1933)

t°	% $\text{CH}_3\text{COOH}$ in solvent	Gms. $\text{Na}_2\text{CrO}_4$ per 100 gms. sat. sol.	t°	% $\text{CH}_3\text{COOH}$ in solvent	Gms. $\text{Na}_2\text{CrO}_4$ per 100 gms. $\text{CrO}$ sat. sol.
0	13.627	0.054	15	53.186	7.354
"	27.599	0.395	28	11.489	0.138
"	49.773	3.728	"	28.154	1.282
15	11.649	0.074	"	52.378	8.750
"	29.264	0.863			

The authors also give data for the lowering of the eutectic point of  $\text{CH}_3\text{COOH} + \text{C}_6\text{H}_6$  by additions of  $\text{Na}_2\text{CrO}_4$ , I, S, and  $\text{AgClO}_4$ .

100 gms. of a saturated solution of sodium chromate in furfural at 25° contain 0.05 gms.  $\text{Na}_2\text{CrO}_4 \cdot 4\text{H}_2\text{O}$ . (Trimble, 1941)

Melting point data are given for:

$\text{Na}_2\text{CrO}_4 + \text{NaF}$	(Rassonskaya and Bergman, 1943)
$\text{Na}_2\text{CrO}_4 + \text{Na}_2\text{SiO}_3$	(Vilinyanskii and Pudovkina, 1947)
	(Diagram only)
$\text{Na}_2\text{CrO}_4 + \text{NaOH}$	(Reshetnikov and Diogenov, 1953; Bergman and Khitrov, 1954)
$\text{Na}_2\text{CrO}_4 + \text{K}_2\text{CrO}_4$	(Rassonskaya and Bergman, 1953a)
$\text{Na}_2\text{CrO}_4 + \text{K}_2\text{CrO}_4 + \text{NaNO}_3$	( " " " " )
$\text{Na}_2\text{CrO}_4 + \text{Na}_2\text{SO}_4$	( " " " " 1953)
$\text{Na}_2\text{CrO}_4 + \text{Na}_2\text{SO}_4 + \text{NaNO}_3$	( " " " " 1953; Rassonskaya, 1951)

SODIUM DICHROMATE  $\text{Na}_2\text{Cr}_2\text{O}_7$

CrO

SOLUBILITY IN WATER  
(Hartford, 1941)

The results in parentheses are from the average curve of Mylius and Funk (1900), Gerassimow (1930), Rakowski and Nikitina (1931) and Robertson (1924). Other data are given by Yuskevich and Karzhavin (1926).

(Cont.)

# Na SO<sub>4</sub>UM

## SOLUBILITY IN WATER--Cont.

	t °	Gms. Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> per 100 gms. Sat. Sol.	Solid Phase
	0.0	0.0 -	Ice
	- 5.0	22.05 -	"
	-10.6	37.47 -	"
	-19.7	48.50 -	"
	-35.7	57.32 -	"
	-44.0	59.96 -	"
	-48.2	60.77 -	Ice+Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> ·2H <sub>2</sub> O
	-45.4	60.84 -	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> ·2H <sub>2</sub> O
	- 8.0	61.73 -	"
CrO	0.0	62.17 (62.0)	"
	5.0	62.49 -	"
	15.0	- (63.9)	"
	25.0	65.01 -	"
	32.2	66.06 -	"
	40.0	- (68.3)	"
	40.6	67.98 -	"
	46.1	69.21 -	"
	50.0	- (70.5)	"
	57.2	71.38 -	"
	60.0	71.76 (72.9)	"
	68.3	73.76 -	"
	74.4	75.65 -	"
	80	- (79.0)	"
	82.5	- (79.9)	" + Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
	84.6	79.18 -	" + "
	90.0	- (80.2)	Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>
	90.1	79.65 -	"
	95.0	80.01 -	"
	100.0	- (80.6)	"

Results for the system Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>+Na<sub>2</sub>SO<sub>4</sub>+H<sub>2</sub>O at 0°, 15°, 25°, 40°, 80° and 98°, and for Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>+NaHSO<sub>4</sub>+H<sub>2</sub>O at 20° are given by Rakowski and Nikitina, 1931.

Results for the systems Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>+NH<sub>4</sub>Cl+H<sub>2</sub>O and Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>+(NH<sub>4</sub>)<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>+H<sub>2</sub>O at 0°, 20°, 50° and 75°, are given by Gerassinow, 1930.

Data at 20°, 40°, 75°, 95° and 125° in the system Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>-NaCl-Na<sub>2</sub>SO<sub>4</sub>-H<sub>2</sub>O are given by Zhukov and Shutova, 1954.

## OTHER SODIUM CHROMATES

SOLUBILITY OF EACH IN WATER  
(Mylius and Funk, 1900)

	<u>Sodium</u> <u>Trichromate</u>	<u>Sodium</u> <u>Tetrachromate</u>	<u>Tetrasodium</u> <u>Chromate</u>	
t°	(Solid Phase Na <sub>2</sub> Cr <sub>3</sub> O <sub>10</sub> ·H <sub>2</sub> O)	(Solid Phase Na <sub>2</sub> Cr <sub>4</sub> O <sub>13</sub> ·4H <sub>2</sub> O)	(Solid Phase Na <sub>4</sub> CrO <sub>5</sub> ·13H <sub>2</sub> O)	
	Gms. anhydrous salt per 100 gms. sat. sol.			
0	80.03	72.96	33.87	CrO
10	-	-	35.58	
15	80.44 (d=2.059)	-	-	
16	-	74.19	-	
18	80.60	74.60 (d=1.926)	37.50 (d=1.446)	
22	-	76.01	-	
27.7	-	-	40.09	
37	-	-	45.13	
55	82.68	-	-	
99	85.78	-	-	

## SODIUM FLUORIDE NaF

F

## SOLUBILITY OF SODIUM FLUORIDE IN WATER

The results of Jehn and Huddleston, 1924; Carter, 1928; Foote and Schairer, 1930; Nowasselow, 1934; Nagerski and Nowasselow, 1935 and Payne, 1937, fall quite irregularly when plotted, and the average curve from which the following values were taken, can be only approximately correct. Somewhat more recent results of Tananaev, 1941 are given in parentheses.

t°	Gms. NaF per 100 gms. sat. sol.	Solid Phase	t°	Gms. NaF per 100 gms. sat. sol.	Solid Phase
-0.75	(1.00)	Ice	30	4.05	
-1.60	(2.00)	"	35	4.13 <sup>c</sup>	
-2.45	(3.00)	"	40	4.21 (4.35)	
-3.40	(3.82)	"	50	4.35	
-3.50	(3.92)	Ice+NaF	60	4.47	
-2.9	1.4 <sup>a</sup>	" + "	80	4.66 (4.48)	
0	3.53 (3.95)	NaF	94	- (4.73)	
20	3.90 (4.10)	"	100	4.83	
25	3.98 <sup>b</sup>	"			

<sup>a</sup>Matheson and Maass, 1929<sup>b</sup>density = 1.0384<sup>c</sup>density = 1.0354THE SYSTEM NaF - H<sub>2</sub>O<sub>2</sub> - H<sub>2</sub>O

Results at 0°, 15° and 25° from 0 to 100% H<sub>2</sub>O<sub>2</sub> are given in graphic form by Floyd and Gross, 1955.

(Cont.)

THE SYSTEM  $\text{NaF} - \text{H}_2\text{O}_2 - \text{H}_2\text{O}$ —Cont.

Results at 25°

(Akerlof and Turck, 1935)

Wt. % $\text{H}_2\text{O}_2$ in Solvent	Gms. Mols. NaF per 1000 gms. solvent
0.0	0.9989
15.72	1.216
31.43	1.457

FREEZING-POINTS OF HYDROGEN PEROXIDE SOLUTIONS OF SODIUM FLUORIDE  
(Matheson and Mass, 1929)

F

t°	Gm. Mols. NaF per 100 gm. mols. $\text{H}_2\text{O} + \text{NaF}$	Solid Phase	t°	Gm. Mols. NaF per 100 gm. mols. $\text{H}_2\text{O} + \text{NaF}$	Solid Phase
- 5.2	3.8	$\text{H}_2\text{O}_2$	-12.1	9.8	$\text{H}_2\text{O}_2$
- 9.1	7.4	"	-13.9	11.1	"
-10.6	8.0	"	-15.2 Eutec.	12.3	" + NaF

THE SYSTEM SODIUM FLUORIDE - HYDROFLUORIC ACID - WATER  
(Tananaev, 1941)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
NaF	HF		NaF	HF	
<u>Results at 0°</u>					
3.95	0.0	NaF	18.77	57.30	NaF·2HF
4.34	0.10	NaF+NaF·HF	19.51	58.50	"
3.71	0.27	NaF·HF	20.10	59.01	"
2.34	0.45	"	20.62	59.56	"
1.27	3.95	"	21.24	59.94	"
1.00	9.27	"	21.30	60.46	NaF·3HF
0.92	15.30	"	20.94	61.20	"
1.34	22.60	"	20.68	62.02	"
2.98	38.96	"	20.73	62.27	"
3.57	40.90	"	21.28	63.20	"
4.63	43.96	"	20.18	64.06	NaF·4HF
5.45	45.46	"	18.54	65.72	"
6.82	47.87	"	17.67	67.26	"
8.74	50.00	"	17.37	68.11	"
9.73	51.25	"	16.93	68.95	"
10.18	51.86	"	16.87	69.40	"
11.67	53.14	"	16.72	70.40	"
13.71	54.21	"	16.70	71.50	"
15.63	55.41	"	16.61	72.57	"
17.20	56.88	"	17.25	73.15	"
18.91	57.10	"	18.22	75.70	"
18.97	57.22	"			

(Cont.)

## THE SYSTEM SODIUM FLUORIDE - HYDROFLUORIC ACID - WATER--Cont.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
NaF	HF		NaF	HF	
Results at 20°					
4.10	0.0	NaF	(Data of Jehn and Hudleston, 1924)		
4.03	0.22	"			
4.12	0.39	"	3.96	0.0	NaF
4.32	0.53	NaF+NaF·HF	4.14	0.081	"
3.26	0.69	NaF·HF	4.19	0.104	"
2.75	0.94	"	4.23	0.135	"
9.57	1.18	"	4.51	0.420	"
1.76	5.70	"	4.56	0.484	" + NaF·HF
1.46	12.60	"	3.45	0.660	NaF·HF
1.51	16.74	"	2.99	0.831	"
1.61	19.40	"	2.46	1.16	"
1.93	26.10	"	2.49	1.20	"
2.20	29.63	"	2.20	1.55	"
2.46	30.92	"	2.04	2.22	"
3.34	36.94	"	2.01	2.70	"
3.67	37.77	"	1.88	4.17	"
4.79	41.88	"	1.83	8.68	"
9.95	50.00	"	1.79	10.28	"
24.07	60.00	NaF·3HF			

Results at 40°

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
NaF	HF		NaF	HF	
4.35	0.0	NaF	2.77	6.45	NaF·HF
4.40	0.47	"	2.58	10.94	"
4.56	0.94	"	2.65	15.50	"
4.14	1.11	NaF+NaF·HF	2.63	20.78	"
3.74	1.20	NaF·HF	2.98	27.18	"
3.33	1.59	"	4.75	38.08	"
2.73	2.75	"	10.40	50.20	"

## SODIUM BIFLUORIDE NaHF

At 25°, 2.78 gms. of NaHF dissolve in 100 gms. ethylene glycol.  
(Palit, 1947)

THE SYSTEM SODIUM FLUORIDE - BORIC ACID - WATER AT 25°  
(Ryse, Slutskaya and Vitukhnovskaya, 1951, 1952)

Sat.Sol.Wt. %		density	Solid Phase	Sat.Sol.Wt. %		density	Solid Phase
H <sub>3</sub> BO <sub>3</sub>	NaF			H <sub>3</sub> BO <sub>3</sub>	NaF		
0.0	3.86	-	NaF	2.85	4.11	-	NaF
1.57	3.99	1.050	"	3.02	4.26	1.057	"
1.54	3.91	-	"	4.23	4.08	-	"

(Cont.)

# Na SODIUM

## THE SYSTEM SODIUM FLUORIDE - BORIC ACID - WATER AT 25°

Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
H <sub>3</sub> BO <sub>3</sub>	NaF	density		H <sub>3</sub> BO <sub>3</sub>	NaF	density	
4.27	4.19	-	NaF	35.44	10.68	1.236	H <sub>3</sub> BO <sub>3</sub>
23.85	7.76	1.185	"	34.61	10.34	-	"
29.73	9.02	1.233	"	35.43	10.61	1.230	"
34.46	9.85	1.263	"	34.76	10.90	1.229	"
36.73	10.68	1.290	"	35.82	8.15	-	"
36.91	11.08	1.299	"	34.06	7.96	1.228	"
38.33	11.22	1.307	"	31.66	7.23	-	"
39.39	11.49	1.315	"	30.02	6.90	-	"
40.52	11.60	1.349	"	23.40	5.11	1.150	"
F 41.92	11.87	1.350	"	14.12	2.70	-	"
44.34	12.63	-	NaF+N <sub>2</sub> BO <sub>3</sub>	8.48	0.91	-	"
43.09	12.50	-	"	5.29	0.0	-	"

## SOLUBILITY OF SODIUM FLUORIDE IN AQUEOUS SOLUTIONS OF SODIUM HYDROXIDE (Nagorski and Nowosselow, 1935)

Wt. Percent NaOH in Solvent	Gms. NaF per 100 gms. sat. solution at:				
	0°	20°	40°	80°	94°
0.0 (=H <sub>2</sub> O)	3.99	4.10	4.47	4.48	4.73
0.81	3.49	3.40	3.51	3.56	3.47
1.67	-	2.89	-	-	-
2.30	2.65	2.70	2.81	2.82	3.03
2.70	2.37	2.45	2.70	2.84	2.73
5.66	-	1.68	-	-	-
7.90	-	1.25	-	-	-
18.40	-	0.38	-	-	-

Results for the quaternary system NaF+NaCl+Na<sub>2</sub>SO<sub>4</sub>+H<sub>2</sub>O at 25° and at 35° are also given.

Phase studies of the system Sodium Fluoride-Sodium Phosphate - Water at 25° and at 40° are given by Mason and Ashcraft, 1939. The results show that the supposed octahedral Na<sub>3</sub>PO<sub>4</sub>·10H<sub>2</sub>O is really the double salt NaF·2Na<sub>3</sub>PO<sub>4</sub>·19H<sub>2</sub>O, in samples of tri sodium phosphate containing as little as 0.1 percent Sodium Fluoride.

100 gms. water dissolve 12 gms. of the double sodium salt NaF·Na<sub>3</sub>PO<sub>4</sub>·12H<sub>2</sub>O at 25°, and 57.5 gms. at 70°. Sp. Gr. of solution at 25° = 1.0329; at 70° = 1.1091. (Briegleb, 1856)

THE SYSTEM SODIUM FLUORIDE - SODIUM SULFATE - WATER  
(Foote and Schairer, 1930)

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
t°	Na <sub>2</sub> SO <sub>4</sub>	NaF		t°	Na <sub>2</sub> SO <sub>4</sub>	NaF	
-3.0	0.0	3.92	Ice+NaF	25	8.67	2.35	NaF+1.1
-1.12	4.07	0.0	" +Na·10	"	11.48	1.74	1.1
-3.06	1.68	3.42	" + " +NaF	"	21.34	0.37	" +Na·10
10	0.0	3.92	NaF	"	31.71	0.0	Na·10
"	3.95	3.20	"	33.26	33.10	trace	" +Na·10+Na
"	6.39	2.98	" +Na·10	35	0.0	4.02	NaF
"	8.34	0.0	Na·10	"	4.34	3.18	"
15	0.0	3.93	NaF	"	8.62	2.50	" +1.1
"	9.50	2.50	" +Na·10	"	9.58	2.09	1.1
"	11.70	0.0	Na·10	"	11.60	1.57	"
17.47	12.58	1.91	1.1+Na·10+NaF	"	18.11	0.62	"
25	0.0	3.98	NaF	"	32.80	trace	" +Ni
"	4.48	3.13	"	"	32.96	0.0	Na

Na·10 = Na<sub>2</sub>SO<sub>4</sub>·10H<sub>2</sub>O; Na = Na<sub>2</sub>SO<sub>4</sub>; 1.1 = NaF·Na<sub>2</sub>SO<sub>4</sub>

THE SYSTEM SODIUM FLUORIDE - SILVER FLUORIDE - WATER AT 25°  
(Abdullaev, Talipov and Babaev, 1954)

Solid Phase NaF			
Sat. Sol. Wt. %		Sat. Sol. Wt. %	
NaF	AgF	NaF	AgF
0.67	26.43	2.90	0.72
2.22	20.36	3.60	0.33
2.55	11.40	3.64	0.13
2.60	4.71	3.70	0.027
2.62	1.14		

THE SYSTEM SODIUM FLUORIDE - BERYLLIUM FLUORIDE - WATER  
(Voro'beva, Novoselova, Shastin and Sitancov, 1956)

m = metastable

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
NaF	BeF <sub>2</sub>		NaF	BeF <sub>2</sub>	
4.00	0.0	NaF	1.42	2.65 <sup>m</sup>	Na <sub>2</sub> BeF <sub>4</sub>
3.76	0.05	NaF+Na <sub>2</sub> BeF <sub>4</sub>	1.60	3.63 <sup>m</sup>	"
0.95	0.10	Na <sub>2</sub> BeF <sub>4</sub>	1.03	1.41	" +4NaF·3BeF <sub>3</sub> ·2H <sub>2</sub> O
0.65	0.37	"	1.12	3.22	4NaF·3BeF <sub>3</sub> ·2H <sub>2</sub> O
1.27	2.06	"	1.30	4.22	"

(Cont.)



# Na SODIUM

## THE SYSTEM SODIUM FLUORIDE - BERYLLIUM FLUORIDE - WATER--Cont.

m = metastable

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
NaF	BeF <sub>2</sub>	Solid Phase	NaF	BeF <sub>2</sub>	Solid Phase
Results at 20°					
4.04	0.0	NaF	1.50	2.09	Na <sub>2</sub> BeF <sub>4</sub> +4NaF·3BeF <sub>2</sub> ·2H <sub>2</sub> O
3.81	0.067	NaF+Na <sub>2</sub> BeF <sub>4</sub>	1.57	3.35	4NaF·3BeF <sub>2</sub> ·2H <sub>2</sub> O
3.00	0.075	Na <sub>2</sub> BeF <sub>4</sub>	1.70	4.61	"
2.54	0.084	"	1.95	7.80	"
1.93	0.116	"	1.89	7.84	"
F 0.88	0.49	"	1.81	8.50	"
1.13	1.25	"	1.96	10.25	"
1.33	1.69	"	2.5	15.0	" + NaBeF <sub>3</sub>
1.44	1.89	"	2.47	15.77	NaBeF <sub>3</sub>
1.52	2.05	"	1.38	28.31	"
1.57	2.39 <sup>m</sup>	"	0.88	31.45	"
			0.75	35.10	"

Results at 80°

4.50	0.0	NaF	2.33	2.20	Na <sub>2</sub> BeF <sub>4</sub>
3.90	0.23	NaF+Na <sub>2</sub> BeF <sub>4</sub>	2.90	3.38	"
1.80	0.51	Na <sub>2</sub> BeF <sub>4</sub>	3.07	6.60	4NaF·3BeF <sub>2</sub> ·2H <sub>2</sub> O
1.64	0.91	"	3.49	15.79	NaBeF <sub>3</sub>

## THE SYSTEM NaF - NaBeF<sub>4</sub> - H<sub>2</sub>O (Nowasselowa, 1934)

Compositions of invariant solutions

t°	Gms. per 100 gms. sat. sol.		Solid Phase	t°	Gms. per 100 gms. sat. sol.		Solid Phase
	NaF	Na <sub>2</sub> BeF <sub>4</sub>			NaF	Na <sub>2</sub> BeF <sub>4</sub>	
0	3.81	0.22	NaF+Na <sub>2</sub> BeF <sub>4</sub>	60	3.85	0.47	NaF+Na <sub>2</sub> BeF <sub>4</sub>
20	3.84	0.26	" "	80	3.85	0.57	" "
40	3.76	0.45	" "	94	3.85	0.80	" "

## SOLUBILITY OF NaBeF<sub>4</sub> IN WATER (Vorobieva and Novoselova, 1948)

The salt was found to exist in both rhombic and monoclinic forms, and some of the results of Novoselova (Vol. I, p. 1260) are shown to be metastable.

(Cont.)

SOLUBILITY OF  $\text{NaBeF}_4$  IN WATER--Cont.

$t^\circ$	Gms. $\text{Na}_2\text{BeF}_4$ per 100 gms. sat. sol.	Solid Phase	$t^\circ$	Gms. $\text{Na}_2\text{BeF}_4$ per 100 gms. sat. sol.	Solid Phase
-0.13	0.24	Ice	0	1.31 (1.31) <sup>a</sup>	$\text{Na}_2\text{BeF}_4$ (1)
-.267	.48	"	0	1.02	" (2)
-.39	.93	"	20	1.37 (1.41) <sup>a</sup>	" (2)
-.44	1.01	Ice+ $\text{Na}_2\text{BeF}_4$	20	1.70	" (1)
-.52	1.26	Ice (3)	40	1.88	" (2)
-.56	1.30	" (3)	60	2.19 (2.19) <sup>a</sup>	" (2)
-.59	1.44	" (3)	80	2.55 (2.55) <sup>a</sup>	" (2)
			94	2.75 (2.70) <sup>a</sup>	" (2)

(1) Monoclinic

(2) Rhombic

(3) Metastable

<sup>a</sup>Nowasselow, 1934

F

THE SYSTEM SODIUM FLUORIDE - AMMONIUM FLUORIDE - WATER  
(Haendler and Clow, 1952)

Sat. Sol. Wt. %		Solid Phase NaF		Sat. Sol. Wt. %	
$\text{NH}_4\text{F}$	NaF	$\text{NH}_4\text{F}$	NaF	$\text{NH}_4\text{F}$	NaF
0.90	4.43	12.08	2.24	34.37	3.49
2.45	4.01	15.10	3.07	35.97	4.22
4.80	2.99	19.26	2.39	41.57	2.88
5.02	3.24	20.31	2.57	44.32	0.08 <sup>a</sup>
6.90	3.25	24.45	2.48	44.49	0.16 <sup>a</sup>
7.26	2.60	29.45	3.25	44.85	0.23 <sup>a</sup>
10.18	2.33	33.26	3.15	45.50	0.0 <sup>a</sup>

<sup>a</sup>Solid phase  $\text{NH}_4\text{F}$ SODIUM PLATINUM FLUORIDE  $\text{Na}_2\text{PtF}_6$ 

At  $25^\circ$ , 100 ml of saturated solution contains 20.49 gms.  $\text{Na}_2\text{PtF}_6$ .  
(Wheeler, Perros and Naeser, 1955)

SODIUM FLUOSILICATE  $\text{Na}_2\text{SiF}_6$ 

SiF

## SOLUBILITY OF SODIUM FLUOSILICATE IN WATER

The data of Anscov and Chirkov, 1933 (1), Chepelevetski and Bolz, 1937 (2), Kleiner, 1944 (3), Nikolaev, Ivanov, and Koltipin, 1936 (4), and Caillat, 1945 (5), Carter, 1930 (6), Stolba, 1872 (7), and Worthington and Haring, 1931 (8) were plotted and an average curve was drawn through all the points.

(Cont.)

# Na $\text{SiF}_6$

## SOLUBILITY OF SODIUM FLUOSILICATE IN WATER--Cont.

t°	Gms. $\text{Na}_2\text{SiF}_6$ per 100 gms. Sat. Sol.		t°	Gms. $\text{Na}_2\text{SiF}_6$ per 100 gms. Sat. Sol.	
	Individual Results	Average Curve		Individual Results	Average Curve
0	0.40 (3) .435 (6)	0.41	40	1.05 (2) 0.99 (3)	1.02
10	.53 (4)	.53	45	1.14 (5)	1.12
15	.57 (3)	.60	50	1.120 (6)	1.22
16	.62 (5)	.61	55	1.27 (4)	1.33
17.5 31F 20	.637 (6)			1.33 (5)	1.33
	.65 (1)	.63		1.328 (6)	
	.64 (3)	.67			
	.66 (4)		60	1.49 (2)	
	.737 (8)			1.42 (5)	1.44
25	.76 (5)	.75	70	-	1.68
	.72 (3)		78	1.822 (6)	-
	.762 (6)		80	1.95 (2)	1.92
30	-	.84	90	-	2.17
35	.96 (5)	.94	100	2.45 (7)	2.42
	.940 (6)				

(1) Ansonov and Chirkov, 1933

(2) Chepelevetski and Bolz, 1937

(3) Kleiner, 1944

(4) Nikolaev, Ivanov, and Koltipin, 1936

(5) Caillat, 1945

(6) Carter, 1930

(7) Stolba, 1872

(8) Worthington and Haring, 1931

## SOLUBILITY OF SODIUM FLUOSILICATE IN HYDROCHLORIC ACID SOLUTIONS (Kleiner, 1944)

Densities are given in parentheses

Gms. HCl per 100 gms. sat. sol.	Gms. $\text{Na}_2\text{SiF}_6$ per 100 gms. sat. sol.				
	0°	15°	20°	25°	40°
0	0.39	0.58	0.64	0.72	0.99
2.1	0.80 (1.0178)	1.11 (1.0191)	1.23 (1.0201)	1.30 (1.0211)	1.69 -
4.1	0.99 (1.0292)	1.28 (1.0303)	1.35 (1.0310)	1.41 (1.0321)	1.80 -
6.0	0.96	1.23	1.30 (1.0410)	1.37 (1.0408)	1.71 -
8.1	0.82 (1.0505)	1.09 (1.0501)	1.17 (1.0495)	1.25 (1.0491)	1.55 -
10.1	0.68 (1.0601)	0.92 (1.0596)	1.02 (1.0592)	1.12 (1.0589)	1.37 -
12.1	0.53 (1.0699)	0.74 (1.0684)	0.85 (1.0678)	0.94 (1.0671)	1.17 -
14.0	0.39 (1.0790)	0.55 (1.0771)	0.66 (1.0760)	0.76 (1.0749)	0.97 -
16.1	0.31 (1.0893)	0.42 (1.0854)	0.52 (1.0850)	0.60 (1.0848)	0.73 -
19.6	0.30 -	0.40 (1.1034)	0.45 (1.1026)	0.52 (1.1020)	0.61 -

SOLUBILITY OF SODIUM FLUOSILICATE IN HYDROCHLORIC ACID SOLUTIONS  
CONTAINING SODIUM CHLORIDE AT 20°  
(Kleiner, 1944)

Gms. per 100 gms. Sat. Sol.			Density	Solid Phase
HCl	NaCl	Na <sub>2</sub> SiF <sub>6</sub>		
0.0	2.06	0.07	1.0150	Na <sub>2</sub> SiF <sub>6</sub>
2.03	1.97	.19	1.0240	"
4.07	1.91	.21	1.0356	"
5.92	1.99	.20	1.0456	"
11.82	1.97	.12	1.0734	"
15.15	1.98	.11	1.0905	"
18.94	2.06	.07	1.1095	"
0.0	26.35	.013	1.2037	Na <sub>2</sub> SiF <sub>6</sub> +NaCl
1.61	23.45	.034	1.1913	NaCl
3.20	21.09	.046	1.1794	"
4.80	18.80	.043	1.1685	"
7.66	14.67	.043	1.1522	"
12.01	9.35	.040	1.1312	"
13.46	7.85	.040	1.1265	"
17.67	4.03	.041	1.1194	"

SOLUBILITY OF SODIUM FLUOSILICATE IN HYDROFLUORIC ACID SOLUTIONS  
(Nikolaev, Ivanov, and Koltipin, 1936)

0°		10°		20°		50°	
Gms. Na <sub>2</sub> SiF <sub>6</sub> per 100 gms. sat. sol.		Gms. Na <sub>2</sub> SiF <sub>6</sub> per 100 gms. sat. sol.		Gms. Na <sub>2</sub> SiF <sub>6</sub> per 100 gms. sat. sol.		Gms. Na <sub>2</sub> SiF <sub>6</sub> per 100 gms. sat. sol.	
Wt. % HF		Wt. % HF		Wt. % HF		Wt. % HF	
0.1	0.46	0	0.53	0	0.66	0	1.27
5.27	.63	5.65	.69	5.0	.84	-	-
15.53	.88	15.7	.89	15.0	.99	16.0	1.35
21.2	.90	21.2	.96	19.56	1.06	20.6	1.40
26.53	1.03	25.6	1.00	21.0	1.15	26.48	1.42

SOLUBILITY OF SODIUM FLUOSILICATE IN PHOSPHORIC ACID SOLUTIONS  
CONTAINING SODIUM CHLORIDE  
(Chepelevetski and Bolz, 1937)

Results are expressed as gms. Na<sub>2</sub>SiF<sub>6</sub> per 100 gms. sat. sol.

Wt.% P <sub>2</sub> O <sub>5</sub>	Wt.% NaCl at 40°			Wt.% NaCl at 80°		
	0	2	4	0	2	4
1	1.10	-	-	2.07	-	-
5	1.15	-	-	2.01	-	-
10	1.09	0.196	0.105	1.9	0.73	0.38
15	0.95	.181	.100	1.75	.59	.34
20	.78	.127	.067	1.45	.47	.24
25	.61	.066	.043	1.25	.38	.18

With 0.6% Al<sub>2</sub>O<sub>3</sub> added, the Solubility is increased:

10	-	-	0.33	-	-	0.90
20	-	-	.25	-	-	.62
25	-	-	.19	-	-	.48

# Na SODIUM

## THE SYSTEM SODIUM FLUOSILICATE - SODIUM CHLORIDE - WATER AT 15° (Anosov and Chirkov, 1933)

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
NaCl	Na <sub>2</sub> SiF <sub>6</sub>	density	NaCl	Na <sub>2</sub> SiF <sub>6</sub>	density
0.0	0.65	-	11.69	0.012	1.0835
0.41	0.206	1.0047	15.00	0.009	1.1080
1.18	0.079	1.0083	18.09	0.007	1.1337
2.48	0.041	1.0171	26.29	0.006	1.2021
4.12	0.028	1.0291	26.36	0.0	1.2023
7.87	0.017	1.0562			

# SiF

## SOLUBILITY OF SODIUM FLUOSILICATE IN AQUEOUS SOLUTIONS OF SODIUM SULFATE (Rees and Hudleston, 1931)

Results at 17°		Results at 20°	
Gm. Mols. Na <sub>2</sub> SO <sub>4</sub> per 1000 gms. solvent	Gm. Mols. Na <sub>2</sub> SiF <sub>6</sub> per 1000 gms. sat. sol.	Gm. Mols. Na <sub>2</sub> SO <sub>4</sub> per 1000 gms. solvent	Gm. Mols. Na <sub>2</sub> SiF <sub>6</sub> per 1000 gms. sat. sol.
0.000	0.0329	0.000	0.0363
0.050	0.0143	0.0050	0.0336
0.125	0.0068	0.0100	0.0309
0.250	0.0042	0.0150	0.0284
0.375	0.0034	0.0250	0.0201
0.500	0.0029	0.0500	0.0168

# TiF SODIUM TITANIUM FLUORIDE Na<sub>2</sub>TiF<sub>6</sub>

## SOLUBILITY OF SODIUM TITANO FLUORIDE IN WATER AND IN ETHYL ALCOHOL (Ginsberg, 1932)

t°	Solvent	Gms. Na <sub>2</sub> TiF <sub>6</sub> per 100 cc sat. sol.
20-22	Water	6.5
20-22	98% C <sub>2</sub> H <sub>5</sub> OH	0.0031

## THE SYSTEM SODIUM FLUORIDE - ETHANOL - WATER (Zhdanov, 1954)

Solid phase is NaF throughout.

Results at 0°		
Sat. Sol. Wt. %		density
C <sub>2</sub> H <sub>5</sub> OH	NaF	
0.0	3.63	1.0893
9.70	2.20	1.0871
20.88	1.23	0.9880
29.80	0.70	0.9706
Sat. Sol. Wt. %		density
C <sub>2</sub> H <sub>5</sub> OH	NaF	
40.60	0.40	0.9523
53.26	0.26	0.9258
61.30	0.03	0.9018
81.38	0.02	0.8623

(Cont.)

## THE SYSTEM SODIUM FLUORIDE - ETHANOL - WATER--Cont.

Solid phase is NaF throughout.

## Results at 25°

Sat. Sol. Wt. %		Sat. Sol. Wt. %	
C <sub>2</sub> H <sub>5</sub> OH	NaF	C <sub>2</sub> H <sub>5</sub> OH	NaF
0.0	3.85	50.54	0.31
10.11	2.41	59.71	0.14
20.81	1.38	67.64	0.08
28.31	0.65	72.33	0.04
42.47	0.40	82.54	0.02

F

 SOLUBILITY OF SODIUM FLUORIDE IN SEVERAL ALCOHOLS,  
 EACH DETERMINED SEPARATELY  
 (Germuth, 1931)

t°	Gms. NaF per 100 gms. sat. solution in:		
	Methyl Alcohol CH <sub>3</sub> OH	Ethyl Alcohol C <sub>2</sub> H <sub>5</sub> OH	n Butyl Alcohol CH <sub>3</sub> (CH <sub>2</sub> ) <sub>2</sub> CH <sub>2</sub> OH
20	0.413 <sup>a</sup>	0.095	0.0030
30	0.440	0.108	0.0041
40	0.458	0.119	0.0043
50	0.476	0.158	0.0049
55	0.484	0.179	0.0054

<sup>a</sup>Pavlopoulos and Strehlow, 1954 give 0.041 and 0.030 gms. NaF per 100 gms. CH<sub>3</sub>OH at 18° and 25° respectively.

## SOLUBILITY OF SODIUM FLUORIDE IN SEVERAL SOLVENTS

Solvent	t°	Solubility	Reference
Acetone	18	0.000024 gms. NaF per liter acetone (d.=0.792)	1
	37	0.000027 gms. NaF per liter acetone (d.=0.770)	1
Acetonitrile	18	0.0014 gms. NaF per 100 gms. solvent (d.=0.783)	2
	25	0.003 gms. NaF per 100 gms. solvent (d.=0.777)	2
Ammonia (liq)	25	0.35 gm. NaF per 100 gm. NH <sub>3</sub>	3
Sulfur dioxide (liq)	0	0.029 gm. NaF per 100 gm. SO <sub>2</sub>	4
Bromine trifluoride	25	3.80 gms. NaF per 100 gms. sat. sol.	5
	70	4.66 gms. NaF per 100 gms. sat. sol.	5

<sup>1</sup>Lannung, 1932<sup>2</sup>Pavlopoulos and Strehlow, 1954<sup>3</sup>Hunt, 1932<sup>4</sup>Jander and Ruppolt, 1937<sup>5</sup>Sheft, Hyman and Katz, 1953

(Cont.)

# Na SODIUM

## SOLUBILITY OF SODIUM FLUORIDE IN SEVERAL SOLVENTS--Cont.

Melting point data are given for the following:

NaF+HF	(Euler, 1957)
NaF+FeF <sub>3</sub>	(Puschin and Baskov, 1913)
NaF+ZnF <sub>3</sub>	" "
NaF+NaI	(Ruff and Plato, 1903)
NaF+NaOH	(Scarpa, 1915)
NaF+Na <sub>2</sub> SO <sub>4</sub>	(Wolters, 1910) (Gladushchenko and Bergman, 1955) (Bergman and Rubleva, 1957a)
NaF+Na <sub>2</sub> SiO <sub>3</sub>	(Booth and Starrs, 1931) (Bergman, Nesterova and Bychkova, 1955)
NaF+Na <sub>2</sub> Si <sub>4</sub> O <sub>9</sub>	(Booth, Starrs and Bahnsen, 1933)
NaF+YF <sub>3</sub>	(Dergunov, 1948)
F NaF+AlF <sub>3</sub>	(Dergunov, 1948) (Mashovets, Beletskii, Saksonov and Svoboda, 1957)
NaF+LaF <sub>3</sub>	(Dergunov, 1948) (Zachariassen, 1948)
NaF+NaVO <sub>3</sub>	(Schmitz-Dumont and Schmitz, 1944)
NaF+ThF <sub>4</sub>	(Zachariassen, 1948)
NaF+UF <sub>4</sub>	(Barton, Friedmsn, et al, 1958) (Zachariassen, 1948)
NaF+UF <sub>4</sub> +ZrF <sub>4</sub>	(Ward, Strehlow, Grimes and Watson, 1958)
NaF+NaBF <sub>4</sub>	(Sullivanov and Stender, 1958)
NaF+CaF <sub>2</sub> +BaCl <sub>2</sub>	(Shul'ga and Bukhalova, 1957)
NaF+NaNO <sub>3</sub>	(Nyankovskaya and Bergman, 1952)
NaF+Na <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	(Sholokhovich and Belyaev, 1957)
NaF+PbF <sub>2</sub>	(Schmitz-Dumont, Bergenhoff and Hartet)
NaF+SrF <sub>2</sub>	(Ershova and Ol'shanskii, 1958)
NaF+MgF <sub>2</sub>	" "
NaF+BaF <sub>2</sub>	(Ershova and Ol'shanskii, 1958) (Bergman and Banashek, 1953)
NaF+CaF <sub>2</sub>	(Ershova and Ol'shanskii, 1958)
NaF+PrF <sub>3</sub>	(Dergunov, 1952)
NaF+MoO <sub>3</sub>	(Schmitz-Dumont and Heckmann, 1952)
NaF+WO <sub>3</sub>	(Schmitz-Dumont, Bruns and Heckmann, 1953)
NaF+Na <sub>2</sub> MoO <sub>4</sub>	(Mateiko and Bukalova, 1955)
NaF-ZrF <sub>4</sub>	(Barton, Grimes, et al., 1958)
NaF-ZrF <sub>4</sub> -UF <sub>4</sub>	" " " "
2NaF+PbSO <sub>4</sub> = Na <sub>2</sub> SO <sub>4</sub> +PbF <sub>2</sub>	(Gladushchenko and Bergman, 1955)
NaF+Li <sub>2</sub> TiO <sub>3</sub>	(Belyaev and Sigida, 1957)
NaF+Li <sub>2</sub> TiO <sub>3</sub> = Na <sub>2</sub> TiO <sub>3</sub> +2LiF	" " " "
NaF+Na <sub>2</sub> TiO <sub>3</sub>	" " " "
2NaF+PbTiO <sub>3</sub> = Na <sub>2</sub> TiO <sub>3</sub> +PbF <sub>2</sub>	(Belyaev, 1954)
NaF-Na <sub>2</sub> U <sub>2</sub> O <sub>7</sub>	(Neuhaus, 1958)
Na <sub>3</sub> AlF <sub>6</sub> +Li <sub>3</sub> AlF <sub>6</sub>	(Beletskii and Saksonov, 1957)
Na <sub>3</sub> AlF <sub>6</sub> +Li <sub>3</sub> AlF <sub>6</sub> +Al <sub>2</sub> O <sub>3</sub>	(Mashovets and Petrov, 1957)
Na <sub>3</sub> AlF <sub>6</sub> +Na <sub>2</sub> O+Al <sub>2</sub> O <sub>3</sub>	(Bonnier, 1954)
Na <sub>2</sub> BeF <sub>4</sub> +RbBeF <sub>4</sub>	(Toropov and Grebenshchikov, 1956)
Na <sub>2</sub> BeF <sub>4</sub> +Li <sub>2</sub> BeF <sub>4</sub>	(Toropov and Shchetnikova, 1957, 1957a)

Reactions of the salts below their melting points were studied with X-rays by Link and Wood, 1940 for the following pairs:

NaF+KCl	NaF+KBr	NaF+KI
NaF+RbCl	NaF+RbBr	NaF+RbI
NaF+CsCl	NaF+CsBr	NaF+CsI

SODIUM GALLATES  $x\text{Na}_2\text{O} \cdot y\text{Ga}_2\text{O}_3$ 

GaO

THE SYSTEM SODIUM OXIDE - GALLIUM OXIDE - WATER  
(Gevorkyan and Gurovich, 1957)

Results at 18°				Results at 60°			
Sat. Sol. Wt. %		Wet Residue Wt. %		Sat. Sol. Wt. %		Wet Residue Wt. %	
Na <sub>2</sub> O	Ga <sub>2</sub> O <sub>3</sub>	Na <sub>2</sub> O	Ga <sub>2</sub> O <sub>3</sub>	Na <sub>2</sub> O	Ga <sub>2</sub> O <sub>3</sub>	Na <sub>2</sub> O	Ga <sub>2</sub> O <sub>3</sub>
Solid Phase Ga <sub>2</sub> O <sub>3</sub> ·3H <sub>2</sub> O				Solid Phase Ga <sub>2</sub> O <sub>3</sub> ·3H <sub>2</sub> O			
0.00	0.00	-	77.60	0.00	0.00	0.00	77.60
0.43	0.74	0.35	50.20	5.50	10.40	3.80	32.80
2.41	2.84	2.00	30.00	8.86	13.43	7.00	27.00
4.00	5.67	2.80	41.80	9.80	16.45	5.00	61.70
4.81	6.28	-	-	12.23	19.20	-	-
7.37	7.35	4.00	42.30	12.63	20.10	8.30	41.50
9.00	12.05	-	-	13.25	21.80	10.50	41.50
9.50	13.88	4.15	52.70	13.00	26.00	-	-
11.05	14.03	-	-	13.05	28.00	7.50	51.00
12.15	15.42	-	-	13.01	39.10	11.50	45.00
11.60	17.20	6.80	44.20	Solid Phase 2Na <sub>2</sub> O·Ga <sub>2</sub> O <sub>3</sub> ·7H <sub>2</sub> O			
14.20	22.00	11.80	32.30	20.00	37.30	24.50	38.90
15.30	26.70	8.40	50.50	21.50	35.00	23.80	36.00
Solid Phase 4Na <sub>2</sub> O·Ga <sub>2</sub> O <sub>3</sub> ·15H <sub>2</sub> O				21.70	29.50	-	-
20.00	28.00	22.00	28.20	25.30	24.70	26.00	38.00
22.30	24.40	24.00	24.55	27.40	20.30	27.00	23.00
24.00	19.00	27.00	21.70	Solid Phase 3Na <sub>2</sub> O·Ga <sub>2</sub> O <sub>3</sub> ·13H <sub>2</sub> O			
25.80	17.30	32.40	22.50	29.50	18.10	25.30	22.00
27.00	15.00	-	-	32.70	14.30	-	-
29.20	13.30	32.30	22.70	37.50	7.40	35.00	20.00
				40.30	3.36	36.50	17.00

SODIUM GERMANATE Na<sub>2</sub>GeO<sub>3</sub>

GeO

SOLUBILITY OF SODIUM GERMANATE IN WATER  
(Pugh, 1932)

Gms. Na <sub>2</sub> GeO <sub>3</sub> per 100 gms.			Gms. Na <sub>2</sub> GeO <sub>3</sub> per 100 gms.		
t°	H <sub>2</sub> O	Solid Phase	t°	H <sub>2</sub> O	Solid Phase
- 0.7	2.38	Ice	30	28.65	Na <sub>2</sub> GeO <sub>3</sub> ·7H <sub>2</sub> O
- 2.0	8.04	"	35	32.6	"
- 3.0	12.40	"	45	42.0	"
- 3.2*	13.1	" + Na <sub>2</sub> GeO <sub>3</sub> ·7H <sub>2</sub> O	52.5	52.7	"
0	14.5	Na <sub>2</sub> GeO <sub>3</sub> ·7H <sub>2</sub> O	63.5	72.0	"
+15.2	21.4	"	70.5	85.5	"
20.2	23.7	"	75.5	99.6	"
25.0	25.9	"	83.5	132.0	"

\*Eutec.



# Na SODIUM

## H SODIUM HYDRIDE NaH

The solubility of NaH in molten sodium is 1.5 wt. % at 400° and greater than 4% at 450°. (Williams, Grand and Miller, 1957)

## I SODIUM IODIDE NaI

### SOLUBILITY IN WATER

The data of Scott and Durham, 1930; Ricci and Yanick, 1936; Hill, Wilson and Bishop, 1933; Ricci, 1934, 1936 lie on a very smooth curve and are listed below to four significant figures. The values of de Coppet, 1883 agree and are given at other temperatures; above 140° the data are those of Keevil, 1942. Additional data are reported by Etard, 1884; Kremens, 1856a; Cocheret, 1911; Greenish, 1900; Meyerhoffer, 1904; Panfiloff, 1893, 1893a. Results on the ice curve and in equilibrium with NaI·5H<sub>2</sub>O are by Briggs and Geigle, 1940 (1); Jones et al., 1907 (2); Rudorff, 1862 (3); de Coppet, 1883 (4); Etard, 1894 (5); Panfiloff, 1893a (6).

t°	Gms. NaI per 100 gms. sat.sol.	Solid Phase	t°	density	Gms. NaI per 100 gms. sat.sol.	Solid Phase
- 0.85	3.74	Ice (3)	-20	-	59.7 <sup>m</sup>	NaI·2H <sub>2</sub> O
- 1.9	7.48	" (3)	0	1.8612	61.54	"
- 2.44	9.34	" (2)	10	-	62.8	"
- 4.25	14.59	" (3)	15	1.881	63.33	"
- 5.37	17.44	" (2)	20	-	64.1	"
- 5.6	18.7	" (1)	25	1.919	64.76	"
- 8.70	24.55	" (2)	30	-	65.6	"
- 9.75	26.50	" (3)	35	1.951	66.35	"
-12.72	30.84	" (2)	40	-	67.2	"
-17.8	37.2	" (1)	50	2.017	69.42	"
-18.0	36.46	" (2)	60	-	72.0	"
-23.0	41.55	" (2)	63.13	2.1068	72.95	"
-23.5	41.9	" (1)	65	-	73.6	"
-26.8	44.2	" (1)	68.1	2.1550	74.85	" + NaI
-29.5	46.00	" (2)	70	-	74.6	NaI
-30.6	46.5	" (1)	75.4	2.1544	74.82	"
-31.5	47.1	Ice + NaI·5H <sub>2</sub> O (1)	80	-	74.7	"
-36.1	49.0	Ice <sup>m</sup> (1)	92.23	2.1425	75.05	"
-26.5	49.0	NaI·5H <sub>2</sub> O (1)	100	-	75.14	"
-20	51.5	" (5)	120	-	75.6	"
-18.5	53.3	" (1)	140	-	76.3	"
-15.2	56.93	" (4)	150	-	78.3	"
-14.0	57.2	" (1)	200	-	81.7	"
-12.3	60.2	" (1)	250	-	84.7	"
-13.5	60.2	" + NaI·2H <sub>2</sub> O (6)	300	-	87.4	"
			350	-	89.7	"
			374	-	90.7	"

<sup>m</sup>metastable

SOLUBILITY OF SODIUM IODIDE IN WATER AND DEUTERIUM OXIDE  
(Eddy and Menzies, 1940)

A new hydrate was found which is metastable with respect to the dihydrate, but its composition was not determined.

In H <sub>2</sub> O			In D <sub>2</sub> O		
t°	Gms. NaI per 100 gms. H <sub>2</sub> O	Solid Phase	t°	Gms. NaI per 100 gms. D <sub>2</sub> O	Solid Phase
45	273.6	NaI·XH <sub>2</sub> O (m)	0	141.4	NaI·2D <sub>2</sub> O
50	279.0	" (m)	10	149.2	"
55	285.2	" (m)	20	158.9	"
58.2	288.9	" (m)	30	170.6	"
60.0	291.5	NaI·XH <sub>2</sub> O+NaI (m)	40	185.3	"
60	257.3	NaI·2H <sub>2</sub> O	50	204.7	"
65	277.1	"	60	232.6	"
55	290.7	NaI (m)	66.0	258.5	NaI·2D <sub>2</sub> O+NaI
60	291.6	" (m)	45	243.0	NaI·XD <sub>2</sub> O (m)
65	292.7	" (m)	50	248.2	" (m)
68.2	293.4	NaI+NaI·2H <sub>2</sub> O	55	253.8	" (m)
75	294.8	NaI	58.2	257.3	NaI·XD <sub>2</sub> O+NaI (m)
110	305.3	"	55	256.8	NaI (m)
120	209.5	"	60	257.6	" (m)
130	313.8	"	70	259.3	"
140	319.1	"	80	261.4	"
150	324.5	"	90	263.8	"
160	330.3	"	100	266.6	"
170	336.7	"	110	269.9	"
180	343.4	"			

(m) = Metastable

SOLUBILITY OF SODIUM IODIDE IN SODIUM HYDROXIDE SOLUTIONS AT 20°  
(Pomeroy and Kirachman, 1944)

Moles per liter			Moles per liter		
NaOH	NaI	Density	NaOH	NaI	Density
0.0	8.14	1.910	8.20	6.92	1.981*
0.97	7.74	1.888	8.66	6.76	1.972
1.40	7.69	1.881	9.29	6.54	1.965
1.77	7.34	1.871	9.61	6.47	1.962
2.62	7.11	1.872	9.70	6.34	1.948
3.72	6.76	1.860	10.36	6.24	1.956
4.04	6.63	1.856	11.38	5.99	1.952
4.90	6.48	1.865	12.71	5.76	1.958
5.45	6.40	1.870	13.49	5.64	1.958
6.38	6.36	1.885	13.95	5.50	1.953
7.10	6.44	1.905	14.24	5.52	1.959
7.24	6.41	1.908	14.41	5.45	1.959
7.54	6.49	1.922	15.21	5.42	1.970
7.74	6.66	1.942			

\*In equilibrium with NaI·2H<sub>2</sub>O+NaI. At concentrations of NaOH less than 8.20 M, the solid phase is NaI·2H<sub>2</sub>O, and above 8.20 M it is NaI.

## Na SODIUM

## SOLUBILITY OF SODIUM IODIDE IN SODIUM HYDROXIDE SOLUTIONS AT 20°--Cont.

Data for the system  $\text{NaI-NH}_3\text{-H}_2\text{O}$  from  $-81^\circ$  to  $+216^\circ$  were determined by a polythermal method by Distanov, 1953.

THE SYSTEM SODIUM IODIDE - SODIUM IODATE - WATER  
(Ricci, 1934)

Additional results for this system at 8°, 25° and 40° are given by Hill, Willson and Bishop, 1933, but these authors failed to determine the true nature of the solid phases. They reported the presence of solid solutions (mixed crystals) instead of the double salt here shown to exist.

d. of sat. sol.	<u>Gms. per 100</u> <u>gms. sat.sol.</u>				<u>Gms. per 100</u> <u>gms. sat.sol.</u>		
	NaI	NaIO <sub>3</sub>	Solid Phase		NaI	NaIO <sub>3</sub>	Solid Phase
	<u>Results at 20°</u>				<u>Results at 40°</u>		
1.318	30.43	1.58	DS20		0.0	11.70	NaIO <sub>3</sub> ·H <sub>2</sub> O
1.409	38.26	0.513	"		40.84	3.02	NaIO <sub>3</sub> +DS15
1.686	54.96	0.062	"		48.20	0.95	DS15
1.811	61.36	0.042	"		56.16	0.36	"
					62.52	0.30	"
	<u>Results at 25°</u>				65.39	0.32	" + DS10
1.075	0.0	8.569	NaIO <sub>3</sub> ·H <sub>2</sub> O		66.40	0.31	DS10
-	31.57	2.42	" + DS20		66.89	0.30	"
1.355	33.06	1.96	DS20		67.10	0.30	" + NaI·2H <sub>2</sub> O
-	34.29	1.62	"		67.35	0.0	NaI·2H <sub>2</sub> O
1.391	36.56	1.18	"				
1.443	40.42	0.704	"		<u>Results at 55°</u>		
1.494	43.91	0.455	" + DS15		60.97	0.82	DS10
-	46.06	0.314	DS15		63.59	0.67	"
1.605	54.42	0.102	"		66.78	0.60	"
1.884	63.71	0.069	"		68.03	0.61	"
-	64.70	0.075	" + NaI·2H <sub>2</sub> O		69.11	0.59	"
1.904	64.71	0.0	NaI·2H <sub>2</sub> O				

$$\text{DS20} = 3\text{NaI} \cdot 2\text{NaIO}_3 \cdot 20\text{H}_2\text{O}; \quad \text{DS15} = 3\text{NaI} \cdot 2\text{NaIO}_3 \cdot 15\text{H}_2\text{O}; \quad \text{DS10} = 3\text{NaI} \cdot 2\text{NaIO}_3 \cdot 10\text{H}_2\text{O}.$$

THE SYSTEM SODIUM IODIDE - SODIUM NITRATE - WATER AT 25°  
(Ricci, Budish and Dorodulia, 1937),.

Gms. per 100 gms. sat.sol.			Gms. per 100 gms. sat.sol.		
NaNO <sub>3</sub>	NaI	Solid Phase	NaNO <sub>3</sub>	NaI <sub>3</sub>	Solid Phase
0.0	64.71	NaI·2H <sub>2</sub> O	6.77	57.64	NaNO <sub>3</sub>
2.57	63.12	"	8.73	52.70	"
3.93	62.06	"	10.64	49.22	"
5.48	61.13	" + NaNO <sub>3</sub>	14.38	42.48	"
5.63	60.88	NaNO <sub>3</sub>	22.57	30.49	"
			47.87	0.0	"

THE SYSTEM SODIUM IODIDE - SODIUM SULFATE - WATER  
(Ricci, 1936)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		
	$\text{Na}_2\text{SO}_4$	NaI	Solid Phase
<u>Results at 15°</u>			
1.881	0.0	63.35	NaI·2H <sub>2</sub> O
1.881	0.03	63.32	" + Na <sub>2</sub> SO <sub>4</sub>
1.875	0.02	62.89	Na <sub>2</sub> SO <sub>4</sub>
1.733	0.15	56.92	"
1.613	0.93	50.15	"
1.542	2.21	44.83	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
1.532	2.13	44.07	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
1.490	2.10	41.78	"
1.460	2.15	39.67	"
1.367	2.51	33.16	"
1.106	11.60	0.0	"
<u>Results at 25°</u>			
-	0.0	64.79	NaI·2H <sub>2</sub> O
-	0.06	64.75	" + Na <sub>2</sub> SO <sub>4</sub>
-	0.14	62.05	Na <sub>2</sub> SO <sub>4</sub>
-	0.30	56.54	"
-	0.70	51.91	"
-	2.06	45.01	"
-	4.09	38.58	"
-	7.97	31.21 <sup>m</sup>	"
-	14.91	21.22 <sup>m</sup>	"
-	26.65	7.60 <sup>m</sup>	"
-	33.97	0.0	"
-	7.63	31.77	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
-	7.94	30.05	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
-	8.70	26.84	"
-	9.37	24.81	"
-	10.81	20.30	"
-	14.87	11.50	"
-	17.54	6.77	"
-	21.78	0.0	"
<u>Results at 45°</u>			
-	0.0	68.32	NaI·2H <sub>2</sub> O
-	0.43	52.75	Na <sub>2</sub> SO <sub>4</sub>
-	2.22	42.85	"
-	6.73	31.73	"
-	17.19	16.52	"
-	32.09	0.0	"

<sup>m</sup>Metastable

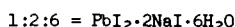
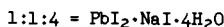
# Na SODIUM

## SODIUM MERCURIC IODIDE

A saturated solution at 24.75°, prepared by adding NaI and HgI<sub>2</sub> in excess to water, contained 4.59% Na, 25% Hg, 58.25% I and 12.2% H<sub>2</sub>O, corresponding to 0.20 mol. alkali, 0.12 mol. Hg and 0.45 mol. I. (Duboin, 1905)

### THE SYSTEM SODIUM IODIDE - LEAD IODIDE - WATER (Roger, 1944)

Refractive indices were determined for many of the solutions at 25°. A complete phase diagram is drawn for the system at both 0° and 25°.

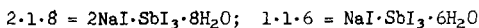


Sat. Sol. Wt. %		density	Solid Phase
PbI <sub>2</sub>	NaI		
Results at 0°			
0.041	0.0	-	PbI <sub>2</sub>
.0006	2.27	-	"
32.94	41.04	-	" + 1:1:4
30.85	43.59	-	1:2:6 + 1:1:4
24.96	47.92	-	" + NaI · 2H <sub>2</sub> O
0.0	61.59	-	NaI · 2H <sub>2</sub> O
Results at 25°			
0.077	0.0	-	PbI <sub>2</sub>
.0555	0.0546	-	"
.0288	.1180	-	"
.0209	.2127	-	"
.0071	.2881	-	"
.0042	.4729	-	"
.0022	1.045	-	"
.0026	3.16	1.023	"
.0054	5.12	-	"
.0262	8.29	-	"
5.43	33.44	1.417	"
11.65	36.82	1.630	"
22.00	39.21	1.909	"
27.70	40.44	2.132	"
30.42	41.61	2.272	"
32.88	41.91	2.427	"
34.59	42.57	2.542	" + 1:1:4
34.09	42.82	2.526	1:1:4
32.02	43.29	2.428	"
31.82	43.56	2.433	"
31.34	44.38	2.475	"
31.38	45.61	2.499	" + 1:1:6
31.04	45.92	2.496	1:1:6
30.49	46.62	2.490	"
29.98	47.05	2.481	"
26.69	47.71	2.492	"
29.41	47.75	2.495	" + NaI · 2H <sub>2</sub> O
26.38	49.79	2.426	NaI · 2H <sub>2</sub> O
21.18	52.45	2.303	"
11.22	58.40	2.119	"
5.97	61.23	2.014	"
0.0	64.58	1.919	"

THE SYSTEM SODIUM IODIDE - ANTIMONY IODIDE - WATER  
(Francois and Delwaulle, 1936)

Numerical results are not given but only a diagram from which the following approximate values were read:

Results at 15°		Results at 35°		Results at 60°		Solid Phase at each temperature
Gms. per 100 gms. H <sub>2</sub> O		Gms. per 100 gms. H <sub>2</sub> O		Gms. per 100 gms. H <sub>2</sub> O		
SbI <sub>3</sub>	NaI	SbI <sub>3</sub>	NaI	SbI <sub>3</sub>	NaI	
0.0	173	0.0	197	0.0	256	
-	-	15.0	200	50	260	NaI·2H <sub>2</sub> O
10	175	25	205	85	275	"
12	150	35	165	80	240	" + 2·1.8
30	125	55	130	90	170	2·1.8
50	100	80	110	150	140	"
65	90	100	105	175	140	"
60	75	100	90	185	120	" + 1·1.6
-	-	-	-	200	110	1·1.6
-	-	-	-	130	70	" + SbI <sub>3</sub>
						SbI <sub>3</sub>



THE SYSTEM SODIUM IODIDE - IODINE - WATER

The system has been studied from the eutectic temperature to 113.5° (the NaI-I eutectic) by Briggs, Geigle, and Eaton, 1941, at 0° by Cheesman, Duncan, and Harris, 1940 and at 25° by Strelnikov, 1933 with good agreement among the various results. At 25° the only solid phases are NaI·2H<sub>2</sub>O and Iodine and the invariant solution contains 25.3 Wt. % NaI and 63.8% I<sub>2</sub>. Three polyiodides are found in the polythermal system and the formulas found by C. D. and H. are simpler than those of B. G. and E., although the % composition of each compound was found to be about the same in both investigations. No Triiodide is formed, in contrast to many other univalent metals.

Results at 0° (C. D. and H.)

Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
NaI	I		NaI	I	
61.4	0.0	NaI·2H <sub>2</sub> O	30.8	49.5	NaI <sub>4</sub> ·2H <sub>2</sub> O
44.9	27.5	"	28.7	52.6	"
38.4	38.2	NaI·2H <sub>2</sub> O + NaI <sub>2</sub> ·3H <sub>2</sub> O	27.5	54.5	"
36.1	41.6	NaI <sub>2</sub> ·3H <sub>2</sub> O	26.7	55.8	NaI <sub>4</sub> ·2H <sub>2</sub> O + I <sub>2</sub>
35.7	42.3	"	24.7	45.1	I <sub>2</sub>
34.9	43.9	NaI <sub>2</sub> ·3H <sub>2</sub> O + NaI <sub>4</sub> ·2H <sub>2</sub> O	21.8	31.9	"
33.2	46.0	NaI <sub>4</sub> ·2H <sub>2</sub> O	17.7	21.2	"

(Cont.)

# Na SODIUM

## THE SYSTEM SODIUM IODIDE - IODINE - WATER--Cont.

### Binary and Ternary Transition Points (B., G. and E.)

In addition to these data the authors report the results of over 100 determinations in the polythermal system of solutions in equilibrium with two or more solids.

t°	Gms. per 100 gms. Sat. Sol.		Solid Phases
	I	NaI	
0	Trace	0	Ice + Iodine
113.5	99.8	0.2	NaI + Iodine
-31.5	0	47.1	Ice + NaI·5H <sub>2</sub> O
-12.3	0	60.2	NaI·5H <sub>2</sub> O + NaI·2H <sub>2</sub> O
68.1	0	74.8	NaI·2H <sub>2</sub> O + NaI
-33.3	22.3	37.3	Ice + Z + NaI·5H <sub>2</sub> O
-24.7	42.2	25.6	Ice + Z + Iodine
-13.9	9.7	54.3	NaI·2H <sub>2</sub> O + Y + NaI·5H <sub>2</sub> O
-21.8	27.7	39.8	Y + Z + NaI·5H <sub>2</sub> O
-10.1	47.0	31.1	X + Y + Z
2.0	45.1	34.5	X + Y + NaI·2H <sub>2</sub> O
-7.0	53.7	27.1	X + Z + Iodine
16.4	60.5	26.3	X + NaI·2H <sub>2</sub> O + Iodine
37.6	66.1	24.3	NaI + NaI·2H <sub>2</sub> O + Iodine

X = Na<sub>4</sub>I<sub>14</sub>·13-15H<sub>2</sub>O

Y = Na<sub>5</sub>I<sub>11</sub>·17-19H<sub>2</sub>O

Z = Na<sub>2</sub>I<sub>8</sub>·10-11H<sub>2</sub>O

### SOLUBILITY OF SODIUM IODIDE IN AQUEOUS ETHYL ALCOHOL AT 30° (Cocheret, 1911)

Gms. per 100 Gms. Sat. Sol.			Gms. per 100 Gms. Sat. Sol.		
NaI	C <sub>2</sub> H <sub>5</sub> OH	Solid Phase	NaI	C <sub>2</sub> H <sub>5</sub> OH	Solid Phase
65.52	0	NaI·2H <sub>2</sub> O	38.5	53.2	NaI·2H <sub>2</sub> O
64	3.42	"	37.49	55.37	" + NaI
54.2	18.5	"	35.65	59.24	NaI
48.8	28.5	"	33.24	61.78	"
42.35	41.7	"	30.90	68.70	"

Data are also given for the solubility of mixtures of NaI + Na<sub>2</sub>CO<sub>3</sub> in aqueous ethyl alcohol at 30°.

The effect of the addition of 0.05 - 0.30 molar sodium iodide on the mutual solubility of n-butyl alcohol and water is reported by Reber, McNabb, and Lucasse, 1942.

THE SYSTEM SODIUM IODIDE - ACETONE - WATER AT 25°  
(Macy and Thomas, 1926)

The materials were carefully purified. Saturation was secured by constant stirring in a thermostat.

d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	NaI	CH <sub>3</sub> COCH <sub>3</sub>			NaI	CH <sub>3</sub> COCH <sub>3</sub>	
1.927	67.0	0.0	NaI·2H <sub>2</sub> O	1.240	40.5	53.4	NaI
1.753	60.2	8.2	"	1.192	37.7	58.0	"
1.565	54.3	19.4	"	1.144	34.7	62.9	"
1.450	49.9	30.1	"	1.067	29.4	70.6	**
1.358	46.3	40.3	"	1.062	25.8	71.5	NaI·3(CH <sub>3</sub> COCH <sub>3</sub> )
1.320	44.5	46.1	" + NaI				

\*unstable

SOLUBILITY OF SODIUM IODIDE IN PURE METHYL ALCOHOL  
(Lloyd, Brown, Glynwyn, Bonnell and Jones, 1928)

t°	Gms. NaI per 100 gms. CH <sub>3</sub> OH	Solid Phase	t°	Gms. NaI per 100 gms. CH <sub>3</sub> OH	Solid Phase
10	65.0	NaI·3CH <sub>3</sub> OH	27	81.3	NaI·3CH <sub>3</sub> OH
18	(72) <sup>c</sup>	"	28	81.8	"
20	72.9	"	30	81.4	NaI
22.5	(77.7) <sup>b</sup>	"	40	80.7	"
25	78.0	"	50	80.1	"
	(80.53) <sup>a</sup>		60	79.4	"
	(83) <sup>c</sup>				

<sup>a</sup>Larson and Hunt, 1939, d. = 1.2615

<sup>b</sup>deBruyn, 1892

<sup>c</sup>Pavlopoulos and Strehlow, 1954, d. = 1.286 at 25°; d. = 1.266 at 18°.

SOLUBILITY OF SODIUM IODIDE IN ABSOLUTE ETHYL ALCOHOL AT TEMPERATURES UP  
TO THE CRITICAL POINT  
(Tyrer, 1910a)

The mixtures were placed in sealed glass tubes which were heated in a specially constructed, electrically heated air bath. The temperature at which the last trace of salt just dissolved was determined in each case. The experiments were made with very great care. Results are also given for the solubility of sodium iodide in the vapor of ethyl alcohol above the critical point.

(Cont.)



# Na SODIUM

## SOLUBILITY OF SODIUM IODIDE IN ABSOLUTE ETHYL ALCOHOL AT TEMPERATURES UP TO THE CRITICAL POINT--Cont.

t°	Gms. NaI per 100 Gms. C <sub>2</sub> H <sub>5</sub> OH	t°	Gms. NaI per 100 Gms. C <sub>2</sub> H <sub>5</sub> OH	t°	Gms. NaI per 100 Gms. C <sub>2</sub> H <sub>5</sub> OH
10	43.77	120	45.2	240	32.7
22.5	(43.1) <sup>a</sup>	160	45.0	250	26.2
25	(42.57) <sup>b</sup>	180	44.3	255	21.0
	(43.32) <sup>c</sup>	200	42.3	260	10.8
30	44.25	220	38.5	261.5*	8.6
50	44.50	230	36.2		
80	45.0				
100	45.1				

\*crit. t. of solution

a) deBruyn, 1892

b) very careful determination by King and Partington, 1926; d. = 1.037.

c) Larson and Hunt, 1939; d. = 1.0466

## SOLUBILITY OF SODIUM IODIDE IN ETHYL ALCOHOL CONTAINING INCREASING AMOUNTS OF LITHIUM PERCHLORATE AT 25° (Hawkins and Partington, 1930)

d. of sat. sol.	Gms. per 100 gms. C <sub>2</sub> H <sub>5</sub> OH			Solid Phase
	NaI	LiClO <sub>4</sub>	Total Solids*	
1.0460	42.85	0.0	42.85	NaI
1.0522	43.15	0.864	43.88	"
1.0554	43.14	1.760	44.81	"
1.0569	43.02	2.33	45.24	"
1.0572	42.79	2.775	45.39	" + NaClO <sub>4</sub> + LiI
1.0553	42.34	2.39	44.73	" " "
1.0558	42.10	1.85	43.58	" " "

\*Determined by evaporation.

## SOLUBILITY OF SODIUM IODIDE AT 25° IN ETHYL ALCOHOL IN PRESENCE OF: (King and Partington, 1927)

<u>Lithium Iodide</u>			<u>Sodium Thiocyanate</u>		
d. of sat. sol.	Gms. per 100 gms. C <sub>2</sub> H <sub>5</sub> OH		d. of sat. sol.	Gms. per 100 gms. C <sub>2</sub> H <sub>5</sub> OH	
	NaI	LiI		NaI	LiI
1.0460	42.85	0.0	1.0460	42.85	0.0
1.0471	34.71	8.08	1.0422	41.81	1.17
1.0476	29.56	13.31	1.0360	39.18	3.93
1.0561	15.57	27.75	1.0309	36.70	6.48
1.0975	3.18	46.80	1.0305	36.25	6.91
1.1099	2.56	49.44	1.0299	35.65	7.61
--	0.0	250.8	0.8825	0.0	20.99

SOLUBILITY OF SODIUM IODIDE IN HIGHER ALCOHOLS AT 25°  
(Larsen and Hunt, 1939)

Solvent	Formula	d. of sat. sol.	Gms. NaI per 100 gms. solvent
1-Propanol	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$	0.9699	27.65
1-Butanol	$\text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{OH}$	0.9397	21.60
2-Propanol (iso)	$\text{CH}_3\text{CHOHCH}_3$	0.9422	26.32
2-Methyl-1-propanol (iso butyl)	$(\text{CH}_3)_2\text{CHCH}_2\text{OH}$	0.9085	17.68
1-Pentanol	$\text{CH}_3(\text{CH}_2)_3\text{CH}_2\text{OH}$	0.9127	16.31
2-Butanol (Sec.)	$\text{CH}_3\text{CH}_2\text{CHOHCH}_3$	0.8068	15.02
Allyl Alcohol	$\text{CH}_2 = \text{CHCH}_2\text{OH}$	--	28.5 <sup>a</sup>
Benzyl Alcohol	$\text{C}_6\text{H}_5\text{CH}_2\text{OH}$	--	14.4 <sup>a</sup>

<sup>a</sup>Partington and Winterton, 1934

SOLUBILITY OF SODIUM IODIDE IN MIXTURES OF ALCOHOLS AT 25°  
(Herz and Kuhn, 1908)

In  $\text{CH}_3\text{OH} + \text{C}_2\text{H}_5\text{OH}$

% $\text{CH}_3\text{OH}$ in Mixture	$d_{25}$ of Sat. Sol.	Gms. NaI per 100 cc. Sat. Sol.
0	1.0806	35.15
4.37	1.1029	37.68
10.4	1.1123	38.71
41.02	1.1742	45.98
80.69	1.2741	57.44
84.77	1.2886	58.92
91.25	1.3056	61.10
100	1.3250	63.22

(% of  $\text{C}_3\text{H}_7\text{OH}$ ) In  $\text{CH}_3\text{OH} + \text{C}_3\text{H}_7\text{OH}$

0	1.3250	63.22
11.11	1.2853	58.45
23.8	1.2528	54.64
65.2	1.1387	40.71
91.8	1.0420	29.14
93.75	1.0178	26.49
100	0.9968	24.11

(% of  $\text{C}_3\text{H}_7\text{OH}$ ) In  $\text{C}_2\text{H}_5\text{OH} + \text{C}_3\text{H}_7\text{OH}$

0	1.0806	35.15
8.1	1.0732	34.60
17.85	1.0720	34.05
56.6	1.0276	28.41
88.6	1.0130	26.13
91.2	1.0104	25.88
95.2	1.0020	24.74
100	0.9968	24.11

## Na SODIUM

## SOLUBILITY OF SODIUM IODIDE IN ABSOLUTE ACETONE

M. &amp; T.--Macy and Thomas, 1926

W. &amp; D.--Wadsworth and Dawson, 1926

B. et al.--Bell, Rowlands, Bamford, Thomas and Jones, 1931

t°	density (M. & T.)	M. & T.	W. & D.	B. et al.	Solid Phase
-76.5	-	-	-	1.57 <sup>b</sup>	NaI·3CH <sub>3</sub> OCH <sub>3</sub>
-72.6	-	-	-	1.73 <sup>b</sup>	"
-67.3	-	-	-	2.25 <sup>b</sup>	"
-43.6	-	-	-	2.58 <sup>b</sup>	"
-34	-	3.3	-	-	"
-21.5	-	-	-	5.69 <sup>b</sup>	"
-20	-	-	5.5	-	"
-12.3	0.873	8.0	-	-	"
-10	-	-	7.8	-	"
0	0.899	13.1	11.8	11.5	"
0.5	-	-	-	12.16 <sup>b</sup>	"
10	-	-	18.2	18.2	"
15	-	-	-	23.2	"
15.9	0.984	26.6	-	-	"
18	-	-	-	24.7 <sup>a</sup>	"
20	-	-	30.0	29.9	"
20.7	-	-	-	31.15 <sup>b</sup>	"
25	1.062	39.9	-	40.1	"
25.7	1.070	41.3	40.7	-	" + NaI
25	1.067	41.7	-	-	NaI(m)
30	-	-	39.2	38.9	"
32.2	1.043	47.5	-	-	"
35	-	-	-	36.7	"
37	-	-	-	33.1 <sup>a</sup>	"
40	-	-	35.6	34.8	"
40.2	-	36.6	-	-	"
45	-	-	-	32.9	"
50	-	33.3	32.0	30.9	"
55	-	-	-	29.3	"
57.2	-	30.9	-	-	"
59.8	-	29.9	-	-	"
60	-	-	28.6	-	"
70	-	-	25.1	-	"
80	-	-	21.8	-	"

<sup>a</sup>Lanning, 1932<sup>b</sup>Evertz and Livingston, 1949

m = metastable

100 gms. pure acetone sat. with CO<sub>2</sub> and NaI contain 23.4 gms. NaI at 16°. A saturated solution of NaI in acetone, through which a stream of CO<sub>2</sub> is passed, yields crystals of NaI·3(CH<sub>3</sub>COOCH<sub>3</sub>).

(Bell, Rowlands, Bamford, Thomas and Jones, 1931)

SOLUBILITY OF SODIUM IODIDE IN METHYL ETHYL KETONE  
(Wadsworth and Dawson, 1926)

t°	Gms. NaI per 100 gms. CH <sub>3</sub> CO·C <sub>2</sub> H <sub>5</sub>	Solid Phase	t°	Gms. NaI per 100 gms. CH <sub>3</sub> CO·C <sub>2</sub> H <sub>5</sub>	Solid Phase
-70	7.3	NaI·3(CH <sub>3</sub> CO·C <sub>2</sub> H <sub>5</sub> )	-10	17.4	NaI
-60	10.0	"	20	15.0	"
-50	14.0	"	30	12.7	"
-30	28.0	" + NaI	40	10.7	"
-20	25.0	NaI	50	8.9	"
-10	22.8	"	60	7.4	"
0	20.1	"	70	6.2	"

SOLUBILITY OF SODIUM IODIDE IN ACETAMIDE  
(Menschutkin, 1908)

Gms. per 100 Gms. Sat. Sol.

t°	NaI·2CH <sub>3</sub> CONH <sub>2</sub> = NaI	Solid Phase
82	m. pt. of pure acetamide	CH <sub>3</sub> CONH <sub>2</sub>
78	9.5	"
74	18	"
70	25.5	"
66	31.9	"
62	37.3	"
58	41.9	"
54	46.1	"
50	50	"
46	53.7	"
41.5	57.7	" + NaI·2CH <sub>3</sub> CONH <sub>2</sub>
50	59	NaI·2CH <sub>3</sub> CONH <sub>2</sub>
60	60.5	"
70	62.2	"
80	64.2	"
90	66.5	"
100	69.2	"
110	72.6	"
120	78.7	"
125	84.7	" + NaI
150	85.1	NaI
175	85.5	"

## Na SODIUM

## SOLUBILITY OF SODIUM IODIDE IN SEVERAL SOLVENTS

Solvent	t°	Solubility
Acetonitrile	0	22.09 gms NaI per 100 cc sat. sol. (Rohland, 1898; Walden, 1906.)
	25	18.43 gms NaI per 100 cc sat. sol. (Rohland, 1898; Walden, 1906.)
	18	26.5 gms NaI per 100 gms solvent (d. = 0.961) (Pavlopoulos and Strehlow, 1954)
	25	24.9 gms NaI per 100 gms solvent (d. = 0.948) (Pavlopoulos and Strehlow, 1954)
Propionitrile	0	9.09 gms NaI per 100 cc sat. sol. (Rohland, 1898; Walden, 1906)
	25	6.23 gms NaI per 100 cc sat. sol. (Rohland, 1898; Walden, 1906)
Nitromethane	0	0.34 gms NaI per 100 cc sat. sol. (Rohland, 1898; Walden, 1906)
	25	0.48 gms NaI per 100 cc sat. sol. (Rohland, 1898; Walden, 1906)
Furfural	25	25.10 gms NaI per 100 cc sat. sol. (Rohland, 1898; Walden, 1906)
Ethylene diamine	25	34.6 gms NaI per 100 gms solvent (Isbin and Kobe, 1945)
Monoethanol amine	25	22.0 gms NaI per 100 gms solvent (Isbin and Kobe, 1945)
Ethylene glycol	25	107.4 gms NaI per 100 gms solvent (Isbin and Kobe, 1945)
Formic acid	18	62.7 gms NaI per 100 gms solvent (d. = 1.668) (Pavlopoulos and Strehlow, 1954)
	25	61.8 gms NaI per 100 gms solvent (d. = 1.657) (Pavlopoulos and Strehlow, 1954)

Data for the distribution of NaI between ethylene glycol and ethyl acetate at 30° are given by Dawson and Griffith, 1951

The effect of small quantities of NaI on the miscibility temperature of methanol and cyclohexane is reported by Eckfeldt and Lucasse, 1943

## SOLUBILITY OF SODIUM IODIDE IN LIQUID AMMONIA

t°	Gms. NaI per 100:		Authority
	gms. sat. sol.	cc sat. sol.	
-42.2	-	44.8	(Sherer, 1931.)
-37.8	-	48.8	" "
-35.2	-	51.3	" "
-31.5	-	54.6	" "
0	56.88	-	(Linhard and Stephan, 1933, 1934.)
25	59.40	-	(Hunt, 1932.)

## SOLUBILITY IN LIQUID SULFUR DIOXIDE

0°	-	15.0 gms NaI per 100 gms SO <sub>2</sub>	(Jander and Ruppolt, 1937)
25°	-	1.59 gms NaI per 100 gms sat. sol	(Shatenstein and Viktorov, 1937).
25°	-	2.1 gms NaI per 100 gms SO <sub>2</sub>	(Watt, Jenkins and Robertson, 1950)

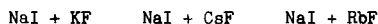
Results for the vapor pressure-temperature relations in the system NaI + SO<sub>2</sub> are given by Foote and Fleischer, 1931.

100 cc. anhydrous hydrazine dissolve 64 gms. NaI at room temp.  
(Welsh and Broderson, 1951.)

Melting points were determined for:

NaI + NaOH	Scarpa, 1915
NaI + CdI <sub>2</sub> + PbI <sub>2</sub>	Il'yasov and Bostandzhiyan, 1957

Reactions of the salts below the melting points were studied with X-rays by Link and Wood, 1940 for the following pairs:

SODIUM IODATE NaIO<sub>3</sub>

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## SOLUBILITY OF SODIUM IODATE IN WATER

(Foote and Vance, 1928; Cornec and Spack, 1931; Hill and Donovan, 1931)

t°	d. of sat. sol.	Gms. NaIO <sub>3</sub> per 100 gms. sat. sol.	Solid Phase
- 0.35	-	2.38	Ice + NaIO <sub>3</sub> ·5H <sub>2</sub> O
0	1.024	2.42	NaIO <sub>3</sub> ·5H <sub>2</sub> O
5	1.028	3.30	"
10	1.041	4.39	"
15	1.052	5.86	"
19.85	1.070	7.83	" + NaIO <sub>3</sub> ·H <sub>2</sub> O
25.0	1.077	8.67	NaIO <sub>3</sub> ·H <sub>2</sub> O
25.0	1.075	8.57(1)	"
30	1.085	9.63	"
35	1.093	10.58	"
40	1.102	11.71	NaIO <sub>3</sub> ·H <sub>2</sub> O
50	1.119	14.0	"
60	1.142	16.5	"
70	1.164	19.0	"
80	1.190	22.2*	"
73.4	1.172	20.0	" + NaIO <sub>3</sub>
67.0	-	19.0*	NaIO <sub>3</sub>
80	1.180	21.0	"
90	1.192	22.8	"
100	1.204	24.8	"

\*Metastable; (1) Ricci, 1934.

# Na SODIUM

## THE SYSTEM SODIUM IODATE - IODIC ACID - WATER AT 30° (Meerburg, 1903)

	Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
	HIO <sub>2</sub>	NaIO <sub>2</sub>		HIO <sub>2</sub>	NaIO <sub>2</sub>	
	0	9.36	NaIO <sub>3</sub> ·1½H <sub>2</sub> O	11.20	7.54	Na <sub>2</sub> O·2I <sub>2</sub> O <sub>5</sub>
	1.98	9.52	"	11.82	7.20	" + NaIO <sub>3</sub> ·2HIO <sub>3</sub>
	4.86	10.22	"	11.62	5.65	NaIO <sub>3</sub> ·2HIO <sub>3</sub>
	5.86	11.04	"	23.23	3.69	"
	7.40	11.60	" unstable	32.68	2.91	"
	9.73	14.73	" "	46.62	2.67	"
	6.70	11.21	" + Na <sub>2</sub> O·2I <sub>2</sub> O <sub>5</sub>	55.48	2.12	"
10	7.80	10.30	Na <sub>2</sub> O·2I <sub>2</sub> O <sub>5</sub>	65.47	1.83	"
	9.15	9.00	"	76.19	1.42	" + HIO <sub>3</sub>
	9.93	8.71	"	76.70	0	HIO <sub>3</sub>

## THE SYSTEM SODIUM IODATE - SODIUM NITRATE - WATER

The isotherms at 8°, 25°, and 35° are given by Foote and Vance, 1929(a); those for 5°, 25° and 50° by Hill and Donovan, 1931; and that for 0° and the triple points for various temperatures up to 100° are given by Cornec and Spack, 1931.

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	NaNO <sub>3</sub>	NaIO <sub>3</sub>			NaNO <sub>3</sub>	NaIO <sub>3</sub>	
<u>Results at 0°</u>				<u>Results at 8°</u>			
1.357	42.0	0.53	NaNO <sub>3</sub>	-	43.99	0.0	NaNO <sub>3</sub>
1.360	41.8	0.82	" + DS	-	43.24	1.67	" + DS
1.351	40.8	0.85	DS	-	40.80	1.88	DS
1.286	33.5	1.25	"	-	39.54	1.96	" + Na·1
1.278	32.5	1.34	" + Na <sub>5</sub>	-	39.36	2.02	Na·1
1.251	29.6	6.25	Na <sub>5</sub>	-	32.23	2.27	Na·1
				-	30.93	2.24	" + Na <sub>5</sub>
<u>Results at 5°</u>				<u>Results at 25°</u>			
1.300	34.1	2.02	DS + Na <sub>5</sub> + Na·1				
1.042	4.50	1.58	Na·5	1.078	3.26	6.38	Na·1
1.182	22.59	1.55	"	1.092	7.32	4.80	"
1.214	26.38	1.65	"	1.149	16.08	3.68	"
1.255	30.70	1.87	"	1.232	27.16	3.06	"
1.275	32.48	2.07	"	1.328	38.19	2.60	"
1.291	34.34	1.94	" + DS	1.408	46.81	2.33	" + NaNO <sub>3</sub>
1.308	36.69	1.76	DS	1.396	47.44	1.09	NaNO <sub>3</sub>
1.324	38.38	1.60	"				
1.336	40.40	1.41	"				
1.359	42.74	1.28	" + NaNO <sub>3</sub>				
1.359	42.94	1.01	NaNO <sub>3</sub>				

(Cont.)

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Na<sub>5</sub> = NaIO<sub>3</sub>·5H<sub>2</sub>O; Na·1 = NaIO<sub>3</sub>·H<sub>2</sub>O; Na = NaIO<sub>3</sub>; DS = 2NaIO<sub>3</sub>·3NaNO<sub>3</sub>·15H<sub>2</sub>O.

## THE SYSTEM SODIUM IODATE - SODIUM NITRATE - WATER--Cont.

$\text{Na}_5 = \text{NaIO}_3 \cdot 5\text{H}_2\text{O}$ ;  $\text{Na} \cdot 1 = \text{NaIO}_3 \cdot \text{H}_2\text{O}$ ;  $\text{Na} = \text{NaIO}_3$ ;  $\text{DS} = 2\text{NaIO}_3 \cdot 3\text{NaNO}_3 \cdot 15\text{H}_2\text{O}$ .

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	NaNO <sub>3</sub>	NaIO <sub>3</sub>			NaNO <sub>3</sub>	NaIO <sub>3</sub>	
<u>Results at 50°</u>							
-	5.74	9.63	Na·1	-	45.23	3.46	Na
-	17.03	6.22	"	-	49.23	3.09	"
-	28.13	4.82	"	-	51.86	2.91	" + NaNO <sub>3</sub>
-	39.15	3.92	"	-	52.55	1.58	NaNO <sub>3</sub>
-	41.53	3.84	" + Na	t° = 70°	55.7	3.16	" + Na
-	42.46	3.77	Na	t° = 100°	61.5	3.94	" + "

THE SYSTEM SODIUM IODATE - SODIUM SULFATE - WATER  
(Foote and Vance, 1930)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
NaIO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>		NaIO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	

<u>Results at 25°</u>			<u>Results at 35° (Cont.)</u>		
3.76	12.64	NaIO <sub>3</sub> ·H <sub>2</sub> O	1.29	25.97	1.3
3.17	17.52	"	0.83	28.84	" + 1.4
2.79	21.18	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	0.30	30.35	1.4
2.20	21.30	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	0.28	31.06	"
			0.10	32.82	"
			0.15	32.88	" + Na <sub>2</sub> SO <sub>4</sub>

<u>Results at 29.5°</u>			<u>Results at 50°</u>		
2.71	25.01	NaIO <sub>3</sub> ·H <sub>2</sub> O + 1.3			
1.90	25.68	1.3			
1.52	26.85	"	5.30	19.97	NaIO <sub>3</sub> ·H <sub>2</sub> O + 1.3
1.57	27.72	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	4.01	21.21	1.3
			2.75	22.85	"
			1.87	23.96	"
			1.25	25.93	"
			1.03	27.42	" + 1.4
			0.63	28.53	1.4
			0.28	30.02	"
			0.15	31.67	"
			0.15	31.65	" + Na <sub>2</sub> SO <sub>4</sub>

<u>Results at 35°</u>		
4.47	15.30	NaIO <sub>3</sub> ·H <sub>2</sub> O
3.73	19.33	"
3.59	20.70	"
3.33	22.57	" + 1.3
2.39	23.79	1.3

1.3 =  $\text{NaIO}_3 \cdot 3\text{Na}_2\text{SO}_4$ ; 1.4 =  $\text{NaIO}_3 \cdot 4\text{Na}_2\text{SO}_4$



# Na SODIUM

## 10 SODIUM PERIODATE $\text{NaIO}_4$

### SOLUBILITY OF SODIUM PERIODATE IN WATER (Hill, 1928)

t°	d. of sat. sol.	Gms. $\text{NaIO}_4$ per 100 gms. sat. sol.	Solid Phase
5.8	1.048	3.93	$\text{NaIO}_4 \cdot 3\text{H}_2\text{O}$
15.0	1.060	7.2	"
20	1.073	9.3	"
25	1.103	12.62	"
30	1.143	16.6	"
31.5	1.161	18.2	"
33.0	1.175	19.6	"
34.5	-	21.3	$\text{NaIO}_4 \cdot 3\text{H}_2\text{O} + \text{NaIO}_4$
31.5	1.173	19.8*	$\text{NaIO}_4$
33.0	1.185	20.6*	"
35	1.192	21.5	"
38	1.202	22.6	"
44.2	1.218	24.9	"
51.5	1.251	28.0	"

\* = Metastable.

### SOLUBILITY OF SODIUM PERIODATE IN AQUEOUS PERIODIC ACID AT 25°

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{NaIO}_4$	$\text{HIO}_4$	
1.103	12.62	0.0	$\text{NaIO}_4 \cdot 3\text{H}_2\text{O}$
1.150	11.43	5.23	"

### THE SYSTEM SODIUM PERIODATE - SODIUM HYDROXIDE - WATER AT 25° (Hill, 1928)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{NaIO}_4$	$\text{NaOH}$	
1.103	12.62	0.0	$\text{NaIO}_4 \cdot 3\text{H}_2\text{O}$
1.103	12.51	0.0	" + $\text{Na}_2\text{H}_3\text{IO}_6$
1.094	11.59	trace	$\text{Na}_2\text{H}_3\text{IO}_6$
1.057	7.63	0.02	"
1.011	1.85	0.01	"
0.999	0.22	0.045	"
1.000	0.15	0.17	"
1.002	0.31	0.45	"
1.006	0.30	0.55	"
1.004	0.33	0.57	" + $\text{Na}_3\text{H}_2\text{IO}_4$
1.006	0.19	0.60	$\text{Na}_3\text{H}_2\text{IO}_4$
1.010	0.15	1.00	"
1.032	0.08	2.41	"
1.111	0.02	10.04	"
-	0.004	22.2	"
1.319	trace	30.75	"

THE SYSTEM  $\text{NaMnO}_4 - \text{H}_2\text{O}$   
(White and Miller, 1953)

Temperatures at which a solid phase appeared. At higher temperatures the solutions decomposed.

Wt.% $\text{NaMnO}_4$	f. pt.	Wt.% $\text{NaMnO}_4$	f. pt.	Wt.% $\text{NaMnO}_4$	f. pt.
SOLID PHASE ICE		SOLID PHASE $\text{NaMnO}_4 \cdot 3\text{H}_2\text{O}$		SOLID PHASE $\text{NaMnO}_4 \cdot \text{H}_2\text{O}$	
2	- 0.5	42	-14.7	76	36.4
4	- 0.9	44	-10.7	78	45.6
6	- 1.4	46	- 6.2	80	51.5
8	- 2.0	48	- 2.0	82	59.0
10	- 2.5	50	+ 2.25	83	62.5
12	- 3.2	52	6.6	84	65.2
14	- 3.8	54	10.8	86	67.7
16	- 4.6	56	15.0	88	68.7 <sup>e</sup>
18	- 5.3	58	18.9	90	68.0?
20	- 6.1	60	22.5	90.7	66.2? <sup>f</sup>
22	- 7.0	62	25.8		
24	- 7.7	64	30.7	SOLID PHASE $\text{NaMnO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}(?)$	
25	(- 9) <sup>a</sup>	66	31.3		
26	- 8.5	68	33.7	92	66.5?
28	- 9.5	70	35.3	94	67.6?
30	-10.3	72	36.0 <sup>c</sup>	96	67.6?
32	-11.2	74	35.3		
34	-12.2	75	34.0		
36	-13.2	75.2	33.7 <sup>d</sup>		
38	-14.1				
40	-15.0				
41	(-15) <sup>a</sup>				
41.4	-15.8 <sup>b</sup>				

<sup>a</sup> (Bellinger, Friedman, et al, 1946)

<sup>b</sup> Solid phase ICE +  $\text{NaMnO}_4 \cdot 3\text{H}_2\text{O}$

<sup>c</sup> melting point of trihydrate

<sup>d</sup> Solid phase  $\text{NaMnO}_4 \cdot 3\text{H}_2\text{O}$  +  $\text{NaMnO}_4 \cdot \text{H}_2\text{O}$

<sup>e</sup> melting point of monohydrate

<sup>f</sup> Solid phase  $\text{NaMnO}_4 \cdot \text{H}_2\text{O}$  +  $\text{NaMnO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}(?)$

# Na SODIUM

## MoO SODIUM MOLYBDATE $\text{Na}_2\text{MoO}_4$

### SOLUBILITY IN WATER (Funk, 1900a)

t°	Gms. $\text{Na}_2\text{MoO}_4$ per 100 Gms. Solution	Mols. $\text{Na}_2\text{MoO}_4$ per 100 Mols. $\text{H}_2\text{O}$	Solid Phase
0	30.63	3.86	$\text{Na}_2\text{MoO}_4 \cdot 10\text{H}_2\text{O}$
	30.60 (1)	-	"
4	33.83	4.47	"
6	35.58	4.83	"
8.5	37.29 (1)	-	"
9	38.16	5.39	"
10	39.28	5.65	$\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$
12.1	39.08 (1)	-	"
15.5	39.27	5.65	"
18	39.40	5.70	"
20	39.30 (1)	-	"
24	39.40 (2)	-	"
25	39.40 (3)	-	"
28	39.74 (1)	-	"
32	39.82	5.78	"
51.5	41.27	6.14	"
100	45.57	7.32	"
	45.47 (4)	-	"
104	45.90 (4)	-	"
107	46.32 (4)	-	"

(1) Cadbury, Jr., 1955

(2) Bye, 1943, 1945

(3) Ricci and Doppelt, 1944; Ricci and Linke, 1947

(4) Linke and Cooper, 1956

### THE SYSTEM SODIUM OXIDE - MOLYBDIC OXIDE - WATER AT 24° (Bye, 1943, 1945)

Gms. per 100 gms. Sat. Sol.

<div> <math>\text{Na}_2\text{O}</math> <math>\text{MoO}_3</math> </div>		Solid Phase
*40.6	0.0	$\text{NaOH} \cdot \text{H}_2\text{O}$
40.3	0.206	$\text{NaOH} \cdot \text{H}_2\text{O} + \text{Na}_2\text{MoO}_4$
38.7	.216	$\text{Na}_2\text{MoO}_4$
36.9	.228	"
33.7	.393	"
32.6	.465	$\text{Na}_2\text{MoO}_4 + \text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$
30.7	.664	$\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$
28.26	.955	"
20.98	4.86	"
17.77	9.92	"
15.40	15.87	"
13.58	21.13	"
*11.85	27.55	"
11.82	27.50	$\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O} + \text{Na}_2\text{Mo}_2\text{O}_7 \cdot 6\text{H}_2\text{O}$

\*Represents the solubility of the substance in pure water.

(Cont.)

## THE SYSTEM SODIUM OXIDE - MOLYBDIC OXIDE - WATER AT 24°--Cont.

Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.		
Na <sub>2</sub> O	MoO <sub>3</sub>	Solid Phase	Na <sub>2</sub> O	MoO <sub>3</sub>	Solid Phase
8.86	20.72	Na <sub>2</sub> Mo <sub>2</sub> O <sub>7</sub> ·6H <sub>2</sub> O	2.21	11.88	Na <sub>2</sub> Mo <sub>3</sub> O <sub>10</sub> ·7H <sub>2</sub> O
8.81	20.82	"	2.09	11.35	"
6.52	15.75	"	1.605	9.30	"
5.43	14.80	"	*1.09	7.51	"
4.89	17.30	"	0.992	8.30	Na <sub>2</sub> Mo <sub>3</sub> O <sub>10</sub> ·7H <sub>2</sub> O + Na <sub>2</sub> Mo <sub>4</sub> O <sub>13</sub> ·7H <sub>2</sub> O
5.30	21.65	"	*0.910	8.50	Na <sub>2</sub> Mo <sub>4</sub> O <sub>13</sub> ·7H <sub>2</sub> O
5.80	27.0	"	.951	8.49	"
6.18	30.37	"	.605	5.58	Mo <sub>6</sub> O <sub>19</sub> Na <sub>1+α</sub> H <sub>1-α</sub> ·5H <sub>2</sub> O
6.46	33.47	Na <sub>2</sub> Mo <sub>2</sub> O <sub>7</sub> ·6H <sub>2</sub> O + Na <sub>2</sub> Mo <sub>3</sub> O <sub>10</sub> ·7H <sub>2</sub> O	.849	7.95	"
5.95	30.85	Na <sub>2</sub> Mo <sub>3</sub> O <sub>10</sub> ·7H <sub>2</sub> O	.88	8.18	"
5.17	26.80	"	.69	6.41	"
4.84	24.88	"	.61	5.65	Mo <sub>6</sub> O <sub>19</sub> Na <sub>1+α</sub> H <sub>1-α</sub> ·5H <sub>2</sub> O
4.57	24.05	"	.343	3.095	"
3.80	20.0	"	.202	1.82	"
2.56	13.82	"	.032	0.455	"

The following are metastable equilibria:

11.80	31.55	Na <sub>2</sub> MoO <sub>4</sub> ·2H <sub>2</sub> O + 3:7:22	.655	6.28	MoO <sub>3</sub>
			.903	8.66	MoO <sub>3</sub> + Na <sub>2</sub> Mo <sub>4</sub> O <sub>13</sub> ·7H <sub>2</sub> O
11.58	31.23	3Na <sub>2</sub> O·7MoO <sub>3</sub> ·22H <sub>2</sub> O	*0.0	0.167	MoO <sub>3</sub> ·2H <sub>2</sub> O
9.35	29.3	"	.049	.682	MoO <sub>3</sub> ·2H <sub>2</sub> O
7.90	30.0	"	.125	1.44	MoO <sub>3</sub> ·2H <sub>2</sub> O
7.41	33.1	"	.27	3.03	MoO <sub>3</sub> ·2H <sub>2</sub> O
7.20	35.6	"	.54	5.88	MoO <sub>3</sub> ·2H <sub>2</sub> O
7.25	36.45	"	.87	9.31	MoO <sub>3</sub> ·2H <sub>2</sub> O + Na <sub>2</sub> Mo <sub>4</sub> O <sub>13</sub> ·7H <sub>2</sub> O
7.25	37.1	3:7:22 + Na <sub>2</sub> Mo <sub>3</sub> O <sub>10</sub> ·7H <sub>2</sub> O	*0.0	0.253	MoO <sub>3</sub> ·H <sub>2</sub> O
*7.31	39.6	Na <sub>2</sub> Mo <sub>3</sub> O <sub>10</sub> ·7H <sub>2</sub> O	.28	4.21	MoO <sub>3</sub> ·H <sub>2</sub> O
*0.0	0.126	MoO <sub>3</sub>	.15	2.23	MoO <sub>3</sub> ·H <sub>2</sub> O
.293	3.06	MoO <sub>3</sub>			
.615	5.99	MoO <sub>3</sub>			

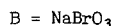
\*Represents the solubility of the substance in pure water.

SOLUBILITY OF SODIUM MOLYBDATE IN MOLYBDIC OXIDE SOLUTIONS AT 25°  
(Ricci and Doppelt, 1944)

Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.		
Na <sub>2</sub> MoO <sub>4</sub>	MoO <sub>3</sub>	Solid Phase	Na <sub>2</sub> MoO <sub>4</sub>	MoO <sub>3</sub>	Solid Phase
39.42	0.0	Na <sub>2</sub> MoO <sub>4</sub> ·2H <sub>2</sub> O	36.38	.00	Na <sub>2</sub> Mo <sub>2</sub> O <sub>7</sub> ·6H <sub>2</sub> O
39.48	.00	Na <sub>2</sub> MoO <sub>4</sub> ·2H <sub>2</sub> O + Na <sub>2</sub> Mo <sub>2</sub> O <sub>7</sub> ·6H <sub>2</sub> O	33.44	.026	"
			32.54	.018	"
38.78	.00	Na <sub>2</sub> Mo <sub>2</sub> O <sub>7</sub> ·6H <sub>2</sub> O	30.85	.047	"
37.66	.00	"	28.81	.083	"
36.66	.010	"	24.82	.320	"

## Na SODIUM

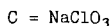
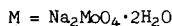
### THE SYSTEM SODIUM MOLYBDATE - SODIUM BROMIDE - WATER AT 25° (Ricci and Linke, 1947)



Sat. Sol. Wt. %		Density	Solid Phase	Sat. Sol. Wt. %		Density	Solid Phase
$Na_2MoO_4$	$NaBrO_3$			$Na_2MoO_4$	$NaBrO_3$		
39.38	0.0	1.432	M	31.49	2.54	1.368	B
39.16	0.58	1.437	M	24.24	3.08	1.277	B
38.63	1.79	1.450	M	17.89	3.42	1.204	B
38.46	2.20	1.453	M+B	11.41	4.16	1.143	B
37.23	2.24	1.436	B	5.57	5.67	1.099	B

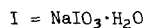
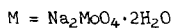
## NaCl

### THE SYSTEM SODIUM MOLYBDATE - SODIUM CHLORATE - WATER AT 25° (Ricci and Linke, 1947)



Sat. Sol. Wt. %		Density	Solid Phase	Sat. Sol. Wt. %		Density	Solid Phase
$Na_2MoO_4$	$NaClO_3$			$Na_2MoO_4$	$NaClO_3$		
39.38	0.0	1.432	M	13.04	37.05	1.472	M
36.11	4.23	1.441	M	11.77	39.21	1.479	M+C
32.42	9.04	1.441	M	11.74	39.29	1.476	C
29.53	14.12	1.440	M	8.87	41.85	1.465	C
22.83	21.94	1.442	M	5.72	44.70	1.456	C
17.85	29.14	1.453	M	2.60	47.60	1.438	C
14.59	34.39	1.466	M	0.0	50.02	1.433	C

### THE SYSTEM SODIUM MOLYBDATE - SODIUM IODATE - WATER AT 25° (Ricci and Linke, 1947)



Sat. Sol. Wt. %		Density	Solid Phase	Sat. Sol. Wt. %		Density	Solid Phase
$Na_2MoO_4$	$NaIO_3$			$Na_2MoO_4$	$NaIO_3$		
39.38	0.0	1.432	M	27.53	9.86	1.398	I
38.30	1.80	1.442	M	22.44	12.56	1.363	I
37.09	3.86	1.453	M	16.18	16.35	1.326	I
35.58	6.30	1.468	M+I	11.47	19.40	1.304	I
32.64	7.49	1.440	I	4.85	24.42	1.278	I
				0.0	28.29	1.264	I

THE SYSTEM SODIUM MOLYBDATE - SODIUM NITRATE - WATER AT 25°  
(Ricci and Doppelt, 1944)

Gms. per 100 gms. Sat. Sol.

Na <sub>2</sub> MoO <sub>4</sub>	NaNO <sub>3</sub>	Density	Solid Phase	
39.42	0.0	1.430	Na <sub>2</sub> MoO <sub>4</sub> ·2H <sub>2</sub> O	
33.28	8.09	-	"	
30.34	11.95	-	"	
25.93	18.07	-	"	
21.20	24.82	-	"	
15.16	34.23	1.446	"	
14.42	35.36	1.453	Na <sub>2</sub> MoO <sub>4</sub> ·2H <sub>2</sub> O + NaNO <sub>3</sub>	
14.28	35.46	1.455	NaNO <sub>3</sub>	MoO
10.74	38.46	1.434	"	
5.03	43.44	1.405	"	
0.0	47.87	1.389	"	

THE SYSTEM SODIUM MOLYBDATE - SODIUM SULFATE - WATER  
(Cadbury, 1955; at 25° Ricci and Linke, 1951; at 35°, 100° Linke and Cooper, 1956)

S = Na<sub>2</sub>SO<sub>4</sub>      S<sub>10</sub> = Na<sub>2</sub>SO<sub>4</sub>·10H<sub>2</sub>O      M = Na<sub>2</sub>MoO<sub>4</sub>      M<sub>2</sub> = Na<sub>2</sub>MoO<sub>4</sub>·2H<sub>2</sub>O  
M<sub>10</sub> = Na<sub>2</sub>MoO<sub>4</sub>·10H<sub>2</sub>O

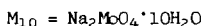
C<sub>M,S</sub> = Decahydrated solid solutions rich in M or S, respectively

Sat. Sol.		Wet Residue		Solid Phase	Sat. Sol.		Wet Residue		Solid Phase
Wt. %		Wt. %			Wt. %		Wt. %		
S	M	S	M		S	M	S	M	
<u>at 0°</u>					<u>at 12.1°</u>				
4.46	0.0	-	-	S <sub>10</sub>	9.65	0.0	-	-	S <sub>10</sub>
3.32	7.00	38.48	1.11	CS	8.85	2.40	40.40	trace	CS
2.23	13.86	36.62	3.02	"	6.32	12.68	36.76	3.21	"
1.16	29.10	33.55	8.34	"	4.00	23.29	39.90	2.50	"
1.08	31.24	8.40	38.40	" + C <sub>M</sub>	3.02	34.03	31.46	11.36	"
0.81	31.52	1.02	48.80	C <sub>M</sub>	2.87	36.57	31.47	12.54	"
0.56	31.12	0.72	54.15	"	2.93	36.52	0.76	73.54	M <sub>2</sub>
0.0	30.60	-	-	M <sub>10</sub>	0.49	38.60	0.13	70.32	"
					0.0	39.08	-	-	"
<u>at 8.5°</u>					<u>at 20°</u>				
7.74	0.0	-	-	S <sub>10</sub>					
5.74	7.75	37.89	1.68	CS	15.96	0.0	-	-	S <sub>10</sub>
3.40	20.66	30.71	7.73	"	13.82	5.04	40.20	0.66	CS
2.45	31.37	30.10	11.98	"	10.97	14.22	37.15	3.48	"
1.90	36.91	6.10	41.82	" + C <sub>M</sub>	7.03	28.49	34.75	8.11	"
1.51	36.95	1.83	47.56	C <sub>M</sub>	6.42	34.10	27.09	22.82	" + M <sub>2</sub>
0.81	37.67	0.89	49.32	"	6.22	34.36	2.74	61.07	M <sub>2</sub>
0.0	37.29	-	-	M <sub>10</sub>	2.99	37.28	1.58	56.78	"
					1.96	37.56	1.44	52.18	"
					0.0	39.30	-	-	"

(Cont.)

# Na SODIUM

## THE SYSTEM SODIUM MOLYBDATE - SODIUM SULFATE - WATER

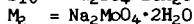
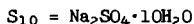


$C_{M,S}$  = Dehydrated solid solutions rich in M or S, respectively

Sat. Sol. Wt. %		Wet Residue Wt. %		Solid Phase	Sat. Sol. Wt. %		Wet Residue Wt. %		Solid Phase	
S	M	S	M		S	M	S	M		
at 28°										
MoO	25.54	0.0	-	-	S <sub>10</sub>	11.84	29.06	89.09	4.53	S
	20.80	10.11	41.48	1.26	C <sub>S</sub>	10.06	31.56	58.63	25.36	" + M <sub>2</sub>
	17.22	17.87	36.71	5.80	"	7.07	33.69	2.73	64.52	M <sub>2</sub>
	15.78	22.97	62.30	2.97	" + S	1.78	38.17	0.78	64.09	"
	12.42	28.09	90.33	3.45	S	0.0	39.74	-	-	"

Results of Ricci and Linke, 1951 at 25°

Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
Na <sub>2</sub> MoO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	Density		Na <sub>2</sub> MoO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	Density	
0.0	21.55	1.201	S <sub>10</sub>	29.50	10.57	1.426	S <sup>e</sup>
6.16	18.50	1.238	S <sub>10</sub>	30.33	10.75	1.446	M <sub>2</sub> + S <sup>e</sup>
12.40	15.53	1.273	S <sub>10</sub>	30.45	10.57	1.444	M <sub>2</sub>
19.31	13.11	1.328	S <sub>10</sub>	32.37	8.23	1.441	M <sub>2</sub>
23.34	12.28	1.360	S <sup>a</sup>	34.19	6.09	1.435	M <sub>2</sub>
25.32	11.57	1.375	S <sup>b</sup>	39.38	0.0	1.432	M <sub>2</sub>
26.19	11.29	1.380	S <sup>c</sup>				
28.31	10.89	1.415	S <sup>d</sup>				
				S <sup>a</sup> = Na <sub>2</sub> SO <sub>4</sub> · 10H <sub>2</sub> O + 1.7% Na <sub>2</sub> MoO <sub>4</sub>			
				S <sup>b</sup> = " + 2.2% "			
				S <sup>c</sup> = " + 2.2% "			
				S <sup>d</sup> = " + 2.5% "			
				S <sup>e</sup> = " + 2.5% "			



Results of Linke and Cooper, 1956

At 35°				At 100°			
Sat. Sol. Wt. %		Density	Solid Phase	Sat. Sol. Wt. %		Density	Solid Phase
Na <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> MoO <sub>4</sub>			Na <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> MoO <sub>4</sub>		
32.90	0.0	1.319	S	14.57	21.45		S
28.14	5.89	1.335	S	9.75	29.66		S
21.66	14.15	1.359	S	5.57	38.02		S
15.40	22.73	1.395	S	4.52	41.85		S
10.50	30.00	1.435	S	4.60	41.91		S + M <sub>2</sub>
9.47	31.89	1.443	S + M <sub>2</sub>	4.39	42.05		S + M <sub>2</sub>
9.42	31.92	1.444	S + M <sub>2</sub>	3.83	41.79		M <sub>2</sub>
9.46	31.90	1.447	S + M <sub>2</sub>	0.0	45.47		M <sub>2</sub>
7.28	33.73	1.443	M <sub>2</sub>				
3.88	36.65	1.435	M <sub>2</sub>				
0.0	39.90	1.434	M <sub>2</sub>				

## SODIUM POLYMOLYBOATES

## SOLUBILITIES IN WATER

Salt	t°	Gms. anhydrous salt per 100 gms. sat. sol.	Reference
$\text{Na}_2\text{Mo}_3\text{O}_{10} \cdot 7\text{H}_2\text{O}$	20	3.878	(Ullik, 1867)
	24	8.60	(Bye, 1943, 1945)
	30	13.68	(Rosenheim, 1916)
	100	13.7	(Ullik, 1867)
$\text{Na}_2\text{Mo}_4\text{O}_{13} \cdot 7\text{H}_2\text{O}$	24	9.41	(Bye, 1943, 1945)
$5\text{Na}_2\text{O} \cdot 12\text{MoO}_3 \cdot 38\text{H}_2\text{O}$	30	54.06	(Rosenheim, 1916)

Melting points are given for:

$\text{Na}_2\text{MoO}_4 + \text{PbMoO}_4$	(Belyaev, 1952)
$\text{Na}_2\text{MoO}_4 + \text{Na}_2\text{SO}_4$	(Belyaev, 1952)(Boeke, 1907)
	(Belyaev and Doroshenko, 1954)
$\text{Na}_2\text{MoO}_4 + \text{PbSO}_4 \rightleftharpoons \text{Na}_2\text{SO}_4 + \text{PbMoO}_4$	(Belyaev, 1952, 1952a)
$\text{Na}_2\text{MoO}_4 + \text{Na}_2\text{WO}_4$	(Boeke, 1907)
$\text{Na}_2\text{MoO}_4 + \text{MoO}_3$	(Hoermann, 1929)
$\text{Na}_2\text{MoO}_4 + \text{Na}_4\text{P}_2\text{O}_7$	(Belyaev and Sholokhov, 1953)
$\text{Na}_2\text{MoO}_4 + \text{PbTiO}_3 \rightleftharpoons \text{Na}_2\text{TiO}_3 + \text{PbMoO}_4$	(Belyaev, 1954)

SODIUM AZIDE  $\text{NaN}_3$ 

N

SOLUBILITY OF SODIUM AZIDE IN WATER  
(Wohlgemuth, 1934)

t°	Gms. $\text{NaN}_3$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{NaN}_3$ per 100 gms. sat. sol.	Solid Phase
-6	10.0	Ice	0	28.0	$\text{NaN}_3$
-15.1 Eutec.	21.6	" + $\text{NaN}_3 \cdot 3\text{H}_2\text{O}$	+16	28.7(1)	"
-20 "	26.8*	" + $\text{NaN}_3$	20	29.0	"
-8	24.0	$\text{NaN}_3 \cdot 3\text{H}_2\text{O}$	100	35.6	"
-2.1 tr.pt.		" + $\text{NaN}_3$			

\*Metastable; (1) Curtius and Rissom, 1898.

100 gms. methanol dissolve 3.16g  $\text{NaN}_3$  at 25° (d. = 0.8083). The solubility in acetone, chloroform, cyclohexane, carbon tetrachloride, trichloroethylene and ethyl acetate is less than 0.005 gm/100 ml of solution

(Hudswell, Nairn and Gadsby, 1951)

100 gms alcohol of  $d_{17} = 0.799$  dissolve 0.22 gms.  $\text{NaN}_3$  at 0° and 0.46 gms. at the b. pt.; 100 gms. benzene dissolve 0.10 gms.  $\text{NaN}_3$  at the b. pt.

(Cranston and Livingstone, 1926.)



# Na SODIUM

## NN SODAMMONIUM $\text{Na}_2(\text{NH}_3)_2$

100 gms. liquid ammonia dissolve 60.5 gms.  $\text{Na}_2(\text{NH}_3)_2$  at  $-23^\circ$ ,  
56.4 gms. at  $0^\circ$ , 56 gms. at  $+5^\circ$  and 55 gms. at  $9^\circ$ . (Joannis, 1906.)

## SODIUM AMIDE $\text{NaNH}_2$

100 gms. Liquid Ammonia dissolve 0.004 gm.  $\text{NaNH}_2$  at  $0^\circ$ . (Hunt and Boncyk, 1933.)

## NO SODIUM NITRITE $\text{NaNO}_2$

### SOLUBILITY OF SODIUM NITRITE IN WATER

(Bureau, 1934, 1937)

The author shows that the previous results of Helberg, 1925, and Oswald, 1912, 1914, in the vicinity of the eutectic point, are erroneous. These authors also failed to detect the hemihydrate.

A = $\text{NaNO}_2 \cdot \frac{1}{2}\text{H}_2\text{O}$				B = $\text{NaNO}_2$			
t°	Gms. $\text{NaNO}_2$ per 100 gms. sat. sol.	d. sat. sol.	Solid Phase	t°	Gms. $\text{NaNO}_2$ per 100 gms. sat. sol.	d. sat. sol.	Solid Phase
- 2.8	5.92	-	Ice	34.08	47.69(a)	-	B
- 3.8	10.0	-	"	37.52	48.37(a)	-	B
- 8.7	16.3	-	"	43.56	49.51(a)	-	B
-11.5	21.0	-	"	48.77	50.56(a)	-	B
-15.2	25.0	-	"	52.0	51.30(a)	-	B
-19.5	28.1	-	Ice + A	56.8	52.00	1.408	B
- 7.6	37.8	-	A	64.7	54.07	1.422	B
- 5.1	41.6	-	A + B	79.5	56.95	1.455	B
0	41.65	-	B	99.9	61.5	1.514	B
+11.90	43.72(a)	-	B	103	62.6 (b)	-	B
15	43.7	1.345	B	128	68.7 (b)	-	B
19.92	45.17(a)	-	B				
22	45.07	1.350	B				
25	45.92(c)	-					

(a) Erdos and Simkova, 1957  
(b) Oswald 1912, 1914  
(c) Cavalca, Nardelli and Braibanti, 1953

### THE SYSTEM SODIUM NITRITE - SODIUM CARBONATE - WATER AT $23.1^\circ$ (Bureau, 1937)

Additional data from  $10^\circ$  to  $35^\circ$  are given by Kuzminykh and Yakhontova, 1951 in graphical form.

## THE SYSTEM SODIUM NITRITE - SODIUM CARBONATE - WATER AT 23.1°--Cont.

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	Na <sub>2</sub> CO <sub>3</sub>	NaNO <sub>2</sub>			Na <sub>2</sub> CO <sub>3</sub>	NaNO <sub>2</sub>	
1.352	0.0	45.25	NaNO <sub>2</sub>	1.363	30.18	11.61	Na·1 + Na·10
1.368	42.95	2.69	"	1.358	28.59	12.63	Na·10
1.376	40.50	5.92	"	1.350	25.50	12.80	"
1.381	38.70	6.55	" + Na·1	1.292	17.85	13.40	"
1.379	37.40	7.84	Na·1	1.279	14.60	14.25	"
1.373	34.40	9.15	"	1.246	10.01	16.10	"
1.372	32.45	10.0	"	1.122	0.0	19.60	"

Na·1 = Na<sub>2</sub>CO<sub>3</sub>·H<sub>2</sub>O, Na·10 = Na<sub>2</sub>CO<sub>3</sub>·10H<sub>2</sub>O

NO

THE SYSTEM SODIUM NITRITE - SODIUM BICARBONATE - WATER AT 23.1°  
(Bureau, 1937)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	NaHCO <sub>3</sub>	NaNO <sub>2</sub>			NaHCO <sub>3</sub>	NaNO <sub>2</sub>	
1.352	0.0	45.25	NaNO <sub>2</sub>	1.288	1.58	36.92	NaHCO <sub>3</sub>
1.359	1.42	45.20	" + NaHCO <sub>3</sub>	1.256	1.20	32.90	"
1.348	1.00	44.0	NaHCO <sub>3</sub>	1.200	2.20	25.65	"
1.320	0.80	40.80	"	1.121	4.33	12.55	"
				2.082	9.91	0.0	"

THE SYSTEM SODIUM NITRITE - SODIUM NITRATE - WATER  
(Oswald, 1912, 1914)

Bureau, 1937 also gives results for the system NaNO<sub>2</sub> + NaNO<sub>3</sub> at 0°, 18.5°, 56.1°, and 98.5°. His results agree closely with the following results of Oswald at 0°. His results at 18.5° are practically identical with those of Rakowski and Slavina, 1931, at 15°. His results at 56.1° are all under those of Oswald at 51° but at 98.5° they exceed Oswald's values at 103°, in the region where both salts are in excess.

In addition to those following, Oswald gives results at 16°, 18°, 65°, 81° and 92°.

Results at 0°		Results at 21°		Results at 52°		Results at 103°	
Gms. per 100 Gms. H <sub>2</sub> O		Gms. per 100 Gms. H <sub>2</sub> O		Gms. per 100 Gms. H <sub>2</sub> O		Gms. per 100 Gms. H <sub>2</sub> O	
NaNO <sub>2</sub>	NaNO <sub>3</sub>	NaNO <sub>2</sub>	NaNO <sub>3</sub>	NaNO <sub>2</sub>	NaNO <sub>3</sub>	NaNO <sub>2</sub>	NaNO <sub>3</sub>
73.0	0.0	84.75	0.0	108.8	0.0	166.0	0.0
68.0	19.0	81.1	9.6	104.3	20.6	153.3	33.2
67.0	36.3	79.7	23.5	99.5	43.2	148.8	58.8
64.9	41.7*	73.8	50.8	98.8	82.0*	142.4	116.0*
50.3	46.8	73.1	54.5*	65.2	88.0	100.0	126.8
30.2	55.4	64.2	56.7	44.2	92.9	60.1	142.9
0.0	74.2	46.8	62.8	27.2	101.4	0.0	181.2
		21.6	74.7	14.7	109.0		
		0.0	89.3	0.0	118.0		

\*Both salts in solid phase

## Na SODIUM

Data for the System  $\text{NaNO}_2 - \text{NaNO}_3 - \text{Na}_2\text{CO}_3 - \text{H}_2\text{O}$  at  $15^\circ$  and  $25^\circ$  are given in graphical form by Kuzminykh and Yezhontova, 1951

### THE SYSTEM SODIUM NITRITE - SILVER NITRITE - WATER (Oswald, 1912, 1914)

	Results at $14^\circ$		Results at $22^\circ$		Solid Phase in Each Case
	Gms. per 100	Gms. $\text{H}_2\text{O}$	Gms. per 100	Gms. $\text{H}_2\text{O}$	
	$\text{NaNO}_2$	$\text{AgNO}_2$	$\text{NaNO}_2$	$\text{AgNO}_2$	
	55	15.2	58.3	21.5	$\text{AgNO}_2 + \text{Na}_2\text{Ag}_2(\text{NO}_2)_4 \cdot \text{H}_2\text{O}$
NO	74.7	11.3	78.3	13.4	$\text{NaNO}_2 + \text{Na}_2\text{Ag}_2(\text{NO}_2)_4 \cdot \text{H}_2\text{O}$

### THE SYSTEM SODIUM NITRITE - THALLIUM NITRITE - WATER AT $25^\circ$ (Cavalca, Nardelli and Braibanti, 1955)

Sat. Sol. Wt. %		Solid Phase
$\text{TlNO}_2$	$\text{NaNO}_2$	
22.72	16.69	$\text{TlNO}_2$
24.80	32.06	"
25.64	35.46	$\text{TlNO}_2 + \text{NaNO}_2$
12.26	41.20	$\text{NaNO}_2$

The System  $\text{NaNO}_2 - \text{Pb}(\text{NO}_3)_2 - \text{H}_2\text{O}$  was studied by Vartak and Kabadi, 1955 by evaporation of various solutions at room temperature. A 1:1:1 compound was found, and possibly solid solutions. Conductivities in the system are given by Vartak and Kabadi, 1954.

### SOLUBILITY OF SODIUM NITRITE IN VARIOUS SOLVENTS

Solvent	$t^\circ$	Solubility
94.5 vol. % ethanol (d. = 0.810)	25	1.424 gms $\text{NaNO}_2$ per 100 gms solvent (Schnellbach and Rosin, 1929.)
abs. methanol	19.5	4.43 gms $\text{NaNO}_2$ per 100 gms solvent (de Bruyn, 1892)
abs. ethanol	19.5	0.31 gms $\text{NaNO}_2$ per 100 gms solvent (de Bruyn, 1892).
ethylene glycol	25	16.78 gms $\text{NaNO}_2$ per 100 gms solvent (Palit, 1947)
propylene glycol	25	8.47 gms $\text{NaNO}_2$ per 100 gms solvent (Palit, 1947)
ethylene diamine	30	12.60 gms $\text{NaNO}_2$ per 100 gms solvent (Maniyappan and Anjaneyalu, 1957)
monoethanol amine	30	8.74 gms $\text{NaNO}_2$ per 100 gms solvent (Maniyappan and Anjaneyalu, 1957)

Melting points have been determined for:

$\text{NaNO}_2 + \text{NaNO}_3$  (Bruni and Meneghini, 1909, 1910; Bergman, Berul and Nikonova, 1953; Berul and Bergman, 1954)  
 $\text{NaNO}_2 + \text{NaOH}$  (Bergman and Reshetnikov, 1954; Reshetnikov and Vilutis, 1958)  
 $\text{NaNO}_2 + \text{KOH}$  (Bergman and Reshetnikov, 1954)  
 $\text{NaNO}_2 + \text{Ca}(\text{NO}_2)_2$  (Protzenko and Belova, 1957)  
 $2\text{NaNO}_2 + \text{Ca}(\text{NO}_3)_2 \rightleftharpoons 2\text{NaNO}_3 + \text{Ca}(\text{NO}_2)_2$  " " " "

# SODIUM RHODONITRITE $\text{Na}_6\text{Rh}_2(\text{NO}_2)_{12}$

100 gms.  $\text{H}_2\text{O}$  dissolve 40 gms. at  $17^\circ$ , and 100 gms. at  $100^\circ$ .  
(Leidie, 1890.)

## SODIUM NITRATE $\text{NaNO}_3$

NO

### SOLUBILITY IN WATER

(A) Nikolajev, 1926 (G) Benrath et al., 1928  
 (B) Saslawsky, Ettinger and Esarova, 1935 (H) Schroder, 1930  
 (C) Engel, 1887 (I) Makin and Kurnaukov, 1937  
 (D) Esentsev, 1923, 1925 (J) Achoumov, 1939  
 (E) Kurnaukov and Nikolajev, 1926 (K) Golani, 1928  
 (F) Cornec and Neumeister, 1929 (L) Rodebush, 1918  
 (M) Mandain-Monval, 1925

t°	Mulder 1864	Berkeley 1904	Christen 1929	Stpunkt 1941	Others			
-18.1*	-	-	-	-	38.07 (A)			
-17.7	-	-	37.83	-	-			
-17.5	-	-	-	38.4	38.5 (L)			
-14	-	-	-	39.1	-			
-9.9	-	-	-	39.8	-			
0	42.2	42.2	42.3	41.9	42.77 (B)	42.1 (C)	42.3 (F)	42.2 (J)
10	44.7	44.6	-	43.9	-			
15	-	-	-	-	45.4 (u)	45.93 (G)		
20	46.7	46.8	-	46.0	46.27 (B)	46.8 (M)		
25	47.6	47.9	47.9 (M)	47.9 (M)	47.8 (E)	47.8 (G)	47.90 (J)	47.78 (K)
30	48.7	49.0	-	48.0	-			
40	50.5	51.2	-	-	-			
50	52.8	53.3	53.3	-	53.2 (F)			
60	54.9	55.4	-	-	-			
70	-	-	-	-	-			
75	-	-	58.6	-	58.3 (D)	58.6 (H)		
80	59.7	59.7	-	-	-			
100	64.3	63.7	63.7	-	63.7 (F)			
120	68.6	67.7†	67.4†	-	-			
180	78.1	-	-	-				
220	83.5	-	-	-				
225	91.5	-	-	-				
313	100	-	-	-				
*eutectic		† 119°	† 118°					

See table following

# Na SODIUM

## SOLUBILITY OF SODIUM NITRATE IN WATER AT TEMPERATURES UP TO ITS MELTING POINT (Kracek, 1931)

t°	Gms. NaNO <sub>3</sub> per 100 gms.		t°	Gms. NaNO <sub>3</sub> per 100 gms.	
	sat. sol.	H <sub>2</sub> O		sat. sol.	H <sub>2</sub> O
94.05	62.39	165.90	218.90	86.70	651.69
106.80	65.02	185.84	224.70	87.78	718.48
114.90	66.78	200.07	242.25	90.81	987.54
136.90	71.05	245.46	253.55	92.59	1248.80
151.60	74.06	285.53	260.90	93.71	1489.8
168.90	77.33	341.05	270.00	95.07	1926.2
178.00	79.11	378.72	289.20	97.59	4052.1
183.80	80.25	406.22	295.35	98.31	5828.9
201.60	83.57	508.62	309.5	100.0	-

More recent determinations agreeing in general with the above extremely accurate values of Kracek are given by Benrath, Gjedebo, Schiffers and Wunderlich, 1937.

## FREEZING-POINTS OF DILUTE AQUEOUS SOLUTIONS OF SODIUM NITRATE (Klein and Svanberg, 1920; Rodebush, 1918)

t° of f. pt.	Gms. NaNO <sub>3</sub> per 100 cc. sat. sol.	t° of f. pt.	Gms. NaNO <sub>3</sub> per 100 gms. H <sub>2</sub> O	t° of f. pt.	Gms. NaNO <sub>3</sub> per 100 gms. H <sub>2</sub> O
-0.340	0.85 (KS)	- 6.67	20.83	-12.85	44.56
-0.822	2.115(KS)	- 8.78	28.77	-15.08	53.14
-1.583	4.25 (KS)	-10.17	34.15	-17.46*	62.50

\*Eutectic

## SOLUBILITY OF SODIUM NITRATE IN WATER - HYDROGEN PEROXIDE SOLUTIONS (Floyd and Gross, 1955)

Read from curves drawn by the authors

Mole fraction H <sub>2</sub> O <sub>2</sub> in solvent	Moles NaNO <sub>3</sub> per 1000 gms. solvent		
	0	15°	25°
0	8.6	9.8	10.9
0.1	7.0	8.2	9.0
0.2	5.8	6.8	7.6
0.4	4.4	5.2	5.8
0.6	3.7	4.4	4.9
0.8	3.5	3.9	4.4
1.0	3.3	3.8	4.2

## SOLUBILITY OF SODIUM NITRATE IN WATER - HYDROGEN PEROXIDE SOLUTIONS--Cont.

Results of Akerlof and Turek, 1935

Wt. Percent $\text{H}_2\text{O}_2$ in solvent	Gm. Mols. $\text{NaNO}_3$ per 1000 gms. solvent
0.0	10.825
15.72	9.252
31.43	7.554

SOLUBILITY OF SODIUM NITRATE IN HYDROGEN PEROXIDE  
(Maass and Hatcher, 1922)

The temperature were determined at which the last trace of solid disappeared in mixtures of weighed amounts of the two constituents.

NO

$t^\circ$	Gms. $\text{NaNO}_3$ per 100 gms. sat. sol.	$t^\circ$	Gms. $\text{NaNO}_3$ per 100 gms. sat. sol.	$t^\circ$	Gms. $\text{NaNO}_3$ per 100 gms. sat. sol.
-2.47	1.62	-5.62	10.11	-10.82	22.25
-2.82	3.23	-6.97	13.19	+11.8	25.22
-3.72	5.11	-8.12	16.66	32.3	28.25
-4.72	7.58	-9.52	20.19	49.3	31.53

## SOLUBILITY OF SODIUM NITRATE IN NITRIC ACID SOLUTIONS

Results at  $0^\circ$ 

(Engel, 1887)

(Saslawsky, Ettinger and  
Eserowa, 1935)

Sp. Gr. of Solutions	Grams per 100 cc. Solution		Gms. per 100 gms. sat. sol.	
	$\text{NaNO}_3$	$\text{HNO}_3$	$\text{NaNO}_3$	$\text{HNO}_3$
1.341	56.5	0.00	42.77	0.0
1.338	54.2	1.67	20.99	20.50
1.331	51.48	3.59	4.32	42.70
1.324	48.42	5.55	2.10	62.81
1.312	44.88	7.92	1.59	72.76
1.308	41.44	10.65	4.39	85.88
1.291	33.61	17.02		
1.285	29.86	20.33		
1.282	26.46	23.48		
1.276	20.0	30.26		
1.276	15.32	36.09		
1.291	10.97	44.76		
			<u>Results at <math>20^\circ</math></u>	
			46.27	0.0
			23.69	18.98
			6.14	41.52
			2.13	59.66
			2.00	72.01
			5.53	84.77

## Na SODIUM

### SOLUBILITY OF SODIUM NITRATE IN NITRIC ACID SOLUTIONS--Cont.

Results of Kazantev, 1923, 1925

At 15°				At 75°			
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
NaNO <sub>3</sub>	HNO <sub>3</sub>	NaNO <sub>3</sub>	HNO <sub>3</sub>	NaNO <sub>3</sub>	HNO <sub>3</sub>	NaNO <sub>3</sub>	HNO <sub>3</sub>
45.4	0.0	2.5	64.6	58.3	0.0	6.8	63.7
33.0	9.5	2.3	74.6	38.5	17.2	6.2	70.8
29.0	13.0	3.5	80.9	25.6	30.5	5.9	78.3
14.5	28.3	4.9	84.8	19.7	38.0	7.4	87.0
NO 5.0	49.7	7.8	89.3	17.2	41.7	7.7	87.7
						8.1	88.9

### THE SYSTEM SODIUM NITRATE - SODIUM HYDROXIDE - WATER

Results at 0°

(Engel, 1891)

Sp. Gr. of Solution	Grams per 100 cc. Solution		Sp. Gr. of Solution	Grams per 100 cc. Solution	
	NaOH	NaNO <sub>3</sub>		NaOH	NaNO <sub>3</sub>
1.341	0.0	56.50	1.326	20.83	25.10
1.338	2.30	53.19	1.332	31.25	14.89
1.333	4.89	48.63	1.356	36.76	11.22
1.327	10.21	40.42	1.401	48.75	5.15

Results at 0°, 25° and 65° are given by Kurnakow and Nikolajew, 1927. The isotherms for 100° and 125° and the complete temperature concentration diagrams for the system are given by Jänecke, 1930.

### SOLUBILITY OF SODIUM NITRATE IN AQUEOUS AMMONIA SOLUTIONS

Results at 0°

The data of Achoumov, 1939, below, and those of Guyer, Bieber, and Schmid, 1934 do not agree well.

(Achoumov, 1939)

Sat. Sol. Wt. %		Sat. Sol. Wt. %		Sat. Sol. Wt. %	
NH <sub>3</sub>	NaNO <sub>3</sub>	NH <sub>3</sub>	NaNO <sub>3</sub>	NH <sub>3</sub>	NaNO <sub>3</sub>
0.0	42.2	25.8	34.0	42.0	45.1
4.28	37.5	26.9	34.3	42.5	48.2
11.0	31.8	27.8	37.2	42.7	50.9
14.8	31.0	30.7	34.6	43.5	50.4
23.1	30.7	33.1	37.6	44.7	51.9
22.7	31.0	35.1	39.2	44.4	55.6
24.4	32.0	40.8	45.2		

## SOLUBILITY OF SODIUM NITRATE IN AQUEOUS AMMONIA SOLUTIONS--Cont.

(Guyer, Bieber and Schmid, 1934)

The authors given their results only in the form of a diagram from which the following approximate values were read.

Gms. per 100 gms. sat. sol.
$$\overbrace{\text{NH}_3 \quad \text{NaNO}_3}^{\text{Reactants}}$$

0	42.3
10	36
20	31.5
28	30
40	33
50	36.5

Gms. per 100 gms. sat. sol.
$$\overbrace{\text{NH}_3 \quad \text{NaNO}_3}^{\text{Reactants}}$$

60	39.5
70	43
80	47
90	52
100	55

**NO**

### Results at 15°

(Fedotieff and Koltunoff, 1914)

In Aqueous  $\text{NH}_3$

In Aqueous  $\text{NH}_3 + \text{NH}_4\text{NO}_3$

d <sub>15</sub> of Sat. Sol.	Gms. per 100 Gms. H <sub>2</sub> O		d <sub>15</sub> of Sat. Sol.	Gms. per 100 Gms. H <sub>2</sub> O		
	NH <sub>3</sub>	NaNO <sub>3</sub>		NH <sub>3</sub>	NH <sub>4</sub> NO <sub>3</sub>	NaNO <sub>3</sub>
1.253	13.87	75.03	1.324	12.91	83.51	74.10
1.233	17.28	73.99	1.330	16.97	128.9	69.40
1.212	20.38	73.18				

THE SYSTEM  $\text{NaNO}_3 - \text{NaH}_2\text{PO}_4 - \text{H}_2\text{O}$

(Shpunt, 1941)

The eutectic temperature is  $-19.4^{\circ}$  and the saturated solution contains 30.8%  $\text{NaNO}_3$  and 7.4%  $\text{NaH}_2\text{PO}_4$ .

$$N = \text{NaNO}_3$$
$$H = \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$$

I = Ice

Sat. Sol. Wt. %			Sat. Sol. Wt. %			Sat. Sol. Wt. %		
$\text{NaNO}_3$	$\text{NaH}_2\text{PO}_4$	Solid Phase	$\text{NaNO}_3$	$\text{NaH}_2\text{PO}_4$	Solid Phase	$\text{NaNO}_3$	$\text{NaH}_2\text{PO}_4$	Solid Phase
<u>at -17.5°</u>			<u>at -14°</u>					
38.4	0.0	N + I	39.1	0.0	N	14.0	19.4	H + I
34.4	3.6	N	35.3	3.7	N	15.5	17.1	I
32.2	6.3	N	33.0	6.4	N	21.2	10.0	I
31.0	7.6	N + H	31.4	8.2	N + H	22.5	7.6	I
30.0	8.0	H	31.2	8.3	H	24.4	6.4	I
27.5	9.4	H	28.2	9.6	H	25.8	5.1	I
25.2	10.7	H + I	25.0	12.0	H	28.2	2.9	I
26.3	8.9	I	16.2	17.8	H	31.4	0.0	I
28.3	7.4	I						
30.0	5.9	I						
32.3	3.4	I						

(Cont.)

(Cont.)



**Na SODIUM**

THE SYSTEM  $\text{NaNO}_3 - \text{NaH}_2\text{PO}_4 - \text{H}_2\text{O}$ --Cont.

$$N = \text{NaNO}_3$$
$$H = \text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$$

I = Ice

Sat. Sol. Wt. %			Sat. Sol. Wt. %			Sat. Sol. Wt. %		
NaNO <sub>3</sub>	NaH <sub>2</sub> PO <sub>4</sub>	Solid Phase	NaNO <sub>3</sub>	NaH <sub>2</sub> PO <sub>4</sub>	Solid Phase	NaNO <sub>3</sub>	NaH <sub>2</sub> PO <sub>4</sub>	Solid Phase
At -9.9°			At 0°, Cont.			At 20°, Cont.		
39.8	0.0	N	32.96	10.64	N + H	33.35	15.57	N
38.99	1.30	N	32.7	10.5	N + H	33.1	15.8	N
36.2	3.8	N	32.0	10.9	H	32.05	17.79	N + H
34.95	6.01	N	28.81	13.17	H	31.5	18.1	N + H
33.7	6.6	N	27.8	13.2	H	24.0	23.0	H
32.13	8.5	N	19.97	19.50	H	22.5	24.7	H
32.37	9.02	N + H	18.2	20.0	H	20.44	26.10	H
32.0	8.8	H	10.8	25.9	H	13.6	32.6	H
29.3	10.0	H	10.52	26.67	H	13.33	32.27	H
29.85	10.43	H	4.70	31.83	H	7.5	38.1	H
25.8	12.3	H	4.0	32.6	H	3.4	42.2	H
21.3	15.75	H	0.0	36.4	H	0.0	45.3	H
16.6	18.1	H						
13.38	20.74	H						
9.8	28.6	H						
9.1	24.1	H	43.9	0.0	N	48.0	0.0	N
4.3	28.4	H	40.5	4.2	N	44.8	4.7	N
0.0	32.4	H + I	37.7	7.4	N	32.98	6.25	N
4.5	25.0	I	36.1	9.5	N	41.9	8.1	N
8.0	19.2	I	34.1	11.6	N	41.31	9.10	N
10.0	17.3	I	32.7	13.6	N + H	39.8	10.4	N
12.1	13.3	I	30.3	14.4	H	38.0	13.0	N
16.6	7.9	I	21.3	20.4	H	37.77	13.31	N
17.7	6.0	I	19.9	21.9	H	34.8	16.7	N
19.0	5.0	I	12.1	29.0	H	32.25	20.3	N
20.2	3.9	I	8.0	33.0	H	28.10	24.99	N
21.8	2.3	I	3.8	36.8	H	26.89	26.72	N + H
23.3	0.0	I	0.0	40.5	H	27.2	26.0	N + H
						25.2	27.6	H
						24.33	28.85	H
						15.4	36.5	H
						14.95	37.45	H
						11.41	30.76	H
						6.6	45.0	H
						6.25	46.20	H
						3.04	48.87	H
						3.0	49.1	H
						0.0	51.2	H
At 0°			At 20°					
41.9	0.0	N	46.0	0.0	N			
38.67	4.02	N	42.7	4.6	N			
38.43	4.0	N	39.8	7.8	N			
35.8	7.0	N	38.89	8.86	N			
35.24	7.98	N	38.0	9.9	N			
34.2	9.0	N	36.1	12.4	N			
(Cont.)			(Cont.)					

THE SYSTEM SODIUM NITRATE - SODIUM SULFATE - WATER  
(Chretien, 1929)

Less complete results differing in certain details from these are given by Massink, 1918, Foote, 1925 and Hamid, 1926. Other results in general agreement are given by Benrath, 1928, in connection with a study of the equilibrium in the reciprocal salt pair  $\text{Na}_2(\text{NO}_3)_2 + \text{MgSO}_4 + \text{H}_2\text{O}$ , at 15°, 25°, 50° and 97°.

A number of other determinations are given by Schroder, 1929a, b, 1930, in connection with his studies of this same reciprocal salt pair.

For data at 240°, see table following.

NO

$\text{S.10} = \text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$      $\text{S} = \text{Na}_2\text{SO}_4$      $\text{N} = \text{NaNO}_3$      $1.1.2 = \text{NaNO}_3 \cdot \text{Na}_2\text{SO}_4 \cdot 2\text{H}_2\text{O}$

t°	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
		NaNO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	
-17.8	-	37.7	0.12	Ice + N + S.10
-10.6	-	25.0	1.32	" + S.10
-10.6	-	39.2	0.56	N + S.10
- 4.0	-	8.99	2.82	Ice + S.10
- 4.0	-	40.7	0.82	N + S.10
- 1.0	-	41.3	1.09	" + "
0	1.128	14.6	1.76	S.10
"	1.222	27.7	1.17	"
"	1.298	35.3	1.15	"
"	1.342	39.7	1.07	"
"	1.355	41.2	1.07	" + N
"	1.352	41.6	0.0	N
6.5	-	41.9	2.12	N + S.10
10.2	1.382	41.8	3.08	" "
15.0	1.381	39.2	5.11	D + "
"	1.394	42.0	4.09	N + 1.1.2
17.5	1.367	36.3	6.66	S.10 + "
"	1.395	42.8	3.78	N + "
20	1.203	13.3	10.91	S.10
"	1.270	21.8	9.20	"
"	1.335	30.5	8.9	"
"	1.356	33.1	8.62	"
"	-	34.1	8.09	1.1.2
"	1.366	36.3	6.73	"
"	-	41.2	4.56	"
"	-	42.7	3.85	"
"	1.397	43.6	3.46	" + N
"	-	44.8	2.27	N
24.3	1.348	26.3	13.9	1.1.2 + S.10 + S
25	1.256	12.6	16.5	S.10
"	1.315	21.2	14.8	"
"	1.346	24.9	14.6	" + S
"	-	25.9	13.9	S
"	1.350	26.8	13.3	" + 1.1.2
"	1.351	27.7	12.70	1.1.2
"	1.350	29.5	11.30	"
"	1.354	31.1	10.20	"
"	1.368	37.7	6.17	" (Cont.)

## Na SODIUM

## THE SYSTEM SODIUM NITRATE - SODIUM SULFATE - WATER--Cont.

S.10 =  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$     S =  $\text{Na}_2\text{SO}_4$     N =  $\text{NaNO}_3$     1.1.2 =  $\text{NaNO}_3 \cdot \text{Na}_2\text{SO}_4 \cdot 2\text{H}_2\text{O}$

t°	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
		$\text{NaNO}_3$	$\text{Na}_2\text{SO}_4$	
25	1.393	43.1	3.74	1.1.2
"	1.404	44.6	3.40	"
"	1.405	45.2	3.04	1.1.2 + N
"	1.398	46.5	1.57	N
30	1.327	8.51	29.9	S.10 + S
"	1.351	20.9	11.20	1.1.2 + S
"	1.411	46.6	2.80	" + N
35	1.315	13.3	21.6	S
"	1.328	25.5	13.8	"
"	1.352	32.4	9.77	"
"	1.357	33.9	8.97	" + 1.1.2
"	1.360	36.1	7.51	1.1.2
"	1.374	40.2	5.41	"
"	1.415	47.2	2.65	"
"	1.417	48.0	2.53	" + N
50	1.219	12.9	20.7	S
"	1.302	23.6	13.3	"
"	1.330	33.2	8.27	"
"	1.365	39.9	5.67	"
"	1.388	43.9	4.43	" + 1.1.2
"	1.392	44.5	4.23	1.1.2 "
"	1.407	46.8	3.35	"
"	1.422	49.5	18.4	"
"	1.440	51.6	2.13	" + N
"	1.432	52.2	1.21	N
75	1.256	13.9	18.4	S
"	1.281	27.8	10.02	"
"	1.346	41.2	4.73	"
"	1.416	50.7	2.62	"
"	1.464	55.8	1.95	"
"	1.478	57.2	1.86	" + N
"	1.475	57.6	1.25	N
83	1.491	59.0	1.70	" + S
91	1.505	60.8	1.64	" "
100	1.230	13.6	17.8	S
"	1.247	24.9	10.9	"
"	1.321	40.5	4.9	"
"	1.403	51.3	2.77	"
"	1.466	58.1	1.97	"
"	1.515	62.6	1.57	" + N
"	1.514	63.1	0.86	N
120.3*	-	66.2	1.48	" + S

\*boiling point

THE SYSTEM SODIUM NITRATE - SODIUM SULFATE - WATER AT 240°  
(Benrath, 1943)

The transition  $\alpha\text{-Na}_2\text{SO}_4 \rightleftharpoons \beta\text{-Na}_2\text{SO}_4$  was found to occur at 240° and the addition of  $\text{NaNO}_3$  did not change the transition temperature.

Gms. per 100 gms. Sat. Sol.

$\text{Na}_2\text{SO}_4$ $\text{NaNO}_3$		Solid Phase
21.6	18.4	$\alpha\text{-Na}_2\text{SO}_4 + \beta\text{-Na}_2\text{SO}_4$
16.1	35.9	"
11.3	51.7	"
4.9	75.1	"
4.3	81.7	"

NO

Results for the Reciprocal Salt Pair  $2\text{NaNO}_3 + \text{MgSO}_4 \rightleftharpoons \text{Na}_2\text{SO}_4 + \text{Mg}(\text{NO}_3)_2 (+\text{H}_2\text{O})$  at various temperatures are given by Benrath, 1928, and Schroder, 1929.

THE SYSTEM  $\text{NaNO}_3 - \text{Na}_2\text{HPO}_4 - \text{H}_2\text{O}$  AT 25°  
(Makin and Karnaukhov, 1957)

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
$\text{NaNO}_3$	$\text{Na}_2\text{HPO}_4$	Solid Phase	$\text{NaNO}_3$	$\text{Na}_2\text{HPO}_4$	Solid Phase
47.90	0.0	$\text{NaNO}_3$	17.06	6.51	$\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$
41.72	1.00	"	12.03	6.69	"
36.05	2.16	"	7.80	7.5	"
32.06	3.57	"	3.31	8.71	"
26.05	6.34	$\text{NaNO}_3 + \text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$	0.0	10.32	"
21.87	6.26	$\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$			

THE SYSTEM SODIUM NITRATE - SODIUM THIOSULFATE - WATER  
(Kremann and Rodemund, 1914)

Results at 9°

Results at 25°

Gms. per 100 Gms. Sat. Sol.			Gms. per 100 Gms. Sat. Sol.		
$\text{NaNO}_3$	$\text{Na}_2\text{S}_2\text{O}_3$	Solid Phase	$\text{NaNO}_3$	$\text{Na}_2\text{S}_2\text{O}_3$	Solid Phase
33.31	12.26	$\text{NaNO}_3$	35.42	12.72	$\text{NaNO}_3$
22.57	23.41	" + $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$	25.40	24.25	"
4.22	34.77	$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}$	19.90	31.81	" + $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$
			18.02	32.83	$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$
			4.33	40.50	"

Data for the System  $\text{NaNO}_3 - \text{Al}(\text{NO}_3)_3 - \text{HNO}_3 - \text{H}_2\text{O}$  at 0° and 20° are given by Saslawsky, Ettinger and Eserowa, 1935

# Na SODIUM

## SOLUBILITY OF MIXTURES OF SODIUM NITRATE AND POTASSIUM NITRATE IN WATER AT 20° (Carnelly and Thomson, 1888)

% NaNO <sub>3</sub> in Mixtures Used	Gms. per 100 Gms. H <sub>2</sub> O		% NaNO <sub>3</sub> in Mixtures Used	Gms. per 100 Gms. H <sub>2</sub> O	
	NaNO <sub>3</sub>	KNO <sub>3</sub>		NaNO <sub>3</sub>	KNO <sub>3</sub>
100	86.8	0	45.7	53.3	34.7
90	96.4	13.2	40	45.6	35.5
80	98.0	38.5	20	20.8	33.3
60	90.0	47.6	10	9.4	31.5
50	66.0	40.0	0	0.0	33.6

**NO** The density, viscosity, reochor, specific conductivity, surface tension, parachor, freezing point depression, magnetic susceptibility transport numbers, and E.M.F. were measured in the system NaNO<sub>3</sub> - Pb(NO<sub>3</sub>)<sub>2</sub> - H<sub>2</sub>O by Nayar and Pande, 1948.

Vapor Pressures in the system NaNO<sub>3</sub> - Pb(NO<sub>3</sub>)<sub>2</sub> - H<sub>2</sub>O from 10° - 150° are reported by Dingemans and Dijkgraaf, 1949.

## THE SYSTEM SODIUM NITRATE - URANYL NITRATE - WATER AT 25° (Colani, 1928)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>	NaNO <sub>3</sub>		UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>	NaNO <sub>3</sub>	
0.0	47.78	NaNO <sub>3</sub>	45.37	14.39	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O
9.12	40.96	"	48.62	9.43	"
20.83	31.71	"	51.59	6.06	"
34.35	22.26	"	53.06	3.45	"
40.76	17.58	"	56.08	0.0	"
44.20	16.20	" + UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O			

## SOLUBILITY OF SODIUM NITRATE IN AQUEOUS SOLUTIONS OF METHYL ALCOHOL AT 25° (Akerlof and Turck, 1935)

Wt. % CH <sub>3</sub> OH in solvent	Gm. Mols. NaNO <sub>3</sub> per 1000 gms. solvent	Wt. % CH <sub>3</sub> OH in solvent	Gm. Mols. NaNO <sub>3</sub> per 1000 gms. solvent
0.0	10.825	70.05	1.364
21.30	7.111	78.46	0.893
40.10	4.172	89.45	0.543
59.94	2.076	100.0	0.485

SOLUBILITY OF SODIUM NITRATE IN AQUEOUS ETHYL ALCOHOL  
(Bodländer, 1891; Taylor, 1897; Bathrick, 1896; Armstrong  
and Eyre, 1910-11)

Results at 13° (B.)

Sp. Gr. of Solutions	Gms. per 100 cc. Solution		
	C <sub>6</sub> H <sub>5</sub> OH	H <sub>2</sub> O	NaNO <sub>3</sub>
1.3700	0.0	75.34	61.66
1.3395	3.08	73.53	57.34
1.3120	6.01	71.81	53.39
1.2845	8.30	70.85	49.30
1.2580	10.91	69.47	45.42
1.2325	13.77	67.12	42.36
1.2010	16.46	66.16	37.48

Results at 30° (T.)

Wt. % Alcohol in Solvent	Gms. NaNO <sub>3</sub> per 100 Gms.	
	Solution	Water
0	49.10	96.45
5	46.41	91.15
10	43.50	85.55
20	37.42	74.75
30	31.31	65.10
40	25.14	55.95
50	18.94	46.75
60	12.97	37.25
70	7.81	28.25
90	1.21	12.25

NO

Results at 16.5° (B.)

1.3745	0.0	75.25	62.20
1.3162	6.16	70.82	54.64
1.2576	11.60	68.10	46.06
1.2140	16.49	65.04	39.87
1.1615	22.17	61.67	32.31
1.0855	32.22	52.92	23.41
1.0558	37.23	48.50	19.85
1.0050	43.98	42.78	13.74
0.9420	52.60	32.13	9.47
0.9030	60.00	25.65	4.65
0.8610	63.16	21.31	1.63

Results at 40° (Bathrick)

Wt. % Alcohol	Gms. NaNO <sub>3</sub> per 100 Gms.
	Aq. Alcohol
0	104.5
8.22	90.8
17.4	73.3
26.0	61.6
36.0	48.4
42.8	40.6
55.3	27.1
65.1	18.1
77.0	9.4
87.2	4.2

Results at 25° (A. & E.)

Solvent		Gms. NaNO <sub>3</sub> per 100 Gms. Sat. Sol.
Mols. C <sub>2</sub> H <sub>5</sub> OH per 1000 Gms. H <sub>2</sub> O	Gms. C <sub>2</sub> H <sub>5</sub> OH per 1000 Gms. H <sub>2</sub> O	
0	0	47.93
0.25	11.51	47.32
0.50	23.03	46.73
1	46.06	45.43
2	92.12	43.04

100 gms. aq. 50% Ethyl Alcohol dissolve 19.4 gms. NaNO<sub>3</sub> at 20°.  
(Wright, 1926.)

# Na SODIUM

## THE SYSTEM SODIUM NITRATE - ISO PROPYL ALCOHOL - WATER AT 25° (Ginnings and Chen, 1931)

Points on the binodal curve of this system were determined by titrating mixtures of the salt and one of the liquids with the other liquid until clouding appeared or disappeared. Tie lines, \*, were located by means of determinations of the salt in two layers in contact with each other. The plait point, PP, was found by plotting.

	Gms. per 100 gms. of the homogeneous mixture			Gms. per 100 gms. of the homogeneous mixture	
	NaNO <sub>3</sub>	CH <sub>3</sub> CH(OH)CH <sub>3</sub>		NaNO <sub>3</sub>	CH <sub>3</sub> CH(OH)CH <sub>3</sub>
NO	10.90	49.50*		29.25	11.54
	14.5	39.50		32.65	8.20
	17.17	33.80		37.70	4.90
	18.20	31.50		40.56	4.04
	21.5	26.0	PP	43.80	3.00
	24.4	19.5			

The effect of the addition of 0.06 - 0.12 molar sodium nitrate on the mutual solubility of n-butyl alcohol and water is reported by Reber, McNabb, and Lucasse, 1942.

The composition of the plait point for the system Sodium Nitrate - Tertiary Butyl Alcohol - Water at 25° was found by Ginnings, Herring and Webb, 1933, to be 32.4 wt. percent NaNO<sub>3</sub> + 11.6 wt. percent (CH<sub>3</sub>)<sub>3</sub>COH

Ginnings and Dees, 1935, and Ginnings, Webb and Hinohara, 1933, have respectively determined the binodal curves for the systems Sodium Nitrate - Allyl Alcohol - Water at 25° and Sodium Nitrate - Pyridine - Water at 25°, but the original results are not given but only the values of constants for the curves calculated by means of empirical equations.

## THE SYSTEM SODIUM NITRATE - DIOXANE - WATER AT 25° (Selikson and Ricci, 1942)

Gms. per 100 gms. Sat. Sol.				Gms. per 100 gms. Sat. Sol.			
NaNO <sub>3</sub>	H <sub>2</sub> O	Density	Solid Phase	NaNO <sub>3</sub>	H <sub>2</sub> O	Density	Solid Phase
47.87	52.13	1.384	N	12.17	27.99	1.108	O(L)
40.91	48.22	1.321	N	0.74	7.88	1.033	O(U)
34.94	44.85	1.266	N	2.34	14.47	-	O(U)
32.35	43.27	1.252	N	0.24	4.63	1.029	N
24.69	36.60	1.191	N	.12	3.86	1.028	N
20.02	31.88	1.157	N	.05	2.00	1.029	N
a) 17.84	30.03	1.146	N(L)	.072	3.74	-	N
b) 0.44	6.16	1.032	N(U)	.032	2.86	-	N
15.36	29.20	-	O(L)	.009	1.90	-	N
14.71	28.70	1.129	O(L)	.005	0.96	-	N
0.57	7.08	1.035	O(U)	.003	0.0	-	N

a, b = Invariant points

N = NaNO<sub>3</sub>

L = Lower Layer

U = Upper Layer

O = No Solid Phase

## SOLUBILITY OF SODIUM NITRATE IN AQUEOUS SOLUTIONS OF ACETONE

Results at 30° (Taylor, 1897)

Wt. % Acetone in Solvent	Gms. NaNO <sub>3</sub> per 100 Gms.	
	Solution	Water
0	49.10	96.45
5	46.96	93.20
9.09	45.11	90.40
20	40.10	83.70
30	35.08	77.20
40	29.80	70.75
50	24.34	64.40
60	18.55	59.95
70	13.15	50.50
80	7.10	38.20
90	1.98	20.20

Results at 40° (Bathrick, 1896)

Wt. % Acetone	Gms. NaNO <sub>3</sub> per 100 Gms.	
	Aq.	Acetone
0.0	105	
8.47	91.2	
16.8	78.3	
25.2	66.4	
34.3	57.9	
44.1	46.2	
53.9	32.8	
64.8	23.0	
76.0	10.8	
87.6	3.2	

NO

At 43.5°, two liquid layers are reported in the above system. See Int. Critical Tables III, p. 410.

Data for the distribution of NaNO<sub>3</sub> between methyl isobutyl ketone and HNO<sub>3</sub> - Ca(NO<sub>3</sub>)<sub>2</sub> solutions at 20° are given by Rydberg and Bernstrom, 1957

Polythermal data for the system NaNO<sub>3</sub> - Urea - Water from -19.55° (eutectic) to +40° are reported by Polosin and Tarasova, 1956.

SOLUBILITY OF NaNO<sub>3</sub> IN VARIOUS SOLVENTS

Solvent	t°	Solubility
CH <sub>3</sub> OH	25	0.41 gms NaNO <sub>3</sub> per 100 gms solvent (deBruyn, 1892)
C <sub>2</sub> H <sub>5</sub> OH	25	0.036 gms NaNO <sub>3</sub> per 100 gms solvent (deBruyn, 1892)
Pyridine	25	0.34 gms NaNO <sub>3</sub> per 100 cc solvent (Muller, 1925)
Dioxane	25	0.003 gms NaNO <sub>3</sub> per 100 gms sat. sol. (Ricci and Selikson, 1942)
Ethylenediamine	25	33.5 gms NaNO <sub>3</sub> per 100 gms solvent (Isbin and Kobe, 1945)
Hydroxylamine	17/18	13.1 gms per 100 gms solvent (deBruyn, 1892)
Hydrazine	room	100 gms per 100 cc solvent (Welsh and Broderson, 1915)
Anhydrous HNO <sub>3</sub>	?	1.5 gms per 100 gms solvent (Jander and Wendt, 1948)

Data for the effect of small quantities of NaNO<sub>3</sub> on the miscibility temperature of CH<sub>3</sub>OH + cyclohexane are reported by Eckfeldt and Lucasse, 1943



# Na SODIUM

## THE SYSTEM $\text{NaNO}_3$ - UREA (Howells, 1930)

$t^\circ$	Wt. % $\text{NaNO}_3$ in sat. sol.	Solid Phase	$t^\circ$	Wt. % $\text{NaNO}_3$ in sat. sol.	Solid Phase
132.0	0.0	$\text{CO}(\text{NH}_2)_2$	88.4	30.5	$\text{NaNO}_3$
121.4	6.9	"	92.5	31.1	"
106.8	16.3	"	109.0	33.2	"
95.8	23.22	"	131.7	36.69	"
88.8	27.0	"	156.0	41.30	"
83.9	29.5	" + $\text{NaNO}_3$			

The author also gives complete results for the ternary system  $\text{NaNO}_3$   
+  $\text{NH}_4\text{NO}_3$  +  $\text{CO}(\text{NH}_2)_2$

## THE SYSTEM $\text{NaNO}_3$ - ACETIC ACID (Davidson and Geer, 1933)

$t^\circ$	Mol. % $\text{NaNO}_3$ in sat. sol.	Solid Phase	$t^\circ$	Mol. % $\text{NaNO}_3$ in sat. sol.	Solid Phase
16.60	0.0	$\text{CH}_3\text{COOH}$	46.5	0.202	$\text{NaNO}_3$
16.53	0.031	"	53.7	0.246	"
16.45	0.150	"	78.5	0.448	"
27.0	0.122	$\text{NaNO}_3$	88.3	0.573	"
31.5	0.150	"	93.4	0.641	"
36.0	0.166	"	95.7	0.677	"
40.0	0.173	"	103.0	0.854	"

## SOLUBILITY OF SODIUM NITRATE IN LIQUID AMMONIA

$t^\circ$	Gms. $\text{NaNO}_3$ per 100 cc sat. sol.	$t^\circ$	Gms. $\text{NaNO}_3$ per 100 cc sat. sol.
-50.5	47.3 (1)	-53.0	99.2 (2)
-49.0	50.3 (1)	-37	110.9 (2)
-48.0	52.3 (1)	0	126.4 (2)
-47.5	53.3 (1)	+ 0.1	127.5 (3)
-47.6	55.8 (1)	25	97.6 (4)
-48.0	58.5 (1)	30	137.4 (2)
-50.2	59.9 (1)	48	143.6 (2)
-48.6	61.2 (1)	60	148.5 (2)
-49.8	63.1 (1)		

(1) Scherer, 1931; (2) Portnow and Rawdine (3) Linhard and  
Stephan, 1933, 1934; (4) Hunt, 1932.

Melting points have been determined for:

$\text{NaNO}_3 + \text{KNO}_3 + \text{SrNO}_3$	(Harkins and Clark, 1915)
$\text{NaNO}_3 + \text{NaOH}$	(Retortillo and Moles, 1933)
$\text{NaNO}_3 + \text{Pb}(\text{NO}_3)_2$	(Glass, Laybourn and Madgin, 1932)
$\text{NaNO}_3 + \text{Pb}(\text{NO}_3)_2 + \text{Sr}(\text{NO}_3)_2$	(Laybourn, Madgin and Freeman, 1934)
$\text{NaNO}_3 + \text{RbNO}_3$	(Puschin and Radoicic, 1937)(Blidin, 1941)
$\text{NaNO}_3 + \text{Sr}(\text{NO}_3)_2$	(Gromakov and Gromakova, 1953)(Protsenko and Bergman, 1951)
$\text{NaNO}_3 + \text{NaOH}$	(Bergman and Reshetnikov, 1954)
$\text{NaNO}_3 + \text{KOH}$	(Bergman and Reshetnikov, 1954)
$\text{NaNO}_3 + \text{Ca}(\text{NO}_3)_2$	(Protsenko and Belova, 1957)
$\text{NaNO}_3 + \text{TiNO}_3$	(Palkin, 1949b)
$\text{NaNO}_3 + \text{NaSCN}$	(Sokolov, 1954a)
$\text{NaNO}_3 + \text{Guanidine Nitrate}$	(Clark and Esterbrook, 1949)
$\text{NaNO}_3 + \text{Na formate}; + \text{Na acetate}; + \text{Na isopropionate}; + \text{Na butyrate};$ $+ \text{Na isobutyrate}; + \text{Na neovalerate}; + \text{Na caproate}$	(Sokolov, 1954a)

SODIUM NIOBATE  $\text{NaNbO}_3$ 

NbO

SOLUBILITY IN WATER  
(Shishkina, Pchelkina and Stepanow, 1955)

Determined with radioactive  $\text{Na}^{24}$  and  $\text{Nb}^{25}$  tracers.

$t^\circ$	moles $\text{NaNbO}_3$ per liter	mg. $\text{NaNbO}_3$ per 100 ml
0	0.00043	7.09
25	0.00059	9.70
50	0.0016	25.8
75	0.0037	60.2
100	0.0074	121.2

SODIUM OXIDE  $\text{Na}_2\text{O}$ 

O

Melting points have been determined for

$\text{Na}_2\text{O} + \text{CaF}_2 + \text{SiO}_2$	(Ershova and Ol'shanskii, 1958)
$\text{Na}_2\text{O} + \text{Na}_2\text{SO}_4$	(Kohlmeyer and Lohrke, 1955)
$\text{Na}_2\text{O} + \text{Na}_2\text{S}$	(Kohlmeyer and Lohrke, 1955)
$\text{Na}_2\text{O} + \text{TiO}_2$	(Lux, 1949)
$\text{Na}_2\text{O} + \text{CaO} + \text{SO}_3 + \text{SiO}_2$	(Kordes, Zofelt and Proger, 1951)
$\text{Na}_2\text{O} + \text{P}_2\text{O}_5 - \text{SiO}_2$	(Turkdogan and Maddocks, 1952)
$\text{Na}_2\text{O} + \text{Na}$	(Salmon and Cashman, 1956)

# Na SODIUM

## SODIUM SUPEROXIDE $\text{NaO}_2$

At  $-30^\circ$ , 0.3 gms  $\text{NaO}_2$  dissolve in 100 cc liquid ammonia.  
(Schechter and Kleinberg, 1954)

## OH SODIUM HYDROXIDE $\text{NaOH}$

SOLUBILITY IN WATER  
(Pickering, 1893; Mylius and Funk (Dietz), 1900)

t°	Gms. NaOH per 100 Gms.		Solid Phase
	Solution	Water	
- 7.8	9.0	8.7	Ice
-20	16.0	19.1	Ice
-28	19.0	23.5	Ice + $\text{NaOH} \cdot 7\text{H}_2\text{O}$
-24	22.2	28.5	$\text{NaOH} \cdot 7\text{H}_2\text{O}$ + $\text{NaOH} \cdot 5\text{H}_2\text{O}$
-17.7	24.5	32.5	$\text{NaOH} \cdot 5\text{H}_2\text{O}$ + $\text{NaOH} \cdot 4\text{H}_2\text{O}^a$
0	29.6	42.0	$\text{NaOH} \cdot 4\text{H}_2\text{O}^a$
+ 5	32.2	47.5	$\text{NaOH} \cdot 4\text{H}_2\text{O}^a$ + $\text{NaOH} \cdot \frac{1}{2}\text{H}_2\text{O}$
10	34.0	51.5	$\text{NaOH} \cdot \frac{1}{2}\text{H}_2\text{O}$
15.5	38.9	63.53	$\text{NaOH} \cdot \frac{1}{2}\text{H}_2\text{O}$ f. pt.
5	45.5	83.5	$\text{NaOH} \cdot \frac{1}{2}\text{H}_2\text{O}$ + $\text{NaOH} \cdot 2\text{H}_2\text{O}$
12	50.7	103.0	$\text{NaOH} \cdot 2\text{H}_2\text{O}$ + $\text{NaOH} \cdot \text{H}_2\text{O}$
20	52.2	-	$\text{NaOH} \cdot \text{H}_2\text{O}$
25	53.3	-	$\text{NaOH} \cdot \text{H}_2\text{O}$
30	54.3	119	$\text{NaOH} \cdot \text{H}_2\text{O}$
40	56.3	129	$\text{NaOH} \cdot \text{H}_2\text{O}$
50	59.2	145	$\text{NaOH} \cdot \text{H}_2\text{O}$
60	63.5	174	$\text{NaOH} \cdot \text{H}_2\text{O}$
64.3	69.0	222.3	$\text{NaOH} \cdot \text{H}_2\text{O}$ f. pt.
61.8	74.2	288	$\text{NaOH} \cdot \text{H}_2\text{O}$ + $\text{NaOH}$
80	75.8	313	$\text{NaOH} (?)$
110	78.5	365	$\text{NaOH} (?)$
92	83.9	521	$\text{NaOH} (?)$
205	85.5	- a	$\text{NaOH} (?)$
265	91.7	- a	$\text{NaOH} (?)$
298	96.7	- a	$\text{NaOH} (?)$
319	98.7	- a	$\text{NaOH} (?)$
322	100.0	- a	$\text{NaOH} (?)$

<sup>a</sup>Von Antropoff and Sommer, 1926

THE SYSTEM NaOH -  $\text{H}_2\text{O}_2$  -  $\text{H}_2\text{O}$  AT  $0^\circ$   
(Makarov and Grigor'eva, 1955, 1955a)

Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
Active $\text{O}_2$	$\text{Na}_2\text{O}$	$\text{H}_2\text{O}$		Active $\text{O}_2$	$\text{Na}_2\text{O}$	$\text{H}_2\text{O}$	
2.84	9.18	87.98	$\text{Na}_2\text{O}_2 \cdot 8\text{H}_2\text{O}$	12.67	11.28	76.05	1:2:4
2.88	8.30	88.82	"	15.31	12.28	72.41	"
3.14	8.78	88.06	"	16.24	11.33	72.43	"
4.81	12.41	82.78	"	19.75	12.44	67.81	"
6.45	11.54	82.01	" + 1:2:4	22.62	13.66	63.72	"
				30.74	12.90	56.36	"

1:2:4 =  $\text{Na}_2\text{O}_2 \cdot 2\text{H}_2\text{O}_2 \cdot 4\text{H}_2\text{O}$

OH

THE SYSTEM SODIUM HYDROXIDE - AMMONIA - WATER  
(Ayres, 1945)

$t^\circ$	Upper Layer		Lower Layer		Pressure lbs. per Sq. in.	Phases Present
	Wt. % $\text{NH}_3$	Wt. % NaOH	Wt. % $\text{NH}_3$	Wt. % NaOH		
60	79.1	1.4	7.8	51.0	318	Vapor + Two Liquids + $\text{NaOH} \cdot \text{H}_2\text{O}$
	77.5	1.7	8.0	50.0	310	Vapor + Two Liquids
	73.3	2.3	9.5	47.7	298	Vapor + Two Liquids
	67.0	4.3	12.3	42.9	290	Vapor + Two Liquids
	61.8	6.8	15.0	39.4	275	Vapor + Two Liquids
	54.0	10.7	19.8	35.2	265	Vapor + Two Liquids
	46.9	14.4	24.2	30.9	263	Vapor + Two Liquids
	43.4	17.1	26.2	29.2	261	Vapor + Two Liquids
	40.5	18.9	28.2	27.6	262	Vapor + Two Liquids
	40.9	18.6	28.7	27.5	262	Vapor + Two Liquids
(One Liquid Phase)			93.1	0.4	367	Vapor + Liquid + $\text{NaOH} \cdot \text{H}_2\text{O}$
(One Liquid Phase)			96.7	0.0	373	Vapor + Liquid + NaOH + $\text{NaOH} \cdot \text{H}_2\text{O}$
50	70.0	3.4	11.4	44.8	235	Vapor + Two Liquids + $\text{NaOH} \cdot \text{H}_2\text{O}$
	67.2	4.5	12.3	42.9	233	Vapor + Two Liquids
	59.4	7.5	15.8	38.7	220	Vapor + Two Liquids
	54.1	10.2	19.2	35.5	212	Vapor + Two Liquids
	45.4	15.6	24.8	30.2	207	Vapor + Two Liquids
	41.9	18.0	29.2	27.3	205	Vapor + Two Liquids
(One Liquid Phase)			96.4	0.0	301	Vapor + Liquid + $\text{NaOH} \cdot \text{H}_2\text{O}$ + NaOH
(One Liquid Phase)			90.1	0.0	277	Vapor + Liquid + $\text{NaOH} \cdot \text{H}_2\text{O}$
40	59.4	7.9	15.9	38.4	165	Vapor + Two Liquids + $\text{NaOH} \cdot \text{H}_2\text{O}$
	56.6	9.5	18.6	35.4	166	Vapor + Two Liquids
	49.2	13.0	21.8	32.6	155	Vapor + Two Liquids
	40.8	19.1	28.5	27.2	153	Vapor + Two Liquids
35	50.9	13.0	20.7	35.3	138	Vapor + Two Liquids + $\text{NaOH} \cdot \text{H}_2\text{O}$
25 (One Liquid Phase)			60.5	6.6	-	$\text{NaOH} \cdot \text{H}_2\text{O}$
(One Liquid Phase)			56.7	8.3	-	$\text{NaOH} \cdot \text{H}_2\text{O}$
(One Liquid Phase)			45.1	15.0	-	$\text{NaOH} \cdot \text{H}_2\text{O}$
(One Liquid Phase)			24.5	29.1	-	$\text{NaOH} \cdot \text{H}_2\text{O}$
(One Liquid Phase)			3.9	48.4	-	$\text{NaOH} \cdot \text{H}_2\text{O}$

## Na SODIUM

THE SYSTEM SODIUM HYDROXIDE - HYDRAZINE - WATER  
(Penneman and Audrieth, 1949)

Lower Liquid (L <sub>1</sub> )			Upper Liquid (L <sub>2</sub> )			Phases Present
t°	Wt. %		Wt. %			
	N <sub>2</sub> H <sub>4</sub>	NaOH	N <sub>2</sub> H <sub>4</sub>	NaOH		
100	5.7	70.3	92.7	2.4	L <sub>1</sub> + L <sub>2</sub> + NaOH	
	9.2	62.9	87.5	3.0	L <sub>1</sub> + L <sub>2</sub>	
	15.5	54.4	80.6	6.4	"	
	23.2	46.1	70.6	11.6	"	
	32.9	37.8	59.0	19.1	"	
	45.9	27.9	45.9	27.9	Plait Point	
OH 90	-	-	98.1	0.1	L + NaOH	
	-	-	93.0	1.2	"	
	5.9	69.3	92.2	2.0	L <sub>1</sub> + L <sub>2</sub> + NaOH	
	6.4	68.4	91.6	2.1	L <sub>1</sub> + L <sub>2</sub>	
	7.8	65.2	89.5	2.6	"	
	9.3	62.8	87.7	3.4	"	
	19.9	49.8	75.1	9.2	"	
	21.9	47.8	72.6	10.8	"	
	25.3	44.9	68.9	12.6	"	
	35.0	36.9	57.0	20.8	"	
	45.6	28.2	45.6	28.2	Plait Point	
	70	6.7	67.6	90.9	3.2	L <sub>1</sub> + L <sub>2</sub> + NaOH
7.8		65.2	90.0	2.4	L <sub>1</sub> + L <sub>2</sub>	
9.0		63.0	87.9	3.6	L <sub>1</sub> + L <sub>2</sub>	
17.5		62.0	78.0	8.0	L <sub>1</sub> + L <sub>2</sub>	
23.6		45.8	70.5	12.2	L <sub>1</sub> + L <sub>2</sub>	
33.6		37.5	57.7	20.1	L <sub>1</sub> + L <sub>2</sub>	
45.4		28.5	45.4	28.5	Plait Point	
60		-	-	92.6	1.8	L + NaOH
	-	-	91.5	2.2	L + NaOH + NaOH·H <sub>2</sub> O	
	-	-	90.0	3.0	L + NaOH·H <sub>2</sub> O	
	-	-	79.6	7.8	L + NaOH·H <sub>2</sub> O	
	19.0	51.2	77.4	8.9	L <sub>1</sub> + L <sub>2</sub> + NaOH·H <sub>2</sub> O	
	22.9	47.4	71.7	12.3	L <sub>1</sub> + L <sub>2</sub>	
	36.7	36.3	55.8	22.7	L <sub>1</sub> + L <sub>2</sub>	
	45.5	29.6	45.5	29.6	Plait Point	
50	-	-	94.0	1.5	L + NaOH·H <sub>2</sub> O	
	-	-	93.1	1.7	L + NaOH·H <sub>2</sub> O	
	-	-	87.8	3.7	L + NaOH·H <sub>2</sub> O	
	-	-	83.1	7.4	L + NaOH·H <sub>2</sub> O	
	-	-	60.0	17.2	L + NaOH·H <sub>2</sub> O	
	-	-	45.9	26.2	L + NaOH·H <sub>2</sub> O	
	-	-	39.3	29.4	L + NaOH·H <sub>2</sub> O	
	-	-	23.1	40.4	L + NaOH·H <sub>2</sub> O	
	-	-	-	-	-	
	-	-	-	-	-	

The System  $\text{Na}_2\text{O} - \text{Ga}_2\text{O}_3 - \text{H}_2\text{O}$  was studied by Gevorkyan and Gurovich 1957 at 18° and 60°. The solid phases were  $\text{Ga}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$  and  $4\text{Na}_2\text{O} \cdot \text{Ga}_2\text{O}_3 \cdot 15\text{H}_2\text{O}$  at 18° and  $\text{Ga}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ ,  $2\text{Na}_2\text{O} \cdot \text{Ga}_2\text{O}_3 \cdot 7\text{H}_2\text{O}$  (in 20 - 30% NaOH), and  $3\text{Na}_2\text{O} \cdot \text{Ga}_2\text{O}_3 \cdot 13\text{H}_2\text{O}$  (in 30 - 40% NaOH). The maximum solubility of  $\text{Ga}_2\text{O}_3$  in NaOH is 28%

THE SYSTEM SODIUM HYDROXIDE - METHANOL - WATER AT 25°  
(Boynton, Masi, Gallagher and Whan, 1957)

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
Na <sub>2</sub> O	CH <sub>3</sub> OH	Solid Phase	Na <sub>2</sub> O	CH <sub>3</sub> OH	Solid Phase
18.6	81.4	NaOH·CH <sub>3</sub> OH	26.7	32.5	3NaOH·2H <sub>2</sub> O·CH <sub>3</sub> OH
18.4	82.5	"	26.8	29.0	"
18.2	79.1	"	28.4	24.2	"
18.7	75.3	"	29.6	18.3	"
20.2	68.7	"	30.8	13.4	"
20.3	66.3	"	32.5	7.9	"
20.6	65.6	" + 3NaOH·2H <sub>2</sub> O·CH <sub>3</sub> OH	33.8	4.3	"
20.5	65.5	" + "	35.3	1.7	"
20.8	64.5	3NaOH·2H <sub>2</sub> O·CH <sub>3</sub> OH	37.3	0.7	"
21.4	60.8	"	39.4	0.24	"
22.3	54.7	"	40.0	0.13	" + NaOH·H <sub>2</sub> O
22.8	50.3	"	40.0	0.13	" + "
24.6	44.7	"	40.0	0.13	" + "
25.6	39.3	"	40.6	0.0	NaOH·H <sub>2</sub> O

OH

THE SYSTEM SODIUM HYDROXIDE - ETHANOL - WATER  
(Peyronel, 1949a)

t°	Upper Layer		Lower Layer	
	Gms. per 100 C <sub>2</sub> H <sub>5</sub> OH	gms. Sat. Sol. NaOH	Gms. per 100 C <sub>2</sub> H <sub>5</sub> OH	gms. Sat. Sol. NaOH
17	52.20	23.28	0.84	39.54
	48.45	18.30	2.77	31.35
	33.50	18.66	7.35	26.70
	23.90	21.90	(one layer)	
30	56.13	24.07	0.76	42.20
	56.08	22.95	0.74	42.65
	52.80	16.63	2.34	32.04
	42.80	16.30	8.17	24.73
	23.90	19.56	(one layer)	
	64.20	22.38	-	44.45
	65.18	13.69	1.79	34.82
	62.50	9.50	5.22	26.44
90	54.10	10.21	9.95	23.32
	71.20	18.99	-	47.45
	70.50	13.06	-	35.47
	71.40	9.90	2.61	31.70
	51.38	10.50	9.50	23.50

Results for the system NaOH - "Industrial Methylated Spirit" (commercial ethyl alcohol in Great Britain) - H<sub>2</sub>O at 25°, 60° are given by Mills and Hughes, 1957, and are similar to those above. NaOH is more soluble in high alcoholic solutions, and less soluble in dilute (below 48 wt. %) solutions

# Na SODIUM

## THE SYSTEM SODIUM HYDROXIDE - ISOPROPYL ALCOHOL - WATER (Mills and Hughes, 1957)

Results at 25°				Results at 60°			
Equilib. Solu. Wt. %		Equilib. Solu. Wt. %		Equilib. Solu. Wt. %		Equilib. Solu. Wt. %	
i-C <sub>3</sub> H <sub>7</sub> OH	NaOH	i-C <sub>3</sub> H <sub>7</sub> OH	NaOH	i-C <sub>3</sub> H <sub>7</sub> OH	NaOH	i-C <sub>3</sub> H <sub>7</sub> OH	NaOH
97.2	1.2	30.9	4.3	96.3	1.6	31.2	3.2
87.1	0.4	21.8	5.8	74.3	0.6	21.9	4.8
75.1	0.4	13.4	7.8	62.5	1.0	13.5	6.7
63.1	1.0	5.8	11.7	51.7	1.4	5.9	10.6
51.5	2.0	2.3	18.2	40.9	2.4	1.5	16.6
OH 41.1	2.7	0.0	50.0	36.0	2.8	0.0	63.5
Tie-Line Data				Tie-Line Data			
0.6	31.5	-	97.4	0.6	30.5	-	98.8
1.5	23.7	-	97.2	0.6	23.4	-	97.0

## THE SYSTEM SODIUM HYDROXIDE - iso BUTYL ALCOHOL - WATER AT 25° (Fritzsche and Stockton, 1946)

Equilib. solu. wt. %		Equilib. solu. wt. %	
i-C <sub>4</sub> H <sub>9</sub> OH	NaOH	i-C <sub>4</sub> H <sub>9</sub> OH	NaOH
93.0	1.1	0.4	21.7
6.2	1.3	0.1	32.1
5.2	2.8	0.0	50.0
4.5	3.9		
3.5	5.8		
3.1	6.7		
0.9	14.5		
Tie-Line Data			
		0.1	35.1
		99.5	0.3
		0.4	24.8
		99.5	0.3

## THE SYSTEM SODIUM HYDROXIDE - ACETONE - WATER AT 0° (Gibby, 1934)

For additional data see Duhamel and Laurent, 1952, 1953.

Points on the binodal curve were determined by titration of acetone into aqueous sodium hydroxide solutions until a permanent separation into two layers was observed. A few mixtures of known composition were prepared in which the amount of NaOH in each layer was determined.

Points on the binodal curve				Gms. per 100 gms. Sat. Sol.			
C <sub>3</sub> H <sub>6</sub> O	NaOH	C <sub>3</sub> H <sub>6</sub> O	NaOH	C <sub>3</sub> H <sub>6</sub> O	NaOH	C <sub>3</sub> H <sub>6</sub> O	NaOH
1.1	27.2	9.8	13.1	18.3	8.0	29.2	5.3
1.4	25.7	9.6	12.2	22.0	7.9	34.0	4.5
2.3	24.3	15.2	9.4	24.0	7.0	34.8	4.3
4.9	19.6	16.1	9.2	25.2	6.9	43.7	2.6
6.4	17.2	16.3	9.1	24.8	6.7	57.4	1.1
9.9	13.3	17.3	8.4	27.1	6.4	62.9	0.7
				26.7	5.9	73.3	0.3

(Cont.)

## THE SYSTEM SODIUM HYDROXIDE - ACETONE - WATER AT 0°--Cont.

Synthetic mixtures:

Original		Wt. % NaOH found in	
C <sub>3</sub> H <sub>6</sub> O	NaOH	Aqueous layer	Acetone layer
42.0	7.1	12.74	0.5
58.3	7.5	19.4	0.1
61.5	8.5	21.1	0.06
41.6	9.8	16.7	0.1

For the solubility of NaOH in dioxane - water mixtures see Duhamel and Laurent, 1952, 1953.

OH

THE SYSTEM NaOH - DIETHYLAMINE - WATER  
(Ishiguro, Kakuma and Okumura, 1954)

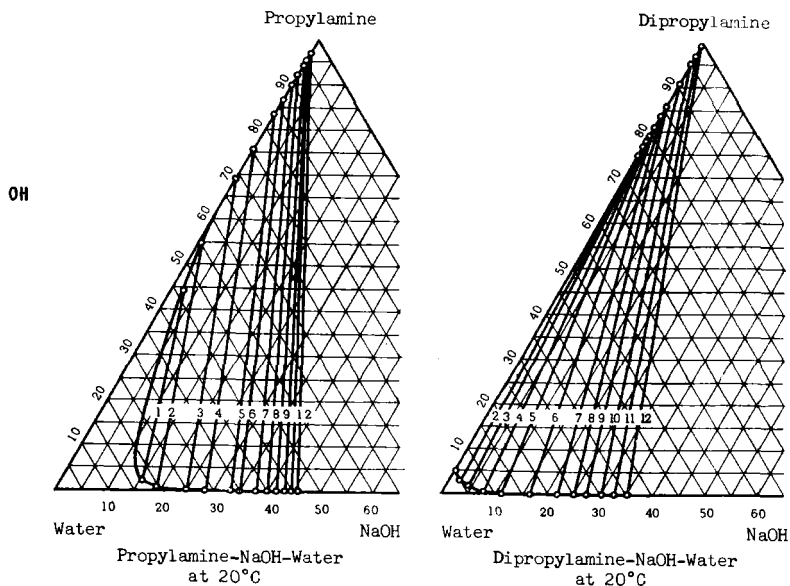
0°C				20°C			
Upper layer		Lower layer		Upper layer		Lower layer	
Amine	NaOH	Amine	NaOH	Amine	NaOH	Amine	NaOH
15.36	5.93			23.14	4.46		
23.46	4.08			30.19	3.21	10.51	7.74
45.55	1.18	6.70	9.58	34.41	2.51	9.71	8.13
58.32	0.40	3.02	12.95	45.08	1.13	4.87	10.06
66.88	0.19	2.66	14.89	57.12	0.49	1.90	13.62
71.26	0.07	0.99	17.01	63.97	0.19	1.03	16.39
81.24	0.06	0.52	18.94	69.15	0.10	0.51	18.69
84.11	0.05	0.20	16.42	74.40	0.05	0.24	21.43
88.42	0.03	0.05	22.35	78.64	0.02	0.12	22.90
93.85	-	-	35.15	81.30	0.02	0.09	26.11
98.66	-	-	45.81	84.42	0.01	0.07	28.93
98.71	-	-	-	89.64	-	-	33.60
				92.85	-	-	36.50
				98.93	-	-	49.82
				99.43	-	-	51.61
40°C							
16.3	3.6			79.96	-	0.02	20.30
37.20	1.57			90.19	-	-	29.72
42.94	1.38	3.72	7.23	94.47	-	-	34.29
49.17	0.71	1.61	8.74	96.66	-	-	41.73
60.75	0.24	0.81	12.17	99.21	-	-	49.62
70.01	0.02	0.28	15.14	99.93	-	-	54.36
74.38	0.001	0.08	17.68				

A diagram of the miscibility curve in the system NaOH - ethylene-diamine - H<sub>2</sub>O at 26° is given by Wilson, 1935



# Na SODIUM

## THE SYSTEMS NaOH - (Di) PROPYLAMINE - WATER AT 20° (Ishiguro, Kametani and Oka, 1956)



## THE SYSTEM NaOH - BUTYLAMINE - WATER (Ishiguro and Kametani, 1955a)

Upper layer				Lower layer			
Butylamine		NaOH		Butylamine		NaOH	
Wt. %	Molar fraction	Wt. %	Molar fraction	Wt. %	Molar fraction	Wt. %	Molar fraction
Results at 20°							
25.7	0.081	4.2	0.024	5.5	0.015	7.7	0.038
50.8	0.205	1.5	0.010	1.0	0.003	12.2	0.059
59.0	0.264	0.9	0.008	0.5	0.001	15.0	0.074
70.3	0.370	0.4	0.004	-	-	20.5	0.104
79.9	0.497	0.3	0.004	-	-	29.5	0.140
83.3	0.551	-	-	-	-	28.9	0.155
86.3	0.608	-	-	-	-	30.8	0.167
89.3	0.673	-	-	-	-	33.3	0.184
91.1	0.716	-	-	-	-	35.8	0.197
95.7	0.846	-	-	-	-	40.8	0.237
96.7	0.878	-	-	(Cont.)	-	43.9	0.260
97.2	0.895	-	-	-	-	45.1	0.270

## THE SYSTEM NaOH - BUTYLAMINE - WATER--Cont.

Upper layer				Lower Layer			
Butylamine		NaOH		Butylamine		NaOH	
Wt. %	Molar fraction	Wt. %	fraction	Wt. %	fraction	Wt. %	fraction
<u>Results at 40°</u>							
24.6	0.076	3.6	0.026	6.8	0.018	6.4	0.032
29.2	0.094	3.1	0.013	4.7	0.012	7.0	0.034
56.4	0.244	1.0	0.008	0.9	0.002	12.2	0.059
64.9	0.315	0.5	0.005	0.4	0.001	16.6	0.083
70.9	0.376	0.2	0.002	0.2	0.001	19.4	0.098
77.5	0.459	-	-	0.2	-	23.6	0.122
78.2	0.469	-	-	0.1	-	23.8	0.123
82.0	0.529	-	-	-	-	27.0	0.143
91.2	0.718	-	-	-	-	34.6	0.192
94.9	0.821	-	-	-	-	39.0	0.224
96.0	0.856	-	-	-	-	41.7	0.243
96.3	0.865	-	-	-	-	41.8	0.245
97.6	0.912	-	-	-	-	46.5	0.281
98.2	0.931	-	-	-	-	48.6	0.299
98.5	0.944	-	-	-	-	53.2	0.338

OH

<u>Results at 60.2°</u>							
29.3	0.094	2.7	0.016	5.2	0.014	6.1	0.030
36.8	0.128	2.3	0.015	3.3	0.009	7.0	0.034
58.2	0.258	0.7	0.006	0.8	0.002	11.9	0.058
68.5	0.353	0.3	0.003	0.3	0.001	16.8	0.083
74.3	0.416	-	-	0.1	-	19.8	0.100
79.6	0.491	-	-	-	-	23.5	0.122
84.5	0.573	-	-	-	-	27.0	0.143
86.2	0.606	-	-	-	-	28.5	0.152
80.0	0.666	-	-	-	-	31.1	0.169
90.7	0.706	-	-	-	-	33.2	0.183
93.2	0.771	-	-	-	-	36.6	0.206
94.2	0.800	-	-	-	-	37.7	0.214
95.1	0.827	-	-	-	-	39.6	0.228
95.4	0.836	-	-	-	-	40.2	0.233
96.7	0.878	-	-	-	-	43.1	0.255
98.4	0.938	-	-	-	-	48.8	0.300

# Na SODIUM

## THE SYSTEM NaOH - DIBUTYLAMINE - WATER (Ishiguro, Kametani and Maruyama, 1956)

<u>20°</u>		<u>30°</u>		<u>60°</u>	
Upper layer	Lower layer	Upper layer	Lower layer	Upper layer	Lower layer
Dibutylamine	NaOH	Dibutylamine	NaOH	Dibutylamine	NaOH
Wt. %	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %
94.3*	4.2	94.8	0**	96.2	0 ***
95.2	7.7	95.1	4.1	96.7	4.1
95.7	11.1	95.8	8.3	96.8	9.5
96.0	14.8	96.2	12.5	97.1	11.8
96.8	18.7	96.8	16.1	97.7	17.7
97.2	22.2	97.3	20.1	98.0	21.0
97.7	25.2	97.7	23.5	98.2	25.2
97.8	26.8	98.3	28.8	98.7	29.9
		98.4	29.8	98.9	35.8
		98.7	34.7	99.2	41.2
		99.0	41.2	99.4	48.3

\*NaOH 0.1%

\*\*Dibutylamine 0.4%

\*\*\*Dibutylamine 0.1%

## THE SYSTEM NaOH - AMYLAMINE - WATER (Ishiguro, Kametani and Maruyama, 1956)

<u>40°</u>				<u>60°</u>			
Upper layer		Lower layer		Upper layer		Lower layer	
Amylamine	NaOH	Amylamine	NaOH	Amylamine	NaOH	Amylamine	NaOH
wt. %	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %	wt. %
39.3	0.9	1.8	3.3	46.1	0.7	1.5	3.3
49.9	0.9	1.0	5.6	55.5	0.6	0.9	5.7
68.4	0.4	0.2	12.9	69.0	0.4	0.2	11.6
76.9	0.1	0.1	18.1	75.7	0.2	-	15.6
83.5	-	-	23.3	84.9	-	-	23.0
87.6	-	-	27.3	89.5	-	-	26.9
90.5	-	-	29.7	93.0	-	-	31.7
92.2	-	-	32.0	95.5	-	-	36.4
94.3	-	-	34.5	97.4	-	-	41.6
95.4	-	-	36.6				
96.5	-	-	39.5				
97.6	-	-	41.8				
98.3	-	-	45.3				

THE SYSTEM NaOH - HEPTYLAMINE - WATER  
(Ishiguro and Kametani, 1955)

Upper Layer				Lower Layer			
Heptylamine		NaOH		Heptylamine		NaOH	
wt. %	Mole frac.	wt. %	Mole frac.	wt. %	Mole Frac.	wt. %	Mole Frac.
<u>Results at 20.3°</u>							
24.6	0.049	1.7	0.010	-	-	3.3	0.015
34.0	0.075	2.2	0.014	-	-	5.0	0.023
68.3	0.252	-	-	-	-	8.4	0.040
71.5	0.282	-	-	-	-	10.0	0.048
82.1	0.418	-	-	-	-	17.5	0.087
85.6	0.482	-	-	-	-	21.4	0.109
90.0	0.582	-	-	-	-	26.5	0.140
93.5	0.692	-	-	-	-	31.1	0.169
<u>Results at 40.2°</u>							
33.1	0.072	0	0	0.3	-	0	0
66.8	0.239	-	-	-	-	4.3	0.020
73.1	0.298	-	-	-	-	8.1	0.038
83.7	0.445	-	-	-	-	16.7	0.083
87.7	0.528	-	-	-	-	21.1	0.108
91.4	0.625	-	-	-	-	25.6	0.134
94.8	0.740	-	-	-	-	30.2	0.163
96.0	0.790	-	-	-	-	33.1	0.182
97.5	0.859	-	-	-	-	36.5	0.206
98.5	0.912	-	-	-	-	41.3	0.241
<u>Results at 59.7°</u>							
74.4	0.313	-	-	-	-	5.8	0.027
80.9	0.399	-	-	-	-	10.8	0.052
88.3	0.542	-	-	-	-	18.6	0.093
92.9	0.672	-	-	-	-	25.8	0.135
93.5	0.692	-	-	-	-	26.3	0.138
95.9	0.785	-	-	-	-	31.1	0.169
97.7	0.869	-	-	-	-	36.2	0.203
98.4	0.906	-	-	-	-	40.1	0.231
<u>Results at 79.4°</u>							
79.5	0.378	-	-	-	-	6.2	0.029
83.7	0.445	-	-	-	-	10.7	0.051
91.4	0.625	-	-	-	-	19.9	0.101
96.2	0.798	-	-	-	-	29.4	0.158

OH

Data for the system NaOH - Hexylamine - Water at 30° are given by Arakawa and Kawaguchi, 1958.

# Na SODIUM

## THE SYSTEM NaOH - PYRIDINE - WATER (Ishiguro, Kawaguchi and Matsumoto, 1955)

See also table following

		Upper Layer				Lower Layer			
		Pyridine		NaOH		Pyridine		NaOH	
		Molar		Molar		Molar		Molar	
		wt. %	fraction	wt. %	fraction	wt. %	fraction	wt. %	fraction
<u>Results at 0°</u>									
OH	38.2	0.130	4.9	0.033	17.9	0.050	9.2	0.051	
	48.2	0.180	3.1	0.023	12.5	0.034	11.0	0.059	
	58.1	0.244	1.5	0.013	5.0	0.013	14.7	0.075	
	70.5	0.355	0.7	0.007	0.5	0.001	19.6	0.099	
	86.8	0.600	0.1	0.001	-	-	28.8 <sup>a</sup>	0.154	
<u>Results at 30°</u>									
	37.4	0.123	3.5	0.023	24.1	0.070	6.1	0.035	
	44.1	0.155	2.3	0.016	19.2	0.054	7.2	0.040	
	47.9	0.176	1.9	0.014	15.3	0.042	8.6	0.046	
	62.4	0.276	0.5	0.005	5.7	0.015	13.7	0.070	
	69.0	0.338	0.3	0.003	2.5	0.006	16.7	0.084	
	77.2	0.437	0.2	0.002	0.4	0.001	20.9	0.107	
	84.5	0.555	0.1	0.001	0.2	0.001	25.8	0.135	
	92.0	0.725	-	-	-	-	32.3	0.177	
	99.4	0.972	-	-	-	-	40.6 <sup>a</sup>	0.235	
<u>Results at 60°</u>									
	44.9	0.159	2.2	0.016	26.3	0.078	5.1	0.030	
	50.2	0.189	1.4	0.011	16.9	0.046	6.8	0.037	
	59.1	0.251	1.1	0.009	8.3	0.022	10.2	0.052	
	72.2	0.374	0.5	0.005	2.8	0.007	16.1	0.081	
	78.7	0.458	0.1	0.002	0.5	0.001	20.2	0.103	
	84.3	0.551	-	-	0.2	0.001	23.6	0.122	
	87.3	0.610	-	-	-	-	26.0	0.137	
	93.2	0.756	-	-	-	-	31.6	0.172	
	98.4	0.933	-	-	-	-	37.8	0.215	
	100	1.000	-	-	-	-	58.6 <sup>a</sup>	0.389	
<u>Results at 90°</u>									
	55.7	0.230	3.1	0.033	10.0	0.036	7.5	0.038	
	70.0	0.344	1.6	0.016	4.8	0.012	12.3	0.062	
	77.3	0.441	0.7	0.008	2.4	0.006	16.9	0.085	
	86.6	0.597	0.1	0.002	0.7	0.002	23.4	0.122	
	92.7	0.746	-	-	0.6	0.002	29.1	0.157	
	93.3	0.932	-	-	-	-	38.6	0.221	
	99.2	0.966	-	-	-	-	48.0	0.294	
	100.0	1.000	-	-	-	-	69.0	0.500	
	100.0	1.000	-	-	-	-	75.1 <sup>a</sup>	0.577	

<sup>a</sup>saturated solution of caustic soda

## THE SYSTEM NaOH - PYRIDINE - WATER--Cont.

Data of Laurent and Duhamel, 1953 at 25°

(Tie lines not identified)

Sat. Sol. Wt. %		Sat. Sol. Wt. %		Sat. Sol. Wt. %	
NaOH	pyridine	NaOH	pyridine	NaOH	pyridine
53.00	0.0	9.64	3.41	1.85	37.05
38.50	0.17	8.45	4.11	1.37	40.60
30.55	0.22	7.59	5.10	1.23	43.00
26.50	0.34	6.78	7.10	0.98	45.45
22.25	0.27	5.69	9.62	1.87	35.61
18.11	1.05	4.40	13.75	1.42	40.95
16.10	1.15	3.70	17.80	1.04	45.20
15.88	1.32	3.11	22.45	0.70	51.00
13.21	1.50	2.71	26.68	0.30	55.70
11.15	2.18	2.04	33.10	0.0	100.0

OH

Data for equilibrium in the system sodium hydroxide - resorcinol - water at 30° are given by van Meura (1916).

SOLUBILITY OF SODIUM HYDROXIDE IN METHYL ALCOHOL AND IN  
ETHYL ALCOHOL AT ABOUT 28°  
(Murray, 1929)

The mixtures were shaken occasionally at room temperature during about three weeks. Portions of the clear supernatant solutions were then removed, weighed and titrated with normal sulfuric acid.

Solvent	d. of sat. sol.	Normality of sat. sol.	Gms. NaOH per:	
			100 cc sat. sol.	100 gms. sat. sol.
Methyl Alcohol	1.01	5.98	23.9	23.6
Ethyl Alcohol	0.93	3.40	13.6	14.7

1000 gms. liquid ammonia dissolve 0.0025 gm. NaOH at -40°.

(Skossareswky and Tchitchinadze, 1918)

Melting points have been determined for:

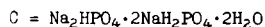
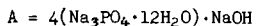
NaOH + Na <sub>2</sub> SO <sub>4</sub>	(Khitrov and Khitrova, 1953)(Ravich and Elenevskaya, 1954)
NaOH + Na <sub>2</sub> CrO <sub>4</sub>	(Khitrov and Khitrova, 1953)
NaOH + Na <sub>2</sub> MoO <sub>4</sub>	(Khitrov and Khitrova, 1953)
NaOH + NaBr	(Okada, Yoshizawa and Watanabe, 1953)(Seward, 1955)
NaOH + NaI	(Okada, Yoshizawa and Watanabe, 1953)
NaOH + NaBr + NaI	(Okada, Yoshizawa and Watanabe, 1953)
NaOH + HCOONa	(Sirotkin, 1950)(Schwab, Glatzer and Kovos, 1955)
NaOH + KBr	(Seward, 1955)
NaOH + K <sub>2</sub> CO <sub>3</sub>	(Seward, 1955)
NaOH + Na <sub>2</sub> CO <sub>3</sub>	(Seward, 1955)

## Na SODIUM

## PO SODIUM PHOSPHATES (ortho)

THE SYSTEM  $\text{Na}_2\text{O} - \text{P}_2\text{O}_5 - \text{H}_2\text{O}$   
(Wendrow and Kobe, 1952, 1954)

The system was investigated in detail from  $0^\circ$  to  $100^\circ$ , and the results compared with those of previous investigators. In general, there is reasonable agreement among the various data. Some of the data of D'Ans and Schreiner, 1910a at  $25^\circ$  are apparently incorrect, e.g. the solubility of trisodium phosphate is too high. The data of Menzel and von Sahr, 1937 at  $20^\circ$  for trisodium phosphate agree with those of W.&K.



TSP = trisodium phosphate

DSP = disodium phosphate

MSP = monosodium phosphate

HSP = hemisodium phosphate

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
$\text{Na}_2\text{O}$	$\text{P}_2\text{O}_5$	Solid Phase	$\text{Na}_2\text{O}$	$\text{P}_2\text{O}_5$	Solid Phase
at $0^\circ$			at $25^\circ$ , Cont.		
2.23	1.75	A	17.87	28.48	DSP·8H <sub>2</sub> O
2.10	0.61	"	19.48	31.39	"
3.03	2.25	"	20.44	32.62	" + C
0.754	0.855	DSP·12H <sub>2</sub> O	19.88	32.60	C
0.746	0.840	"	19.48	32.93	"
9.28	21.26	"	19.08	33.49	"
9.36	21.43	MSP·2H <sub>2</sub> O	18.93	33.53	" + MSP·2H <sub>2</sub> O
			17.28	31.20	MSP·2H <sub>2</sub> O
			13.24	28.06	"
			13.22	27.84	"
30.35	0.16	TSP·1/2H <sub>2</sub> O	12.01	27.50	"
28.61	0.28	"	11.15	29.50	"
28.30	0.31	" + TSP·6H <sub>2</sub> O	10.83	31.65	"
26.48	0.28	TSP·6H <sub>2</sub> O	10.71	33.94	"
24.77	0.30	"	10.82	36.23	"
23.73	0.29	" + A	10.98	38.60	"
20.82	0.22	A	11.41	40.51	"
12.13	0.31	"	11.33	40.95	MSP·H <sub>2</sub> O
5.75	0.75	"	10.93	42.70	"
4.65	1.40	"	10.88	43.37	"
4.61	2.50	"	11.31	44.85	" + MSP
4.79	2.70	"	11.16	45.39	MSP
7.76	6.12	"	11.08	45.65	"
8.99	7.50	"	10.30	48.26	"
9.91	8.53	"	10.19	49.80	" + HSP
10.66	9.39	" + DSP·12H <sub>2</sub> O	7.25	51.33	HSP
9.04	8.20	DSP·12H <sub>2</sub> O	2.88	56.77	"
8.93	8.01	"			
4.52	5.23	"			
8.61	12.95	"			
11.02	17.59	"			
15.30	24.58	"	34.71	0.12	TSP·1/2H <sub>2</sub> O
15.82	25.05	"	29.19	0.31	"
16.07	25.32	"	28.79	0.38	"
16.24	25.37	"	28.37	0.42	"
16.71	25.69	" + DSP·8H <sub>2</sub> O	27.78	0.48	TSP·6H <sub>2</sub> O
16.71	26.33	DSP·8H <sub>2</sub> O	27.54	0.47	"
16.76	26.91	"	26.98	0.47	"
17.58	28.26	"	25.43	0.53	"
			24.42	0.56	"

(Cont.)

THE SYSTEM  $\text{Na}_2\text{O} - \text{P}_2\text{O}_5 - \text{H}_2\text{O}$ --Cont.A =  $4(\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}) \cdot \text{NaOH}$ B =  $\text{Na}_2\text{HPO}_4 \cdot \text{NaH}_2\text{PO}_4$ C =  $\text{Na}_2\text{HPO}_4 \cdot 2\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$ 

TSP = trisodium phosphate

DSP = disodium phosphate

MSP = monosodium phosphate

HSP = hemisodium phosphate

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
$\text{Na}_2\text{O}$	$\text{P}_2\text{O}_5$	Solid Phase	$\text{Na}_2\text{O}$	$\text{P}_2\text{O}_5$	Solid Phase
at 40°, Cont.			at 40°, Cont.		
23.80	0.61	TSP·6H <sub>2</sub> O	16.92	34.39	"
23.36	0.66	" + A	15.77	33.78	"
19.85	0.55	A	14.66	33.62	"
15.64	0.55	"	13.96	35.31	"
15.32	0.59	"	13.61	36.71	"
9.30	1.17	"	13.07	38.05	"
8.59	1.54	"	12.37	41.70	"
7.63	3.18	"	12.53	42.27	"
7.54	3.73	"	12.25	42.73	MSP
8.97	6.30	"	11.77	45.10	"
12.21	9.60	"	11.44	46.38	"
12.38	9.81	"	10.92	48.72	"
13.88	11.31	" + TSP·8H <sub>2</sub> O	10.66	51.35	"
14.16	11.76	TSP·8H <sub>2</sub> O	10.33	52.07	HSP
14.33	12.13	"	7.39	53.66	"
15.00	12.73	"	5.10	55.39	"
15.59	13.94	"	2.68	60.24	"
17.15	16.52	"			
17.72	17.31	"			
19.27	19.18	" + DSP·7H <sub>2</sub> O		at 60°	
18.78	18.92	DSP·7H <sub>2</sub> O	34.39	0.094	TSP
16.05	17.52	"	30.14	0.136	"
15.10	17.33	"	28.72	0.31	"
14.71	17.09	"	28.29	0.52	" + TSP·1/2H <sub>2</sub> O
15.34	18.32	"	26.25	0.90	TSP·1/2H <sub>2</sub> O
16.14	20.24	"	25.68	1.19	"
17.87	24.05	"	25.01	1.37	"
18.36	25.58	"	23.76	1.54	"
19.18	26.43	" + DSP·2H <sub>2</sub> O	20.60	2.16	"
19.39	26.72	DSP·2H <sub>2</sub> O	19.72	2.47	A
19.33	26.99	"	18.71	2.55	"
19.54	27.41	"	15.79	2.59	"
19.55	27.82	"	14.71	3.05	"
19.90	29.94	"	13.71	4.18	"
20.44	31.23	"	13.28	7.41	"
20.63	32.00	"	15.91	11.02	"
20.74	32.34	"	17.15	12.24	" + TSP·8H <sub>2</sub> O
20.82	32.53	"	17.29	12.71	TSP·8H <sub>2</sub> O
21.34	33.79	"	17.79	13.01	"
21.12	34.73	C	19.20	15.94	"
20.68	35.79	"	21.73	20.63	"
20.32	36.26	"	22.13	21.04	"
20.44	37.01	" + MSP·H <sub>2</sub> O	22.48	21.65	"
19.46	35.90	MSP·H <sub>2</sub> O	22.62	22.06	" + DSP·2H <sub>2</sub> O
18.95	35.71	"	22.12	21.85	DSP·2H <sub>2</sub> O
18.76	35.52	"	20.86	21.82	"
17.56	34.60	"	20.68	21.99	"
17.09	34.50	"	19.26	22.11	"

(Cont.)



**Na** SODIUM

THE SYSTEM  $\text{Na}_2\text{O} - \text{P}_2\text{O}_5 - \text{H}_2\text{O}$ --Cont.

$$A = 4(\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}) \cdot \text{NaOH}$$

TSP = trisodium phosphate

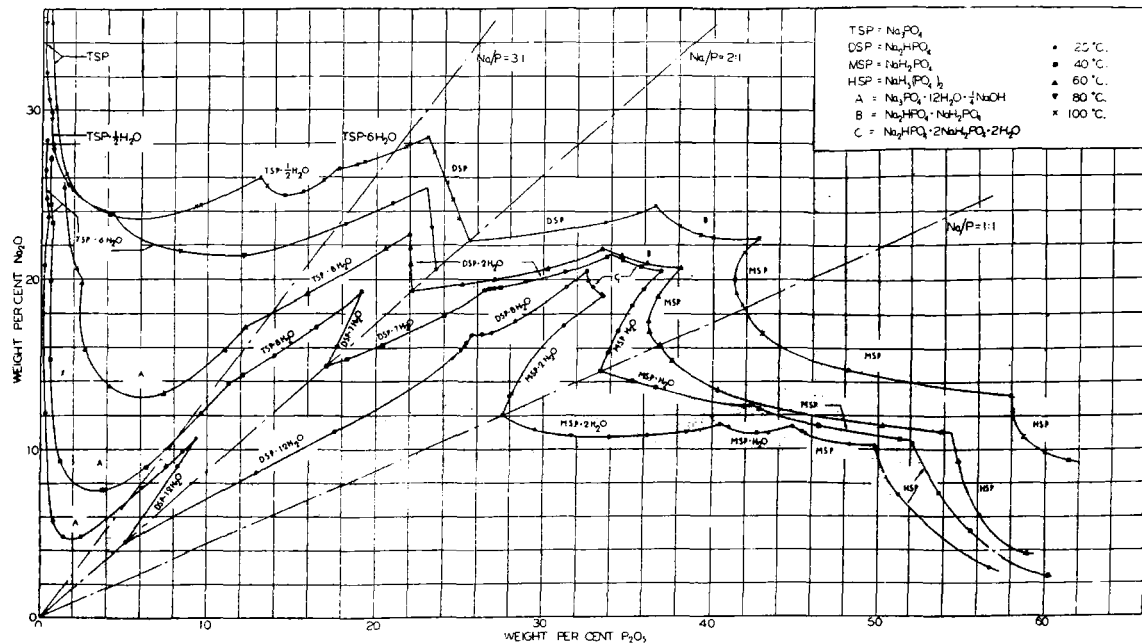
$$B = \text{Na}_2\text{HPO}_4 \cdot \text{NaH}_2\text{PO}_4$$

DSP = disodium phosphate

$$C = \text{Na}_2\text{HPO}_4 \cdot 2\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$$

MSP = monosodium phosphate  
HSP = hemisodium phosphate

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
Na <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>	Solid Phase	Na <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>	Solid Phase
at 60°, Cont.			at 80°, Cont.		
19.69	25.13	DSP·2H <sub>2</sub> O	21.35	12.15	TSP·6H <sub>2</sub> O
19.95	27.09	"	23.20	18.20	"
20.58	30.32	"	24.51	20.96	"
21.38	32.29	"	22.94	23.29	DSP·2H <sub>2</sub> O
21.55	32.90	"	20.59	23.56	"
21.81	33.43	" + B			
21.79	33.53	B			
21.79	33.60	"			
21.66	33.69	"			
21.37	34.52	"	38.36	0.41	TSP
21.30	34.67	"	30.05	0.80	"
20.93	36.17	"	26.19	1.33	"
21.02	36.78	"	23.79	4.17	"
20.79	37.52	"	24.37	9.26	"
20.74	38.20	" + MSP	24.26	9.53	"
18.92	36.76	MSP	25.98	13.18	"
17.50	36.21	"	25.43	13.41	TSP·1/2H <sub>2</sub> O
17.16	36.16	"	24.97	14.60	"
16.83	36.13	"	25.18	15.62	"
16.11	36.89	"	25.76	16.93	"
15.08	37.72	"	26.51	17.79	"
13.54	30.29	"	26.75	18.87	TSP·6H <sub>2</sub> O
12.41	43.02	"	26.90	19.29	"
11.43	49.48	"	27.89	21.77	"
11.39	50.32	"	28.31	23.01	"
11.19	51.52	"	27.48	23.46	DSP
10.89	54.09	"	25.73	24.29	"
8.91	54.53	HSP	24.69	24.59	"
7.59	55.46	"	23.53	24.84	"
6.01	56.11	"	22.13	25.56	"
3.63	59.01	"	23.39	33.64	"
			24.34	36.61	" + B
			23.07	38.09	B
			22.54	39.21	"
			22.33	40.00	"
			22.40	42.73	" + MSP
			21.48	41.91	MSP
			19.87	41.25	"
			19.16	41.40	"
			18.36	41.72	"
			18.31	41.92	"
			16.71	42.90	"
			14.63	48.22	"
			13.14	58.04	"
			12.32	57.95	HSP
			10.70	58.68	"
			9.86	60.08	"
			9.37	61.42	"
at 80°					
36.39	0.140	TSP			
32.11	0.210	"			
30.64	0.314	"			
30.28	0.373	"			
29.85	0.514	"·1/2H <sub>2</sub> O			
28.03	0.605	"			
27.72	0.617	"			
25.60	1.65	"			
25.24	1.79	"			
24.83	2.60	"			
23.87	4.29	" + TSP·6H <sub>2</sub> O			
21.61	8.35	TSP·6H <sub>2</sub> O			



SYSTEM SODIUM OXIDE - PHOSPHORUS PENTOXIDE - WATER FROM 25° TO 100° C.  
 (Wendrow and Kobe, 1953, 1954)

PO

SODIUM Na

# Na SODIUM

## PO TRISODIUM PHOSPHATE $\text{Na}_3\text{PO}_4$

### SOLUBILITY IN WATER

The solubility results have been reviewed by Kobe and Leipper, 1940 and Wendrow and Kobe, 1954, 1956. Below about 55° the solid phase  $\text{Na}_3\text{PO}_4 \cdot 1/4\text{NaOH} \cdot 12\text{H}_2\text{O}$  is in equilibrium with a solution having  $\text{Na}_2\text{O}/\text{P}_2\text{O}_5$  ratio of 3.00. The composition of this solid has been reported as containing 1/7, 1/5 or 1/11 - 2/9 (variable) moles NaOH. Differences between the several results are probably due to the particular solid phase chosen as the "triphosphate". The data below are for solutions containing  $\text{Na}_2\text{O}/\text{P}_2\text{O}_5 = 3.00$ .

- |                                  |                                       |
|----------------------------------|---------------------------------------|
| (1) Wendrow and Kobe, 1952, 1954 | (5) Oboukhov and Mikhailova, 1935     |
| (2) Kobe and Leipper, 1940       | (6) Schroeder, Berk and Gabriel, 1937 |
| (3) Mulder                       | (7) Teeple, 1929                      |
| (4) Apfel, 1911                  | (8) Korf and Balyasnaya, 1941         |

t°	Gms $\text{Na}_3\text{PO}_4$ per 100 gms $\text{H}_2\text{O}$					Solid Phase (Ref. 1; see foot note)
	(1)	(2)	(3)	(4)	(6)	
0	5.38	4.43	1.49	4.4	-	$\text{Na}_3\text{PO}_4 \cdot \frac{1}{4}\text{NaOH} \cdot 12\text{H}_2\text{O}$
10	-	-	4.10	8.22	-	"
20	-	-	11.0	12.1	12.9 (7)	"
25	14.53	11.08	15.5	13.7	15.5 (5); 17.5 (8)	"
30	-	-	20.0	16.3	-	"
40	23.3	20.0	31.0	20.2	-	"
50	-	-	43.0	29.4	-	"
55	-	-	-	35.5	-	$\text{Na}_3\text{PO}_4 \cdot 8\text{H}_2\text{O}$
60	46.2	40.3	55.0	39.7	-	"
65	-	-	-	43.3	-	"
70	-	-	-	48.5	-	$\text{Na}_3\text{PO}_4 \cdot 6\text{H}_2\text{O}$
75	-	-	-	54.2	57.0	"
80	68.0	61.5	81.0	-	60.0	"
90	-	-	-	-	68.0	"
100	94.6	86.7	107.7	-	77.0	"
105	-	-	-	-	99.2 (5)	"

### Results at Higher Temperatures (6)

110°	86.0	180°	67	230°	22
121°	94.0	200°	61	240°	14
130°	90.0	215°	59	250°	9.5
140°	85.0	216°	46	300°	2.5
150°	80.0	218°	40	350°	0.15
160°	76.0	220°	37		

### Note on solid phases:

Ref (2) considers the complex salt as  $\text{Na}_3\text{PO}_4 \cdot 1/5\text{NaOH} \cdot 12\text{H}_2\text{O}$

Ref (3) gives no solid compositions

Ref (4) thought  $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$  stable 0 - 40°;  $\text{Na}_3\text{PO}_4 \cdot 10\text{H}_2\text{O}$  from 50° to 65°, and  $\text{Na}_3\text{PO}_4 \cdot 8\text{H}_2\text{O}$  at 70, 75°.

Ref (6) Reported  $\text{Na}_3\text{PO}_4 \cdot 10\text{H}_2\text{O}$  below 75°; transition to  $\text{Na}_3\text{PO}_4 \cdot 8\text{H}_2\text{O}$  (?) at 75°;  $\text{Na}_3\text{PO}_4 \cdot 8\text{H}_2\text{O}$  (?) at 80°-121°; transition to  $\text{Na}_3\text{PO}_4 \cdot \text{H}_2\text{O}$  at 121°;  $\text{Na}_3\text{PO}_4 \cdot \text{H}_2\text{O}$  from 121° to 215°; transition to  $\text{Na}_3\text{PO}_4$  at 215°;  $\text{Na}_3\text{PO}_4$  stable above 215°.

SOLUBILITY OF  $\text{Na}_3\text{PO}_4$  IN-AQUEOUS SOLUTIONS OF SODIUM HYDROXIDE  
(Schroeder, Berk and Gabriel, 1937)

For data at  $0^\circ$ - $100^\circ$  see Wendrow and Kobe, 1952, 1954 under the system  $\text{Na}_2\text{O} - \text{P}_2\text{O}_5 - \text{H}_2\text{O}$ .

t°	Gms. per 100 gms. $\text{H}_2\text{O}$		t°	Gms. per 100 gms. $\text{H}_2\text{O}$		
	NaOH	$\text{Na}_3\text{PO}_4$		NaOH	$\text{Na}_3\text{PO}_4$	
150	0.0	82	250	20.6	5.5	
"	8.2	49	"	29.5	5.7	
"	20.0	20.6	350	0.0	0.15	
250	0.0	8.6	"	8.0	0.44	
"	8.2	7.0	"	21.9	2.0	
			"	21.3	2.2	PO

These determinations were made in connection with boiler feed-water studies.

THE SYSTEM TRISODIUM PHOSPHATE - SODIUM CARBONATE - WATER  
(Kobe and Leipper, 1940)

Also see table following.

Gms per 100 gms $\text{H}_2\text{O}$			Gms per 100 gms $\text{H}_2\text{O}$		
$\text{Na}_3\text{PO}_4 \cdot \frac{1}{2}\text{NaOH}$	$\text{Na}_2\text{CO}_3$	Solid Phase	$\text{Na}_3\text{PO}_4 \cdot \frac{1}{2}\text{NaOH}$	$\text{Na}_2\text{CO}_3$	Solid Phase
<u>Results at <math>-2.48^\circ</math></u>			<u>Results at <math>40^\circ</math></u>		
1.8	5.5	TSP+ $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	20.8	0.0	TSP
			15.1	15.1	"
<u>Results at <math>-2.10^\circ</math></u>			11.6	35.0	"
0.0	6.1	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	11.1	43.1	TSP+ $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
			0.0	49.2	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
<u>Results at <math>-1.21^\circ</math></u>			<u>Results at <math>60^\circ</math></u>		
4.2	0.0	TSP	41.8	0.0	TSP
<u>Results at <math>0^\circ</math></u>			36.6	11.1	"
			31.0	23.5	"
4.58	0.0	TSP	28.0	31.2	TSP+ $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
2.58	6.43	TSP+ $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	11.4	40.0	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
0.0	6.93	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	0.0	46.3	"
<u>Results at <math>25^\circ</math> (see below)</u>			63.8	0.0	TSP
			52.3	20.0	TSP+ $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
11.9	0.0	TSP	0.0	45.1	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
10.7	3.60	"	90.0	0.0	TSP
9.30	6.96	"	88.0	10.9	TSP+ $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
8.05	13.0	"	67.1	17.4	$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$
7.01	19.4	"	62.1	18.7	"
5.79	28.0	TSP+ $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	39.0	27.7	"
3.44	28.5	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	23.0	35.2	"
0.0	29.4	"	0.0	44.8	"

TSP = Trisodium Phosphate

(Cont.)

# Na SODIUM

THE SYSTEM TRISODIUM PHOSPHATE - SODIUM CARBONATE - WATER--Cont.

Data of Korf and Balyasnaya, 1941 at 25°

Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
Na <sub>3</sub> PO <sub>4</sub>	Na <sub>2</sub> CO <sub>3</sub>		Na <sub>3</sub> PO <sub>4</sub>	Na <sub>2</sub> CO <sub>3</sub>	
13.4	0.0	Na <sub>3</sub> PO <sub>4</sub> ·12H <sub>2</sub> O	5.82	19.00	Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O
8.95	4.91	"	4.73	20.02	"
7.48	8.65	"	3.93	20.50	"
7.12	11.25	"	1.87	21.00	"
6.78	14.91	"	0.0	22.75	"
6.40	19.30	Na <sub>3</sub> PO <sub>4</sub> ·12H <sub>2</sub> O+Na <sub>2</sub> CO <sub>3</sub> ·10H <sub>2</sub> O			
6.34	19.32	"			

PO

Results for the systems Na<sub>3</sub>PO<sub>4</sub> - Na<sub>2</sub>SO<sub>4</sub> - H<sub>2</sub>O and Na<sub>3</sub>PO<sub>4</sub> - Na<sub>2</sub>SO<sub>4</sub> - NaOH - H<sub>2</sub>O 150° and 350° are given by Schroeder, Gabriel and Partridge, 1935 and Schroeder, Berk and Gabriel, 1937.

## PO DISODIUM HYDROGEN PHOSPHATE Na<sub>2</sub>HPO<sub>4</sub>

### SOLUBILITY IN WATER

The data of various investigators is in reasonably good agreement. The  $\alpha \rightleftharpoons \beta$  dodecahydrate transition was reported by ref. 2.

- |                                     |                              |
|-------------------------------------|------------------------------|
| (1) Shiomi, 1908                    | (5) Wendrow and Kobe, 1952   |
| (2) Menzies and Humphrey, 1912      | (6) Osaka, 1903-8            |
| (3) Hammick, Goadby and Booth, 1920 | (7) Greenish and Smith, 1901 |
| (4) Menzel and Gabler, 1929         | (8) Palitzsch, 1929          |

t°	Gms. Na <sub>2</sub> HPO <sub>4</sub> per 100 gms. H <sub>2</sub> O				Average Curve	Solid Phase
	(1)	(2)	(3)	(4, 5)		
- 0.47	-	-	1.47	1.55(4)	1.5	Eutectic
0.0	-	-	-	1.63, 1.73	1.6	
+ 0.05	-	1.67	-	-	-	
5	-	-	-	-	2.5	
6	-	-	2.81	-	-	
10	-	-	-	-	3.6	Na <sub>2</sub> HPO <sub>4</sub> ·12H <sub>2</sub> O ( $\alpha$ -form)
10.26	3.55	-	-	-	-	
15	-	5.23(7)	-	-	5.3	
15.11	5.23	-	-	-	-	
18	-	-	-	6.367(4)	-	
19.95	-	-	7.83	-	-	
20	-	7.66	-	-	7.7	
22.77	-	-	9.80	-	-	
24.15	-	-	10.52	-	-	
25	12.2(6)	12.00	11.75(8)	12.144, 11.52	11.8	
25.75	-	-	12.24	-	-	TRANSITION POINT $\alpha \rightarrow \beta$
27.80	-	-	16.48	-	-	
28.65	-	-	18.86	-	-	
29.05	-	-	19.13	-	-	
29.5	-	-	20.7	-	20.6	

(Cont.)

## SOLUBILITY IN WATER--Cont.

- (1) Shiomi, 1908 (5) Wendrow and Kobe, 1952  
 (2) Menzies and Humphrey, 1912 (6) Osaka, 1903-8  
 (3) Hammick, Goadby and Booth, 1920 (7) Greenish and Smith, 1901  
 (4) Menzel and Gabler, 1929 (8) Palitzsch, 1929

t°	Gms. Na <sub>2</sub> HPO <sub>4</sub> per 100 gms. H <sub>2</sub> O				Average Curve	Solid Phase
	(1)	(2)	(3)	(4, 5)		
30	-	-	-	-	21.7	Na <sub>2</sub> HPO <sub>4</sub> ·12H <sub>2</sub> O (β-form)
30.1	-	-	24.15	-	-	
30.21	20.81	-	-	-	-	
30.76	23.41	-	-	-	-	
30.9	-	-	25.15	-	-	
32	-	25.7	-	-	-	
32.5	-	-	29.15	-	-	
33.04	30.88	-	-	-	-	
33.7	-	-	32.7	-	-	
34	-	33.8	-	-	-	
34.7	-	-	42.4	-	-	TRANSITION POINT
35	-	-	-	-	36.5	
35.4	-	-	-	-	38.0	
36.5	-	-	45.2	-	-	
37.27	47.51	-	-	-	-	
39.2	-	51.8	-	-	-	Na <sub>2</sub> HPO <sub>4</sub> ·7H <sub>2</sub> O
40	-	-	-	51.7(5)	52.7	
40.02	-	-	55.2	-	-	
45	-	67.3	-	-	66.0	
47.23	76.58	-	-	-	-	TRANSITION POINT
48.1	-	-	-	-	79.9	
50	-	80.2	-	-	80.1	
55	-	-	-	-	-	
55.17	81.4	-	-	-	-	Na <sub>2</sub> HPO <sub>4</sub> ·2H <sub>2</sub> O
60	-	82.9	-	78.8	82.8	
70	-	-	-	-	87.0	
70.26	88.11	-	-	-	-	
80	-	92.4	-	89.0	93.5	
89.74	102.87	-	-	-	-	TRANSITION POINT
90	-	-	-	-	100.7	
90.2	-	101.1	-	-	-	
95.1	-	-	-	-	104.5	
96.2	-	104.6	-	-	-	
99.77	102.15	-	-	-	-	Na <sub>2</sub> HPO <sub>4</sub>
100	-	-	-	102.4	103.3	
105	-	103.3	-	-	-	
110	-	-	-	-	101.5	
120	-	99.2	-	-	100.0	

SOLUBILITY OF DISODIUM HYDROGEN PHOSPHATE IN AQUEOUS SOLUTIONS  
 OF HYDROGEN PEROXIDE AT 0°  
 (Menzel and Gabler, 1929)

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
H <sub>2</sub> O <sub>2</sub>	Na <sub>2</sub> HPO <sub>4</sub>	H <sub>2</sub> O <sub>2</sub>	Na <sub>2</sub> HPO <sub>4</sub>
0.00	1.605	0.9349	1.789
0.2501	1.652	1.288	1.860
0.7132	1.742	1.633	1.923

## Na. SODIUM

Data in the system  $\text{Na}_2\text{HPO}_4 - \text{NaOH} - \text{H}_2\text{O}$  at  $365^\circ$  are given by Ravich and Shcherbakova, 1955. For lower temperature results see under  $\text{Na}_2\text{O} - \text{P}_2\text{O}_5 - \text{H}_2\text{O}$ .

### SOLUBILITY OF DI SODIUM PHOSPHATE IN AQUEOUS SOLUTIONS OF URETHAN AT $25^\circ$ (Palitzsch, 1928, 1929)

Gm. Mola. per 1000 gms. $\text{H}_2\text{O}$		Solid Phase
$\text{Na}_2\text{HPO}_4$	$\text{NH}_2\text{COOC}_2\text{H}_5$	
0.54	1.152	$\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$
0.374	3.62	"

100 gms. alcohol of  $d_{15}$  = 0.941 dissolve 0.33 gm.  $\text{Na}_2\text{HPO}_4$  at  $15.5^\circ$ .  
(Greenish and Smith, 1901)

## PO MONOSODIUM HYDROGEN PHOSPHATE $\text{NaH}_2\text{PO}_4$

### SOLUBILITY IN WATER

The results of various workers are in fair agreement. The following values were read from a plot of the data and are probably correct to  $\pm 0.5$ . The individual results are given in the table following for reference.

$t^\circ$	Gms. $\text{NaH}_2\text{PO}_4$ per 100 gms.		Solid Phase	$t^\circ$	Gms. $\text{NaH}_2\text{PO}_4$ per 100 gms.		Solid Phase
	sat.	sol.			sat.	sol.	
-9	31		ICE + $\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$	50	61.5		$\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$
0	36.5		$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$	55	63.5		"
5	38.5		"	5	58		" + $\text{NaH}_2\text{PO}_4$
10	41.0		"	60	65		$\text{NaH}_2\text{PO}_4$
15	43.5		"	70	66.0		"
20	45.5		"	80	68.0		"
25	48.5		"	90	69.5		"
30	51.5		"	100	71		"
40	57.0		"				
41(?)	58.5		" + $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$				

### Individual Results - System $\text{NaH}_2\text{PO}_4 + \text{H}_2\text{O}$

I = ICE      A =  $\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$       B =  $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$       C =  $\text{NaH}_2\text{PO}_4$

(Apfel, 1911)

$t^\circ$	sat. sol. wt. %	$t^\circ$	sat. sol. wt. %	
0	36.1A	50	61.8A	••
18	45.8A	55	63.8B	
25	48.6A	58	65.5B	
35.5	53.6A	61	65.8C	
40	56.4A	65	65.9C	
44	58.0A	70	66.2C	
44	60.7B	75	67.2C	
		83	69.1C	(Cont.)

## SOLUBILITY IN WATER--Cont.

Individual Results - System  $\text{NaH}_2\text{PO}_4 + \text{H}_2\text{O}$ --Cont.

I = ICE

A =  $\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$ B =  $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$ C =  $\text{NaH}_2\text{PO}_4$ 

(Imadsu, 1911-12)

(Shpunt, 1941)

(Wendrow and  
Kobe, 1952)

t°	sat. sol. wt. %	t°	sat. sol. wt. %	t°	sat. sol. wt. %	t°	sat. sol. wt. %	
0.1	36.7A	45	59.8B	-2.0	7.0I	0	35.9A	
5	39.0A	50	61.3B	-2.7	10.0I	25	48.0A	
10	41.2A	55	63.0B	-3.5	12.8I	40	56.8A	
15	44.0A	57	63.8B	-4.9	17.8I	60	62.4B	PO
20	46.0A	57.4	- BC	-6.3	22.0I	100	70.8C	
25	48.7A	60	64.2C	-7.5	25.6I			
30	51.6A	65	65.0C	-8.7	28.8I			
35	54.8A	69	65.6C	-9.9	32.4IA			(Schnellbach and Rosin, 1931)
40	58.1A	80	67.5C	+1.8	37.1A			
40.8	- AB	90	69.3C	4.4	38.1A			
41	58.8B	99.1	71.2C	9.9	40.6A	25	48.69A	
				15.6	43.2A			
				19.6	45.2A			Bugubaev, Imanakov and Zhakipov, 1954
				23.4	47.3A			
				25.7	48.7A			
				28.6	50.1A			
						-8.4	30.5IA	

SOLUBILITY OF MONO SODIUM PHOSPHATE IN AQUEOUS SOLUTIONS  
OF SODIUM SULFATE AT 25°  
(Apfel, 1911)

Mols. per 1000 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Solid Phase
$\text{PO}_4$	$\text{SO}_4$	$\text{NaH}_2\text{PO}_4$	$\text{Na}_2\text{SO}_4$	
4.05	0.0	48.6	0.0	$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$
3.92	0.11	47.0	1.56	"
3.82	0.26	45.8	3.69	"
3.58	0.45	43.0	6.39	"
3.28	0.71	39.2	10.1	"

Melting points in the system  $\text{NaH}_2\text{PO}_4 - \text{H}_3\text{PO}_4$  are given by Parravano and Mieli, 1908.



# Na SODIUM

## PO SODIUM ACID PHOSPHATE $\text{NaH}_2\text{PO}_4 \cdot \text{H}_3\text{PO}_4$

SOLUBILITY IN WATER  
(Parravano and Mieli, 1908)

t°	Gms. $\text{NaH}_2\text{PO}_4 \cdot \text{H}_3\text{PO}_4$ per 100 Gms.		Solid Phase	t°	Gms. $\text{NaH}_2\text{PO}_4 \cdot \text{H}_3\text{PO}_4$ per 100 Gms.		Solid Phase
	Sat.	Sol.			Sat.	Sol.	
- 5.7	20.77		Ice	79.7	87.48		$\text{NaH}_2\text{PO}_4$
- 7.9	26.92		"	85	88.65		"
- 11.4	34.15		"	101.7	91.47		" + $\text{NaH}_2\text{PO}_4 \cdot \text{H}_3\text{PO}_4$
- 38	56.66		"	104.5	92.67		$\text{NaH}_2\text{PO}_4 \cdot \text{H}_3\text{PO}_4$
- 34	80.46		$\text{NaH}_2\text{PO}_4$	110	95.79		"
41	81.82		"	119	97.99		"
51.7	83.68		"	126.5	100		"

SOLUBILITY OF  $\text{NaH}_2\text{PO}_4 \cdot \text{H}_3\text{PO}_4$  IN PHOSPHORIC ACID  
(Parravano and Mieli, 1908)

m. pt. of the  $\text{H}_3\text{PO}_4 = 40.6^\circ$

t°	Gms. $\text{NaH}_2\text{PO}_4 \cdot \text{H}_3\text{PO}_4$ per 100 Gms. Sat. Sol.	
98.5	52.72	
111	69.59	
119	77.55	
122	81.71	
123	87.20	

## PO TETRA SODIUM PYROPHOSPHATE $\text{Na}_4\text{P}_2\text{O}_7$

SOLUBILITY OF TETRA SODIUM PYROPHOSPHATE IN WATER  
(Menzel and Gäbler, 1929; Menzel and Sieg, 1932)

The older values of Mulder do not agree with these.

t°	Gms. $\text{Na}_4\text{P}_2\text{O}_7$ per 100 gms.		Solid Phase	t°	Gms. $\text{Na}_4\text{P}_2\text{O}_7$ per 100 gms.		Solid Phase
	sat.	sol.			sat.	sol.	
-0.43	2.132		$\text{ICE} + \text{Na}_4\text{P}_2\text{O}_7 \cdot 10\text{H}_2\text{O}$	60	19.75		$\text{Na}_4\text{P}_2\text{O}_7 \cdot 10\text{H}_2\text{O}$
0	2.236		$\text{Na}_4\text{P}_2\text{O}_7 \cdot 10\text{H}_2\text{O}$	70	27.49		"
18	5.147		"	76	33.04		"
20	5.220		"	79.5T	-		" + $\text{Na}_4\text{P}_2\text{O}_7$
25	6.618		"	82	35.13		$\text{Na}_4\text{P}_2\text{O}_7$
30	7.04		"	89	32.65		"
45	11.61		"	96	31.15		"
50	13.98		"				

T = transition point

SOLUBILITY OF TETRA SODIUM PYROPHOSPHATE IN AQUEOUS SOLUTIONS OF  
HYDROGEN PEROXIDE AT 0°  
(Henzel and Gäbler, 1920)

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
H <sub>2</sub> O <sub>2</sub>	Na <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	H <sub>2</sub> O <sub>2</sub>	Na <sub>4</sub> P <sub>2</sub> O <sub>7</sub>
0.5107	2.460	1.345	2.980
0.5795	2.506	2.082	3.475
0.9430	2.710	2.440	3.766

THE SYSTEM TETRA SODIUM PYROPHOSPHATE - DISODIUM PYROPHOSPHATE - WATER  
(Selva, 1935)

P0

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
Na <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	Na <sub>2</sub> H <sub>2</sub> P <sub>2</sub> O <sub>7</sub>	Solid Phase	Na <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	Na <sub>2</sub> H <sub>2</sub> P <sub>2</sub> O <sub>7</sub>	Solid Phase
Results at 20°			Results at 20°, Cont.		
5.25	0.00	Na <sub>4</sub> ·10	5.61	12.8	Na <sub>2</sub> ·6
7.18	3.01	"	0.0	10.70	"
9.43	6.80	"	Results at 30°		
11.66	10.31	"	7.35	0.0	Na <sub>4</sub> ·10
15.45	16.22 <sup>m</sup>	"	12.82	9.30	" + Na <sub>3</sub> ·1
12.55	11.58	" + Na <sub>3</sub> ·7	11.47	10.37	Na <sub>3</sub> ·1
11.90	12.67	Na <sub>3</sub> ·7	10.62	13.25	"
11.58	13.74	"	9.72	18.30	" + Na <sub>2</sub> H <sub>2</sub> P <sub>2</sub> O <sub>7</sub>
11.07	16.55	" + Na <sub>2</sub> ·6	0.0	14.50	Na <sub>2</sub> H <sub>2</sub> P <sub>2</sub> O <sub>7</sub>
8.26	14.51	Na <sub>2</sub> ·6			

m = Metastable

Na<sub>4</sub>·10 = Na<sub>4</sub>P<sub>2</sub>O<sub>7</sub>·10H<sub>2</sub>O; Na<sub>3</sub>·7 = Na<sub>3</sub>HP<sub>2</sub>O<sub>7</sub>·7H<sub>2</sub>O; Na<sub>2</sub>·6 = Na<sub>2</sub>H<sub>2</sub>P<sub>2</sub>O<sub>7</sub>·6H<sub>2</sub>O  
Na<sub>3</sub>·1 = Na<sub>2</sub>HP<sub>2</sub>O<sub>7</sub>·1H<sub>2</sub>O

Melting points are given for:

Na <sub>4</sub> P <sub>2</sub> O <sub>7</sub> + Na <sub>2</sub> WO <sub>4</sub>	(Sholokovich and Bergman, 1954)
Na <sub>4</sub> P <sub>2</sub> O <sub>7</sub> + K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	(Sholokovich and Bergman, 1954)
Na <sub>4</sub> P <sub>2</sub> O <sub>7</sub> + Na <sub>3</sub> P <sub>3</sub> O <sub>9</sub>	(Dymon and King, 1951)
Na <sub>4</sub> P <sub>2</sub> O <sub>7</sub> + NaPO <sub>3</sub>	(Morey and Ingerson, 1944)

# Na SODIUM

## PO TRISODIUM PYROPHOSPHATE $\text{Na}_3\text{HP}_2\text{O}_7$

### SOLUBILITY IN WATER (Hubbard, 1949)

The salt was prepared by adding NaOH to a suspension of  $\text{Na}_2\text{H}_2\text{P}_2\text{O}_7$  in water, and subsequent recrystallization. Solutions of the salt slowly hydrolyzed and the results are listed for solutions which stood between 24 and 48 hours, which corresponds to about 0.1% orthophosphate produced in the solution.

$t^\circ$	Gms. $\text{Na}_3\text{HP}_2\text{O}_7$ per 100 gms. Sat. Sol.	Solid	$t^\circ$	Gms. $\text{Na}_3\text{HP}_2\text{O}_7$ per 100 gms. Sat. Sol.	Solid
20.7	14.15	9	32.9	27.50	9
21.0	14.28	9	36.1	32.70	9
26.5	20.00	9	32.9	22.15	1
27.3	20.25	9	36.1	21.55	1
27.3	20.30	9	42.2	20.30	1
29.0	22.62	9	48.0	19.20	1
32.2	26.50	9	49.5	18.90	1

9 =  $\text{Na}_3\text{HP}_2\text{O}_7 \cdot 9\text{H}_2\text{O}$

1 =  $\text{Na}_3\text{HP}_2\text{O}_7 \cdot \text{H}_2\text{O}$

## PO DISODIUM PYROPHOSPHATE $\text{Na}_2\text{H}_2\text{P}_2\text{O}_7$

### SOLUBILITY IN WATER (Selva, 1935)

$t^\circ$	d. of sat. sol.	Gms. $\text{Na}_2\text{H}_2\text{P}_2\text{O}_7$ per 100 gms. sat. sol.	Solid Phase
-0.7	-	4.08	Ice + $\text{Na}_2\text{H}_2\text{P}_2\text{O}_7 \cdot 6\text{H}_2\text{O}$
0	-	4.28	$\text{Na}_2\text{H}_2\text{P}_2\text{O}_7 \cdot 6\text{H}_2\text{O}$
10	1.0509	6.50	"
20	1.0847	10.70	"
25	1.1040	13.00	"
30	1.1312	16.48	$\text{Na}_2\text{H}_2\text{P}_2\text{O}_7 \cdot 6\text{H}_2\text{O}^m$
27	1.1156	14.35	" + $\text{Na}_2\text{H}_2\text{P}_2\text{O}_7$
30	-	14.58	$\text{Na}_2\text{H}_2\text{P}_2\text{O}_7$
35	1.1171	15.04	"
40	1.1180	15.52	"

<sup>m</sup> Metastable

Data for the solubility of metal oxides in  $\text{Na}_4\text{P}_2\text{O}_7$  melts are given by Andreeva, 1958

SODIUM METAPHOSPHATE  $\text{NaPO}_3$ THE SYSTEM  $\text{NaPO}_3 - \text{H}_2\text{O}$   
(Morey, 1953)

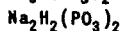
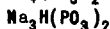
wt. fraction $\text{NaPO}_3$	liquidus temp.	solid phase	wt. fraction $\text{NaPO}_3$	liquidus temp.	solid phase
0.70	147	$\text{NaH}_2\text{PO}_4$	0.849 <sup>b</sup>	305	$\text{Na}_2\text{H}_2\text{P}_2\text{O}_7$
0.739 <sup>a</sup>	159	"	0.92	348	"
0.765	210	$\text{Na}_2\text{H}_2\text{P}_2\text{O}_7$	0.93	402	$\text{NaPO}_3$ II
0.78	235	"	0.96	517	$\text{NaPO}_3$ I
0.794	256	"			

<sup>a</sup>composition of  $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$ <sup>b</sup>composition of  $\text{NaH}_2\text{PO}_4$ SOLUBILITY OF  $\text{NaPO}_3$  IN STEAM  
(Morey, Boyd, England and Chen, 1955)

t°	gms $\text{NaPO}_3$ per 100 g sat sol.	t°	gms $\text{NaPO}_3$ per 100 gms sat sol
100	0.605	300	0.84
150	0.705	350	0.92
200	0.75	374	0.925
250	0.79		

Fusion-point data for mixtures of  $\text{NaPO}_3 + \text{Na}_4\text{P}_2\text{O}_7$  are given by Parravano and Calcagni (1908, 1910).

Data for the solubility of metal oxides in  $\text{NaPO}_3$  melts are given by Andreeva, 1958

SODIUM HYPOPHOSPHATES  $\text{Na}_n(\text{PO}_3)_2$ THE SYSTEM SODIUM OXIDE - PHOSPHORUS TETROXIDE - WATER AT 30°  
(Müller, 1916)

Saturation was secured by constant agitation in a thermostat. The author's determinations were plotted and the following results were read from the diagram.

The author was unable to identify the solid phases corresponding to the three branches of the solubility diagram of this system.

(Cont.)

## Na SODIUM

THE SYSTEM SODIUM OXIDE - PHOSPHORUS TETROXIDE - WATER AT 30°--Cont.

$\text{Na}_4 = \text{Na}_4(\text{PO}_3)_2 \cdot 10\text{H}_2\text{O}$			$\text{Na}_3 = \text{Na}_3\text{H}(\text{PO}_3)_2 \cdot 9\text{H}_2\text{O}$			$\text{Na}_2 = \text{Na}_2\text{H}_2(\text{PO}_3)_2 \cdot 6\text{H}_2\text{O}$		
Gms. per 100 gms. sat. sol.		Solid Phase	Gmg. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Na}_2\text{O}$	$\text{P}_2\text{O}_4$		$\text{Na}_2\text{O}$	$\text{P}_2\text{O}_4$		$\text{Na}_2\text{O}$	$\text{P}_2\text{O}_4$	
0.83	0.84	$\text{Na}_4$	0.75	1.53	$\text{Na}_2$	0.75	1.53	$\text{Na}_2$
1.00	1.12	y	1.0	1.75	x	0.80	1.85	
1.2	1.40	y	1.2	1.97	x	0.90	2.55	
1.4	1.67	y	1.4	2.20	x	1.00	3.16	
1.6	1.97	y	1.6	2.44	x	1.10	3.85	
1.8	3.28	y	1.8	2.65	x	1.20	4.50	
2.0	2.56	y	2.0	2.90	x	1.30	5.25	
2.2	2.85	y	2.2	3.15	x	1.40	5.90	
2.35	3.07	$\text{Na}_3$	2.35	3.38	$\text{Na}_3$	1.47	6.57	

### SOLUBILITY OF SODIUM HYPOPHOSPHATES, SEPARATELY, IN WATER (Miller, 1916)

Sodium Hypophosphate $\text{Na}_2\text{PO}_3 \cdot 5\text{H}_2\text{O}$		Sodium Hydrogen Hypophosphate $\text{Na}_3\text{H}(\text{PO}_3)_2 \cdot 9\text{H}_2\text{O}$		Sodium Dihydrogen Hypophosphate $\text{Na}_2\text{H}_2(\text{PO}_3)_2 \cdot 6\text{H}_2\text{O}$	
t°	Gms. $\text{Na}_2\text{PO}_3$ per 100 gms. sat. sol.	t°	Gms. $\text{Na}_3\text{H}(\text{PO}_3)_2$ per 100 gms. sat. sol.	t°	Gms. $\text{NaHPO}_3$ per 100 gms. sat. sol.
25.2	1.47	25	4.46	25	1.95
30	1.68	30.2	5.55	30	2.50
35	1.91	35.2	6.68	35	2.90
40.2	2.24	40	8.30	40	3.66
45	2.64	45	10.60	45	4.55
50	3.08	50	13.02	50	5.61
				B.pt.	16.7 <sup>a</sup>

<sup>a</sup>Salzer, 1877, in gms. hydrated salt.

## PO SODIUM HYPOPHOSPHITE $\text{NaH}_2\text{PO}_2$

### SOLUBILITY IN WATER (U.S.P.)

15° - 108 gms.  $\text{NaH}_2\text{PO}_2$  per 100 gms.  $\text{H}_2\text{O}$  (d. = 1.388)<sup>a</sup>  
 25° - 100 gms  $\text{NaH}_2\text{PO}_2 \cdot \text{H}_2\text{O}$  per 100 gms.  $\text{H}_2\text{O}$   
 b.pt. 830 gms  $\text{NaH}_2\text{PO}_2 \cdot \text{H}_2\text{O}$  per 100 gms.  $\text{H}_2\text{O}$

<sup>a</sup>Greenish and Smith, 1901

### SOLUBILITY IN GLYCOLS

At 25°, 33.01 gms.  $\text{NaH}_2\text{PO}_2$  dissolve in 100 gms. of ethylene glycol.

At 25°, 9.70 gms.  $\text{NaH}_2\text{PO}_2$  dissolve in 100 gms. of propylene glycol.  
 (Palit, 1947)

SODIUM PHOSPHITES  $\text{Na}_2\text{HPO}_3$   
 $\text{NaH}_2\text{PO}_3$ 

PO

SOLUBILITY OF  $\text{NaH}_2\text{PO}_3$  IN WATER  
(Amat, 1888)

t°	Gms. $\text{NaH}_2\text{PO}_3 \cdot 2\frac{1}{2}\text{H}_2\text{O}$ per 100 gms. $\text{H}_2\text{O}$	Solid Phase
0	56	$\text{NaH}_2\text{PO}_3 \cdot 2\frac{1}{2}\text{H}_2\text{O}$
10	66	"
42	193	"

SOLUBILITY OF  $\text{Na}_2\text{HPO}_3$  IN WATER  
(Rosenheim and Reglin, 1921)Solid phase  $\text{Na}_2\text{HPO}_4 \cdot 5\text{H}_2\text{O}^a$ 

t°	Gms. $\text{Na}_2\text{HPO}_4$ per 100 gms. sat. sol.	t°	Gms. $\text{Na}_2\text{HPO}_4$ per 100 gms. sat. sol.
0	80.72	30	84.96
20	81.06	38	91.94
25	82.21	43	92.70

<sup>a</sup>The authors report  $\text{Na}_2\text{HPO}_4 \cdot 5\frac{1}{2}\text{H}_2\text{O}$ SODIUM POLYPHOSPHATE  $\text{Na}_5\text{P}_3\text{O}_{10}$ 

PO

THE SYSTEM  $\text{Na}_5\text{P}_3\text{O}_{10} - \text{H}_2\text{O}$   
(Quimby, 1954)<sup>c</sup>Solutions of  $\text{Na}_5\text{P}_3\text{O}_{10}$  slowly hydrolyze to orthophosphate, and solubilities above about 50° are subject to error.

Solid Phase Ice		Solid Phase $\text{Na}_5\text{P}_3\text{O}_{10} \cdot 6\text{H}_2\text{O}$			
t°	Sat. Sol. wt. % $\text{Na}_5\text{P}_3\text{O}_{10}$	t°	Sat. Sol. wt. % $\text{Na}_5\text{P}_3\text{O}_{10}$	t°	Sat. Sol. wt. % $\text{Na}_5\text{P}_3\text{O}_{10}$
-0.45	3.03	0.0	13.98	31.2	13.36
-0.74	5.54	1.04	13.19	32.39	13.32
-0.93	7.36	14.70	13.00	33.95	13.30
-1.08	8.91	17.82	13.02	35.0	13.50
-1.11	9.44	20.10	12.92	40.0	13.65
-1.22	10.45	25.00	12.96	45.0	13.95
-1.33	12.13	30.9	13.28	50.07	14.34 <sup>b</sup>
-1.41 <sup>a</sup>	13.92			55	(14.8) <sup>b</sup>
				70	(16.5) <sup>b</sup>

<sup>a</sup>close to eutectic<sup>b</sup>approximate data<sup>c</sup>Data quoted from Jones,  
Cook and McCrone

The solubility of the polymer  $(\text{Na}_5\text{P}_3\text{O}_{10})_x$  where  $x$  is 2 or more, is 32.5 gms. per 100 gms. saturated solution at 25°. This is more than twice as soluble as the monomer. (King, 1947).

## Na SODIUM

### SODIUM METHYL PHOSPHATE (neutral) $\text{Na}_2\text{CH}_3\text{PO}_4 \cdot 6\text{H}_2\text{O}$

100 gms. sat. solution of neutral sodium methyl phosphate in water contain 30.79 gms. of the anhydrous salt at  $12^\circ.5$ . (Bailly, 1919.)

### SODIUM $\beta$ GLYCERO PHOSPHATE $\text{Na}_2\text{C}_3\text{H}_5(\text{OH})_2\text{PO}_4 \cdot 5\text{H}_2\text{O}$

100 gms. sat. solution of sodium  $\beta$  glycerophosphate in water contain 27.16 gms. of the anhydrous compound at  $17^\circ$ . (Bailly, 1916.)

100 gms.  $\text{H}_2\text{O}$  dissolve 27.38 gms. sodium glycerophosphate at  $18^\circ$ .  
(H. Rogier, These, Paris, 1912.)

100 gms. 86.5% Glycerol ( $d = 1.2326$ ) dissolve 79.7 gms. of sodium glycerophosphate (?hydrated) at  $20^\circ$ .

100 gms. 98.5% Glycerol ( $d = 1.2645$ ) dissolve 82.4 gms. of sodium glycerophosphate (?hydrated) at  $20^\circ$ . (Holm, 1921, 1922.)

The partition and distribution of various phosphate species between solutions of  $\text{Na}_2\text{O} \cdot \text{P}_2\text{O}_5$  glasses in water and added acetone was studied by Van Wazer and Holst, 1950.

## ReO SODIUM PERRHENATE $\text{NaReO}_4$

### SOLUBILITY IN WATER (Smith and Long, 1948)

t°	Gms. $\text{NaReO}_4$ per 100 gms $\text{H}_2\text{O}$
0	103.3
20(?)	25 (?) <sup>a</sup>
30	145.3
50.3	173.8

<sup>a</sup>) gms. per 100 cc sat. sol. (Noddak and Noddak, 1929)

### SOLUBILITY OF SODIUM PERRHENATE IN ETHYL ALCOHOL (Tollert, 1932.)

Solvent	t°	Gms. $\text{NaReO}_4$ per liter sat. sol.
89.7 Wt. % $\text{C}_2\text{H}_5\text{OH}$	19.5	22.42
99.1 " " "	18.0	11.14

Data for the distribution of  $\text{NaReO}_4$  between  $\text{H}_2\text{O}$  and nitromethane solutions at  $25^\circ$  are reported by Friedman and Hangen, 1954.

## SOLUBILITY IN WATER

The results of various authors are in only approximate agreement.

(Parravano and Fornaini, 1907)			(Saufourche and Liebaut, 1922)*		
t°	Gms. Na <sub>2</sub> S per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. Na <sub>2</sub> S per 100 Gms. Sat. Sol.	Solid Phase
-10°	9.34	Na <sub>2</sub> S·9H <sub>2</sub> O+Ice	- 2	2.0	Ice
+10	13.36	Na <sub>2</sub> S·9H <sub>2</sub> O	- 5	5.0	"
15	14.36	"	- 9.5°	7.5	" + Na <sub>2</sub> S·9H <sub>2</sub> O
18	15.30	"	0	8.8	Na <sub>2</sub> S·9H <sub>2</sub> O
22	16.20	"	10	10.8	"
28	17.73	"	20	13.6	"
32	19.09	"	30	17.0	"
37	20.98	"	40	21.0	"
45	24.19	"	50 <sup>t</sup>	28.0	Na <sub>2</sub> S·9H <sub>2</sub> O+Na <sub>2</sub> S·5½H <sub>2</sub> O
48.9 <sup>t</sup>	-	" + Na <sub>2</sub> S·5½H <sub>2</sub> O	70	32.5	Na <sub>2</sub> S·5½H <sub>2</sub> O
50	28.48	Na <sub>2</sub> S·5½H <sub>2</sub> O <sup>c</sup>	90	39.5	"
60	29.92	"	97.5 <sup>m</sup>	45.0	"
70	31.38	"	90	52.5	"
80	33.95	"	86°	54.5	" + Na <sub>2</sub> S·H <sub>2</sub> O
90	37.20	"	90	57.8	Na <sub>2</sub> S·H <sub>2</sub> O
48 <sup>t</sup>	-	Na <sub>2</sub> S·9H <sub>2</sub> O+Na <sub>2</sub> S·6H <sub>2</sub> O	95	60.1	"
50	26.7	Na <sub>2</sub> S·6H <sub>2</sub> O	(Konopik and Schutz, 1949)		
60	28.1	"	20	16.57	Na <sub>2</sub> S·9H <sub>2</sub> O
70	30.22	"		(d.=1.1682)	
80	32.95	"	30	19.80	Na <sub>2</sub> S·9H <sub>2</sub> O
90	36.42	"		(d.=1.1972)	
91.5 <sup>t</sup>	-	" + Na <sub>2</sub> S·5½H <sub>2</sub> O	40	23.25	Na <sub>2</sub> S·9H <sub>2</sub> O
*Read from a plot of the author's data				(d.=1.2287)	
<sup>e</sup> eutectic					
<sup>t</sup> transition point					
<sup>m</sup> melting point					
			(Konopik and Fiala, 1950)		
			20	16.48	Na <sub>2</sub> S·9H <sub>2</sub> O
			40	23.47	"

The system Na<sub>2</sub>S - H<sub>2</sub>S - H<sub>2</sub>O was studied at 25°, 50°, and 100° by Sagaidachni, Vasiliev, and Roskina, 1939.

THE SYSTEM SODIUM SULFIDE - SODIUM SULFATE - WATER  
(Hogg, 1926)

The attainment of equilibrium was effected by (1) cooling homogeneous solutions from higher temperatures and, when necessary, inoculating with the appropriate solid phase (systems at 0°.1 and 18°), (2) heating heterogeneous systems from lower temperatures (systems at 25° and 31°) (3) evaporating homogeneous solutions under reduced pressure at the temperature of the experiment (40°) until sufficient solid appeared. When all phases were present the tubes were mechanically rotated in a thermostat for from 4 to 40 hours. The saturated solutions and moist solid phases were analyzed. MC with formula, indicates mixed crystals and the major constituent.



# Na SODIUM

## THE SYSTEM SODIUM SULFIDE - SODIUM SULFATE - WATER--Cont.

Densities, refractive indices and vapor pressures are given by Mun, 1956

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	Na <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> S	
<u>Results at 0.1°</u>			
1.041	2.99	1.44	M.C.Na <sub>2</sub> SO <sub>4</sub> .10H <sub>2</sub> O
1.052	2.11	3.16	"
1.066	1.68	4.79	"
1.081	1.54	6.16	"
1.091	1.48	7.36	"
1.099	1.28	8.32	"
1.110	1.27	9.49	"
1.124	1.24	10.77	"
1.129	1.19	11.11	"
1.132	1.18	11.23	M.C.Na <sub>2</sub> SO <sub>4</sub> .10H <sub>2</sub> O + M.C.Na <sub>2</sub> S.10H <sub>2</sub> O
1.129	1.23	11.18	
1.129	1.16	11.16	" "
1.131	1.19	11.23	" "
1.130	1.25	11.14	" "
1.131	1.23	11.21	" "
1.137	1.16	11.94	M.C.Na <sub>2</sub> S.10H <sub>2</sub> O
-	0.93	11.22	"
1.125	0.63	11.34	"
1.122	0.0	11.33	"

<u>Results at 18°</u>			
1.126	13.31	0.62	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
1.126	11.91	1.51	"
1.131	10.67	2.84	"
1.130	9.30	4.54	"
1.132	9.05	5.33	"
1.143	8.09	6.82	"
1.149	7.64	7.99	"
1.162	7.15	9.47	"
1.165	9.96	7.09	"
1.167	7.17	10.04	"
1.175	6.96	10.91	"
1.186	6.93	12.14	"
1.208	7.01	13.08	"
1.225	9.75	13.15	"
1.210	7.24	13.95	" + M.C. $\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$
1.212	7.21	13.90	"
-	6.44	13.98	M.C. $\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$
1.212	5.83	14.02	"
1.197	5.20	14.50	"
1.187	3.47	15.08	"
-	2.28	15.33	"
-	0.53	15.65	"
1.169	-	15.95	$\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$

(Cont.)

## THE SYSTEM SODIUM SULFIDE - SODIUM SULFATE - WATER--Cont.

m d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	Na <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> S			Na <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> S	
Results at 25°				Results at 31°, Cont.			
-	19.71	1.63	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	1.214	4.79	18.69	Na <sub>2</sub> SO <sub>4</sub>
1.203	17.84	3.27	"	1.253	2.56	22.22	"
1.204	17.12	4.40	"	1.222	4.32	19.69	"Na <sub>2</sub> S·9H <sub>2</sub> O
1.241	14.67	9.96	"Na <sub>2</sub> SO <sub>4</sub>	1.229	4.04	19.33	" "
1.241	14.70	9.96	" "	-	3.04	19.57	Na <sub>2</sub> S·9H <sub>2</sub> O
1.241	14.51	10.04	Na <sub>2</sub> SO <sub>4</sub>	1.210	1.05	20.44	"
1.237	12.50	11.21	"	1.202	0.0	20.60	"
1.222	10.80	12.68	"				
1.228	8.06	14.68	"	Results at 40°			
1.221	6.32	16.07	"Na <sub>2</sub> S·9H <sub>2</sub> O	1.302	28.90	1.32	Na <sub>2</sub> SO <sub>4</sub>
1.224	6.87	15.87	" "	-	24.43	3.56	"
1.229	7.18	15.84	" "	1.260	20.25	6.18	"
1.205	5.01	16.61	Na <sub>2</sub> S·9H <sub>2</sub> O	-	15.23	9.49	"
1.202	3.40	17.17	"	1.236	14.14	9.78	"
1.183	0.0	17.86	"	1.223	8.72	14.25	"
Results at 31°				-	7.37	14.97	"
1.285	29.97	0.40	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	1.223	6.53	15.45	"
1.294	29.15	1.47	"	-	5.22	14.08	"
1.291	28.72	2.43	"	1.223	3.41	20.36	"
1.290	28.65	2.31	"Na <sub>2</sub> SO <sub>4</sub>	1.239	2.79	21.27	"
1.288	27.39	2.85	" "	1.223	1.91	23.04	"
1.264	23.06	4.81	Na <sub>2</sub> SO <sub>4</sub>	1.253	1.84	23.57	"
1.248	19.47	6.97	"	1.248	1.90	23.72	"Na <sub>2</sub> S·9H <sub>2</sub> O
-	18.92	7.47	"	1.256	1.62	24.25	" "
1.228	14.46	9.83	"	1.238	0.88	23.93	Na <sub>2</sub> S·9H <sub>2</sub> O
1.219	11.56	12.14	"	1.236	0.49	24.06	"
1.214	8.59	14.39	"	1.248	0.0	25.01	"
-	6.58	16.36	"	1.248	0.0	25.09	"

## Transition Points

d. of sat. sol.	Gms. per 100 gms. sat. sol.		
	Na <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> S	Solid Phase
1.128	-	12.46 (4.7°)	Na <sub>2</sub> S.10H <sub>2</sub> O = Na <sub>2</sub> S.9H <sub>2</sub> O
1.135	1.40	11.49 (2.3°)	The above in sat. Na <sub>2</sub> SO <sub>4</sub>
-	9.48	13.41 (20.9°)	Na <sub>2</sub> SO <sub>4</sub> .10H <sub>2</sub> O = Na <sub>2</sub> SO <sub>4</sub> in sat. Na <sub>2</sub> S
1.331	4.48	19.97 -	(?)

**Na SODIUM**

THE SYSTEM SODIUM SULFIDE - SODIUM SULFATE - WATER--Cont.

### Results of Beremizhanov, 1956 at high temperatures

wt. % of each salt.

	90°		100°		110°		130°		140°	
	Na <sub>2</sub> S	Na <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> S	Na <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> S	Na <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> S	Na <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> S	Na <sub>2</sub> SO <sub>4</sub>
	-	30.40	-	30.10	-	29.60	-	29.10	-	29.30
	7.80	14.80	8.30	13.30	11.54	10.65	13.40	7.30	15.10	5.75
	12.35	10.17	15.50	9.60	19.10	6.80	24.70	3.50	26.00	2.63
	17.40	7.79	21.11	6.20	27.90	3.91	37.10	2.00	40.30	1.78
	21.96	3.90	31.30	2.50	31.71	2.52	40.54	1.41	43.40	0.70
\$	29.51	2.17	33.61	1.81	35.90	2.33	44.80	1.20	45.20	0.56
	33.47	1.84	35.33	1.60	36.61	1.19	45.70	1.05	46.11	0.35
	35.20	1.45	36.47	0.89	39.10	1.09	46.00	0.50	46.80	0.29
	35.80	0.81 <sup>a</sup>	37.80	0.65 <sup>a</sup>	39.50	0.97	46.90	0.27 <sup>a</sup>	47.20	0.20 <sup>a</sup>
	36.30	-	38.45	-	39.90	0.50 <sup>a</sup>	47.15	-	48.37	-
					40.39					

<sup>a</sup>invariant point

THE SYSTEM  $\text{Na}_2\text{S} - \text{Sb}_2\text{S}_3 - \text{H}_2\text{O}$   
(Konopik and Fiala, 1950)

S.S. = solid solution of  $\text{NaSbS}_2$  in  $\text{Na}_2\text{Sb}_4\text{S}_7 \cdot 2\text{H}_2\text{O}$

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
Na <sub>2</sub> S	Sb <sub>2</sub> S <sub>3</sub>	Solid Phase	Na <sub>2</sub> S	Sb <sub>2</sub> S <sub>3</sub>	Solid Phase
<u>Results at 20°</u>			<u>Results at 20°--Cont.</u>		
16.48	0.0	Na <sub>2</sub> S·9H <sub>2</sub> O	17.10	30.94	S.S.
17.52	4.65	"	16.73	30.58	"
18.46	9.68	"	16.80	29.90	"
19.27	13.83	"	16.66	29.94	"
20.47	19.52	"	15.22	28.40	"
21.63	24.00	"	14.53	27.31	"
22.15	25.60	"	12.09	23.69	Na <sub>2</sub> Sb <sub>4</sub> S <sub>7</sub> ·2H <sub>2</sub> O
22.98	28.00	"	9.35	18.25	"
23.42	28.52	" + Na <sub>3</sub> SbS <sub>2</sub> ·8H <sub>2</sub> O	6.64	12.63	"
23.40	28.22	Na <sub>2</sub> SbS <sub>2</sub> ·8H <sub>2</sub> O	5.62	10.40	"
23.42	28.52	"	2.545	4.560	"
22.43	30.92	"	0.331	0.287	" + Sb <sub>2</sub> S <sub>3</sub>
22.17	31.85	"	0.283	0.278	" + "
22.15	32.45	" + NaSbS <sub>2</sub>	0.138	0.138	Sb <sub>2</sub> S <sub>3</sub>
21.75	32.28	NaSbS <sub>2</sub>	0.038	0.019	
21.54	32.43	"			
20.58	31.72	"			
20.32	32.00	"			
19.98	31.75	"	23.47	0.0	Na <sub>2</sub> S·9H <sub>2</sub> O
19.00	31.70	"	23.88	4.76	"
18.66	31.59	+ S.S.	24.40	11.46	"
17.47	30.72	S.S.	25.06	18.01	"
17.23	30.92	"			

SOLUBILITY OF SODIUM SULFIDE IN LIQUID AMMONIA  
CONTAINING INCREASING AMOUNTS OF AMMONIUM BROMIDE AT  $-33^{\circ}$   
(Johnson and Wheatley, 1934)

Gm. Mols. per liter sat. sol.

$\text{NH}_4\text{Br}$	$\text{Na}_2\text{S}$
0.0	0.002
0.15	0.036
0.3	0.06
0.6	0.18

This increase in solubility of  $\text{Na}_2\text{S}$  is considered to be due to the formation of ammonium sulfide.

S

Melting point data are given for:

$\text{Na}_2\text{S} + \text{S}$	(Friedrich, 1914; Thomas and Rule, 1917; Pearson and Robinson, 1930)
$\text{Na}_2\text{S} + \text{Na}_2\text{SO}_4$	(Tammann and Olsen, 1930; Kohlmeier and Lohrke, 1955)
$\text{Na}_2\text{S} + \text{Na}_2\text{O}$	(Kohlmeier and Lohrke, 1955)

**ROMGALITE  $\text{NaHSO}_2 \cdot \text{CH}_2\text{O} \cdot 2\text{H}_2\text{O}$**

SOLUBILITY IN WATER  
(Kunin and Vlasjuk, 1951)

$t^{\circ}$	Gms. $\text{NaHSO}_2 \cdot \text{CH}_2\text{O} \cdot 2\text{H}_2\text{O}$ per 100 gms. sat. sol.	$t^{\circ}$	Gms. $\text{NaHSO}_2 \cdot \text{CH}_2\text{O} \cdot 2\text{H}_2\text{O}$ per 100 gms. sat. sol.
0	39	30	54
5	41	40	61
10	44	50	70
20	49		

The authors give results for the system  $\text{NaHSO}_2 \cdot \text{CH}_2\text{O} \cdot 2\text{H}_2\text{O} - \text{NaHSO}_2 \cdot \text{CH}_2\text{O} \cdot \text{H}_2\text{O} - \text{H}_2\text{O}$  at  $10^{\circ}$ ,  $20^{\circ}$  and  $40^{\circ}$ .

**SODIUM SULFITE  $\text{Na}_2\text{SO}_3$**

S0

THE SYSTEM  $\text{Na}_2\text{SO}_3 - \text{H}_2\text{O}$

The data for solutions in equilibrium with ice and with  $\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$  are all in good agreement. Above the transition point  $\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O} \rightleftharpoons \text{Na}_2\text{SO}_3$ , the results of Hartley and Barrett, 1909, are in error; those of Lewis and David, 1924, and of Kobe and Hellwig, 1955, agree; those of Foerster, Brosch and Norberg-Shulz, 1924, are somewhat higher.

## Na SODIUM

THE SYSTEM  $\text{Na}_2\text{SO}_3 - \text{H}_2\text{O}$ —Cont.

t°	Gms. $\text{Na}_2\text{SO}_3$ per 100 gms. $\text{H}_2\text{O}$			t°	Gms. $\text{Na}_2\text{SO}_3$ per 100 gms. $\text{H}_2\text{O}$		
	Kobe and Hellwig	Foerster et al.	Hartley and Barrett		Kobe and Hellwig	Foerster et al.	Lewis and David
Solid Phase = Ice				Solid Phase = $\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O} + \text{Na}_2\text{SO}_3$			
-0.667	-	1.898	-	32.95 <sup>c</sup>	38.0	-	-
-0.76	-	-	2.15	Solid Phase = $\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$			
-1.27	-	3.88	-				
-1.37	-	-	4.21				
-1.96	-	-	6.24	33.8 <sup>b</sup>	-	40.00	-
-2.23	-	7.17	-	34.7 <sup>b</sup>	-	40.50	-
-2.77	-	-	9.44	35.9 <sup>b</sup>	-	42.6	-
Solid Phase = Ice + $\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$				Solid Phase = $\text{Na}_2\text{SO}_3$			
-3.45 <sup>a</sup>	-	11.70	-	32.0	-	-	36.1 (H)
-3.5 <sup>a</sup>	-	-	12.48	33.00	-	-	36.6
Solid Phase = Ice				33.82	37.5	-	-
				34.5	-	39.2	-
				35.0	-	-	36.2 (R)
-4.5 <sup>b</sup>	-	-	17.91	35.6	-	38.5	-
Solid Phase = $\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$				37.5	-	-	35.7
				40.00	35.7	-	-
-1.9	-	-	13.09	41.0	-	37.3	-
-1.30	-	12.70	-	42.5	-	-	34.6
0.0	13.3	14.4	-	46.0	-	35.8	-
0.15	-	-	14.0 (H)	47.5	-	-	33.8
2.0	-	-	14.82	50.0	-	34.7	-
5.9	-	-	17.61	52.5	-	-	32.8
9.2	-	18.50	-	57.5	-	-	31.8
10.6	-	-	20.01	58.1	-	32.9	-
16.5	-	23.70	-	60.0	31.7	-	-
18.2	-	-	25.31	62.5	-	-	30.9
19.9	-	26.36	-	66.0	-	31.7	-
20.0	-	-	27.1 (H)	67.5	-	-	30.2
23.5 <sup>b</sup>	-	-	29.92	70.0	-	31.3	-
24.0	-	29.40	-	80.0	28.0	-	-
25.0	30.7	30.9 (H)	29.9 (R)	94.4	-	27.3	-
26.85	-	32.10	-	97.0	-	27.1	-
28.2	-	34.00	-	99.0	-	27.7	-
29.00 <sup>b</sup>	-	-	34.99	100.0	26.3	-	-
29.30	34.9	-	-	saccharohydrate point			
33.00	-	38.80	-	metastable region			
37.2 <sup>b</sup>	-	-	44.08	incongruent melting point			
21.6 <sup>c</sup>	-	-	28.1	(L) Lewis and David, 1924			
31.5 <sup>c</sup>	-	-	37.3 (L)	(R) Arai, 1932			
33.4 <sup>c</sup>	-	39.1	-	(H) Hammick and Currie, 1925			

THE SYSTEM  $\text{Na}_2\text{SO}_3 - \text{NaOH} - \text{H}_2\text{O}$   
(Hammick and Currie, 1925)

The mixtures were constantly stirred for 24 to 48 hours. Silver vessels were used for the stronger sodium hydroxide solutions. Both the saturated solutions and the solid phases were analyzed. The temperatures were constant to within  $0.1^\circ$ . The results are probably accurate to  $\pm 0.5$  per cent.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
NaOH	$\text{Na}_2\text{SO}_3$	Solid Phase	NaOH	$\text{Na}_2\text{SO}_3$	Solid Phase
<u>Results at <math>0.15^\circ</math></u>			<u>Results at <math>25^\circ</math></u>		
29.5	0.0	$\text{NaOH} \cdot 4\text{H}_2\text{O}$	53.3	0.0	$\text{NaOH} \cdot \text{H}_2\text{O}$
29.1	0.1	" $+\text{Na}_2\text{SO}_3$	43.9	trace	$\text{Na}_2\text{SO}_3$
27.9	0.1	$\text{Na}_2\text{SO}_3$	42.7	0.1	"
27.1	0.4	"	29.4	0.3	"
26.6	0.7	"	28.7	0.5	"
25.4	1.3	"	25.2	1.0	"
23.3	2.2	" $+\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$	20.7	2.5	"
21.9	2.21	$\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$	20.7	2.9	"
16.9	2.8	"	17.2	5.8	"
9.0	5.2	"	14.2	8.2	"
3.0	9.0	"	12.6	10.1	"
0.0	12.3	"	12.2	10.2	"
<u>Results at <math>20^\circ</math></u>			9.6	13.8	" $+\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$
52.2	0.0	$\text{NaOH} \cdot \text{H}_2\text{O}$	9.8	13.2	"
50.1	trace	$\text{Na}_2\text{SO}_3$	9.7	13.0	$\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$
36.3	0.1	"	5.0	17.7	"
26.8	1.0	"	2.5	19.3	"
24.9	1.1	"	0.7	22.5	"
20.2	3.5	"	0.0	23.6	"
16.0	6.7	"	<u>Results at <math>32^\circ</math></u>		
15.5	7.0	"	54.4	0.0	$\text{NaOH} \cdot \text{H}_2\text{O}$
13.8	8.6	" $+\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$	51.8	0.001	$\text{Na}_2\text{SO}_3$
14.0	9.0	"	36.2	0.1	"
13.4	9.2	$\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$	27.2	0.6	"
12.7	9.4	"	20.1	2.9	"
12.2	9.6	"	16.5	5.4	"
11.6	9.9	"	11.1	11.2	"
9.9	11.0	"	7.6	15.7	"
8.3	12.0	"	5.1	19.1	"
4.4	15.4	"	2.3	23.1	"
1.6	18.7	"	0.6	26.4	"
0.0	21.3	"	0.0	26.5	"

SO

THE SYSTEM SODIUM SULFITE - SODIUM SULFATE - WATER  
(Rivett and Lewis, 1923)

Constant agitation was employed for assuring saturation. The solutions and solid phases were analyzed and the compositions of the latter identified by the "rest method." At  $25^\circ$  both a stable and a metastable system exists, and each was determined. The solid phases in contact

# Na SODIUM

## THE SYSTEM SODIUM SULFITE - SODIUM SULFATE - WATER--Cont.

with the solutions corresponding to the two branches of the stable system were respectively a series of mixed crystals of  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O} + \text{Na}_2\text{SO}_3 \cdot 10\text{H}_2\text{O}$  and  $\text{Na}_2\text{SO}_4 \cdot 7\text{H}_2\text{O} + \text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$ . The solid phases for the two branches of the metastable system were mixed crystals of anhydrous sulfite and sulfate.

Results at 25° for the Stable System			Results at 25° for the Metastable System		
So	$d_{25}^4$ of sat. sol.	Gms. per 100 gms. sat. sol.	$d_{25}^4$ of sat. sol.	$d_{25}^4$ of sat. sol.	Gms. per 100 gms. sat. sol.
		$\text{Na}_2\text{SO}_4$ $\text{Na}_2\text{SO}_3$			$\text{Na}_2\text{SO}_4$ $\text{Na}_2\text{SO}_3$
	1.211	20.40    2.53	1.347	20.51	14.39
	1.227	19.66    4.11	1.347	19.12	15.43
	1.239	18.11    6.59	1.347	17.82	16.94
	1.258	17.31    9.22	1.347	16.32	18.34
	1.269	16.43    11.39	-	16.18	18.52
	1.292	15.25    14.61	1.346	13.82	20.35
	1.311	14.55    16.80	-	12.34	21.88
	1.312	14.49    16.81	1.346	10.93	23.40
	-	11.05    18.27	1.340	7.47	26.32
	1.274	8.97    19.44	1.322	6.75	25.45
	1.250	4.14    21.61	1.302	3.99	26.57
	-	0.00    23.75	1.285	1.69	27.29

The authors also determined the isotherms for 0.1°, 17.5° and 37.5°. At the latter temperature the solid phases were mixed crystals of the anhydrous salts. In subsequent papers by Lewis and David, 1924, data are given for many other isotherms.

A complete examination of the whole ternary system, at temperatures where only the anhydrous solids appeared, was made. The results showed that these two salts are capable of mixing in quite a number of distinct series of mixed crystals of varying stabilities. More than 80 solutions were prepared at 40°, 45° and 60° by more or less complicated methods, involving evaporation of unsaturated solutions of suitable concentrations to yield the solid phases in desired quantity at the temperature of the experiment. The analytical results, when plotted, show that there are no fewer than five solution curves and five corresponding series of mixed crystals. The precise limits of these are uncertain "but the error is not sufficient to affect the general conclusions."

## THE SYSTEM SODIUM SULFITE - SODIUM PYROSULFITE - WATER (Arii, 1927)

Results at 25°			Results at 35°		
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Na}_2\text{SO}_3$	$\text{Na}_2\text{S}_2\text{O}_5$		$\text{Na}_2\text{SO}_3$	$\text{Na}_2\text{S}_2\text{O}_5$	
23.05	0.0	$\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$	26.57	0.0	$\text{Na}_2\text{SO}_3$
20.98	3.66	"	25.00	2.13	"

(Cont.)

## THE SYSTEM SODIUM SULFITE - SODIUM PYROSULFITE - WATER--Cont.

## Results at 25°--Cont.

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Na}_2\text{SO}_3$	$\text{Na}_2\text{S}_2\text{O}_5$	
17.70	10.39	$\text{Na}_2\text{SO}_3 \cdot 7\text{H}_2\text{O}$
17.01	12.49	"
15.67	16.70	"
15.06	18.65	"
13.89	21.91	"
11.83	26.73	"
11.28	29.10	" + $\text{Na}_2\text{S}_2\text{O}_5$
10.87	29.45	$\text{Na}_2\text{S}_2\text{O}_5$
9.63	30.70	"
8.33	31.77	"
7.22	32.70	"
4.46	35.34	"
1.78	37.93	"
0.0	39.75	"

## Results at 35°--Cont.

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Na}_2\text{SO}_3$	$\text{Na}_2\text{S}_2\text{O}_5$	
24.17	3.27	$\text{Na}_2\text{SO}_3$
21.04	8.00	"
19.22	11.54	"
16.60	16.33	"
14.80	20.40	"
11.86	25.80	"
8.86	30.84	"
6.77	43.03	"
5.99	34.91	" + $\text{Na}_2\text{S}_2\text{O}_5$
4.12	36.48	$\text{Na}_2\text{S}_2\text{O}_5$
3.11	37.42	"
1.74	38.69	"
0.0	40.55	"

SOLUBILITY OF SODIUM SULFITE IN AMMONIUM SULFITE SOLUTIONS  
(Silberman and Ivanov, 1941)

## Results at 60°

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Na}_2\text{SO}_3$	$(\text{NH}_4)_2\text{SO}_3$	
12.20	38.11	$\text{Na}_2\text{SO}_3$
11.06	41.94	"
8.35	45.08	$\text{Na}_2\text{SO}_4 + (\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O}$

## Results at 85°

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Na}_2\text{SO}_3$	$(\text{NH}_4)_2\text{SO}_3$	
5.52	47.16	$\text{Na}_2\text{SO}_3$
5.25	49.40	"
5.51	54.67	$\text{Na}_2\text{SO}_3 + (\text{NH}_4)_2\text{SO}_3$

100 gms. liquid Sulfur Dioxide ( $\text{SO}_2$ ) dissolve 0.023 gm.  $\text{Na}_2\text{SO}_3$  at 0°. (Jander and Ruppolt, 1937)

SODIUM SULFATE  $\text{Na}_2\text{SO}_4$ 

SO

## THE SYSTEM SODIUM SULFATE - WATER

The values were read from a plot of the very carefully determined values of Berkeley (1904) and Richards and Yugve (1918), whose original data are given in the tables following. Between 100° and 200° the results of White (1913-14) and of Schroeder, Gabriel and Cartridge (1935) agree and the average curve of these workers is given. Above 200° the results of these authors and of Booth and Bidwell (1950) and Beurath (1941), are given for comparison.

A large number of other determinations (below 100°) are in substantial agreement with those listed below. Early workers reported somewhat higher solubilities just above the transition point (32.38°), probably



# Na SODIUM

## THE SYSTEM SODIUM SULFATE - WATER--Cont.

due to supersaturation. For other data see Nishizawa (1920), Mulder, Lowel (1851), Tilden and Shenstone (1883), Etard (1894), Funk (1900a), Küpper (1927), Benrath, et al. (1928), Flöttmann (1928), Caven and Johnson (1928); Schröder (1929), Matsin, Oguri, Noda and Kumagi (1929), Makarow and Wachberg (1930), Rakowski and Nikitina (1931), Belopolski (1933), Keevil, 1942.

The values for wholly metastable  $\text{Na}_2\text{SO}_4 \cdot 7\text{H}_2\text{O}$  are by Eddy and Menzies (1940). Considerable additional data are given by Hartley, Jones and Hutchinson (1908) and other early workers.

30 Data for the effect of various salts upon the transition temperature of  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$  are given by Norton and Johnston, 1926.

t°	Gms. $\text{Na}_2\text{SO}_4$ per 100 gms. $\text{H}_2\text{O}$	t°	Gms. $\text{Na}_2\text{SO}_4$ per 100 gms. $\text{H}_2\text{O}$	t°	Gms. $\text{Na}_2\text{SO}_4$ per 100 gms. $\text{H}_2\text{O}$
Solid Phase $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$		Solid Phase $\text{Na}_2\text{SO}_4$ (rhombic)		Solid Phase $\text{Na}_2\text{SO}_4$ (monoclinic)	
0	4.5	35	49.1	250	44.0(41.8) <sup>e</sup>
5	6.2	40	48.1	260	41.8
10	9.0	45	47.2	262	(39.2) <sup>b</sup>
15	13.2	50	46.4	270	38.8
20	19.0	60	45.2	275	(33) <sup>f</sup>
25	28.0	70	44.2	279	(33.8) <sup>e</sup>
27.5	33.6	75	43.6	280	35.2
30	41.2	80	43.2	289	(25) <sup>b</sup>
32	48.0	90	42.6	290	30.8
32.4 <sup>a</sup>	49.7	100	42.2	299	(18) <sup>b</sup>
		101.9 <sup>d</sup>	42.2	300	24.8
Solid Phase $\text{Na}_2\text{SO}_4 \cdot 7\text{H}_2\text{O}^*$		110	42.0	308	(11) <sup>f</sup>
		120	41.8	310	18.5
0	17.8	130	41.9	319	(20.7) <sup>e</sup> (5) <sup>f</sup>
5	23.3	140	42.0	320	13.1
10	29.9	150	42.2	330	7.3
15	37.2	160	42.5	340	4.2
20	45.2	170	43.0	350	2.4
23.7 <sup>b</sup>	52.4	180	43.4	354	(1.65) <sup>g</sup>
		190	43.8	360	(0.900) <sup>g</sup>
		200	44.1	382	(0.377) <sup>g</sup>
		210	44.2		
		220	44.8		
		230	45.6		
		241 <sup>c</sup>	46.8(44.9) <sup>e</sup>		

\*metastable

<sup>a</sup>transition temperature, solid phase  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O} + \text{Na}_2\text{SO}_4$  (rhombic)

<sup>b</sup>transition temperature, solid phase  $\text{Na}_2\text{SO}_4 \cdot 7\text{H}_2\text{O}$  (metastable) +  $\text{Na}_2\text{SO}_4$  (rhombic)

<sup>c</sup>transition temperature, solid phase  $\text{Na}_2\text{SO}_4$  (rhombic) +  $\text{Na}_2\text{SO}_4$  (monoclinic). White, 1913-14 reports the transition to occur at 235°.

<sup>d</sup>boiling point

<sup>e</sup>White, 1913-14

<sup>f</sup>Benrath, 1941

<sup>g</sup>Booth and Bidwell, 1950

(Cont.)

## THE SYSTEM SODIUM SULFATE - WATER--Cont. .

Original, carefully determined values of Berkeley, 1904.

t°	d <sub>t</sub> Sat.Sol.	Gms. Na <sub>2</sub> SO <sub>4</sub> per 100 gms. H <sub>2</sub> O	Solid Phase
0.70	1.0432	4.71	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
10.25	1.0802	9.21	"
15.65	1.1150	14.07	"
20.35	1.1546	-	"
24.90	1.2067	27.67	"
27.65	1.2459	34.05	"
30.20	1.2894	41.78	"
31.95	1.3230	47.98	"
32.5 tr.pt.	-	-	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O+Na <sub>2</sub> SO <sub>4</sub>
33.5	1.3307	49.39	Na <sub>2</sub> SO <sub>4</sub>
38.15	1.3229	48.47	"
44.85	1.3136	47.49	"
60.10	1.2918	45.22	"
75.05	1.2728	43.59	"
89.85	1.2571	42.67	"
101.9*	1.2450	42.18	"

\*B. pt.

Solubility of Richards and Yuge, 1918, made with great care:

t°	Gms. Na <sub>2</sub> SO <sub>4</sub> per 100 gms. H <sub>2</sub> O	t°	Gms. Na <sub>2</sub> SO <sub>4</sub> per 100 gms. H <sub>2</sub> O	t°	Gms. Na <sub>2</sub> SO <sub>4</sub> per 100 gms. H <sub>2</sub> O
15.000	13.181	19.000	17.698	23.000	23.888
16.000	14.185	20.000	19.064	24.000	25.762
17.000	15.268	21.000	20.549	25.000	27.795
18.000	16.437	22.000	22.155		

## SOLUBILITY OF SODIUM SULFATE IN STEAM

(Styrikovich, Khaibullin and Tskhviraashvili, 1955)

Additional data at 110 atm. are reported by Aleinikov, Kostrikin, Novi and Taratuta, 1956.

[mg. Na<sub>2</sub>SO<sub>4</sub> per kg. steam]

t°	30 atm.	100 atm.	140 atm.	180 atm.	200 atm.	220- <sup>a</sup> 300 atm.
325	-	0.015	-	-	-	-
350	-	0.01	0.02	-	-	-
370	0.02	0.015	0.01	0.08	-	-
380	-	0.02	0.02	0.04	0.14	-
400	-	-	0.03	0.03	0.08	-
430	0.04	0.04	0.04	0.04	0.05	-
450	0.05	0.05	0.05	0.05	0.06	-
460	-	-	-	-	-	0.02
500	0.08	0.09	0.09	0.08	-	-
550	0.14	0.14	-	0.13	-	-

<sup>a</sup>Styrikovich and Khokhlov, 1957

# Na SODIUM

At 200 atm., Spillner, 1940 reports 1 mg.  $\text{Na}_2\text{SO}_4$  solubility in saturated steam; at 220 atm., 3 mg.

## SOLUBILITY OF SODIUM SULFATE IN DEUTERIUM OXIDE (Eddy and Menzies, 1940)

	t°	Gms. $\text{Na}_2\text{SO}_4$ per 100 gms. $\text{D}_2\text{O}$	Solid Phase
	0	12.7	$\text{Na}_2\text{SO}_4 \cdot 7\text{D}_2\text{O}$ (m)
	5	17.4	" (m)
	10	22.6	" (m)
	15	28.6	" (m)
	20	35.2	" (m)
	25	42.9	" (m)
	26.7	46.0	$\text{Na}_2\text{SO}_4 \cdot 7\text{D}_2\text{O}$ (m) + $\text{Na}_2\text{SO}_4$
	0	3.41	$\text{Na}_2\text{SO}_4 \cdot 10\text{D}_2\text{O}$
	5	4.47	"
	10	6.53	"
	15	9.83	"
	20	14.3	"
	25	21.1	"
	30	30.9	"
	34.2	44.0	$\text{Na}_2\text{SO}_4 \cdot 10\text{D}_2\text{O}$ + $\text{Na}_2\text{SO}_4$
	25	46.7	$\text{Na}_2\text{SO}_4$ (m)
	40	42.9	"
	60	39.8	"
	80	38.0	"
	100	37.3	"
	120	37.0	"
	140	37.3	"
	160	37.4	"
	180	37.7	"

(m) = Metastable

## THE SYSTEM $\text{Na}_2\text{SO}_4 - \text{H}_2\text{O}_2 - \text{H}_2\text{O}$ (Ozerova and Khomyako, 1955) (Pani and Terrey, 1955)

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
Na <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> O <sub>2</sub>		Na <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> O <sub>2</sub>	
<u>Results at - 10° (O. and K.)</u>			<u>Results at 0° (O. and K.)</u>		
16.30	30.42	Na <sub>2</sub> SO <sub>4</sub> ·7H <sub>2</sub> O	25.15	55.66	Na <sub>2</sub> SO <sub>4</sub>
13.46	27.54	"	24.75	52.73	"
13.00	24.10	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	23.00	30.41	"
9.10	22.79	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	20.61	24.18	"
8.30	21.20	"	19.68	22.72	" + Na <sub>2</sub> SO <sub>4</sub> ·7H <sub>2</sub> O
7.08	18.50	"	15.60	21.20	" + "
5.60	14.90	"	14.51	20.70	" + "
3.56	13.00	"	13.03	18.51	" + "
			12.62	17.41	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O + "
			9.86	15.44	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
			5.56	4.98	"

THE SYSTEM  $\text{Na}_2\text{SO}_4 - \text{H}_2\text{O}_2 - \text{H}_2\text{O}$ --Cont.

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
Na <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> O <sub>2</sub>		Na <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> O <sub>2</sub>	

Results at 20°

(O. and K.)			(P. and T.)		
27.00	56.22	Na <sub>2</sub> SO <sub>4</sub> ·0.5H <sub>2</sub> O <sub>2</sub>	[P. and T. give excellent tie-line data indicating that the formulas of the compounds are as indicated.]		
25.90	47.80	"			
24.60	39.39	"			
23.78	31.00	"			
27.00	19.40	"	24.62	60.8	Na <sub>2</sub> SO <sub>4</sub> ·H <sub>2</sub> O <sub>2</sub>
27.90	15.60	"	25.01	59.9	"
28.00	14.73	"	26.36	56.0	Na <sub>2</sub> SO <sub>4</sub> ·0.5H <sub>2</sub> O <sub>2</sub> ·H <sub>2</sub> O
29.78	12.44	"	26.63	53.6	"
30.00	12.05	" + Na <sub>2</sub> SO <sub>4</sub>	26.64	52.6	"
25.50	11.20	Na <sub>2</sub> SO <sub>4</sub> (?)	25.95	52.4	"
21.09	6.77	"	25.19	49.08	"
19.84	4.10	"	24.23	44.99	"
			23.93	40.10	"
			23.89	35.51	"
			24.40	30.09	"
			25.13	25.45	"
			26.17	20.88	"
			28.51	13.38	"
			28.89	12.07	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
			25.95	10.78	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
			21.61	7.32	"
			19.21	4.82	"
			15.75	0.0	"

SO

Results at 35° (P. and T.)

26.28	61.8	$\text{Na}_2\text{SO}_4 \cdot \text{H}_2\text{O}_2$	25.04	39.87	$\text{Na}_2\text{SO}_4 \cdot \text{H}_2\text{O} \cdot 1/2\text{H}_2\text{O}_2$
26.35	60.7	"	25.61	33.25	"
26.71	58.8	"	26.07	27.29	"
26.08	56.3	"	26.65	23.89	"
27.36	54.3	"	27.54	21.76	"
26.07	47.56	"	27.99	19.52	"
27.65	50.7	$\text{Na}_2\text{SO}_4 \cdot \text{H}_2\text{O} \cdot 1/2\text{H}_2\text{O}_2$	29.43	18.11	$\text{Na}_2\text{SO}_4$
26.22	48.75	"	30.54	12.77	"
25.84	47.92	"	31.54	7.54	"
25.65	46.76	"	33.06	0.0	"
25.43	44.77	"			

SOLUBILITY OF SODIUM SULFATE IN PURE HYDROGEN PEROXIDE  
(Maass and Hatcher, 1922)

The temperatures were determined at which the last trace of solid disappeared from mixtures of accurately weighed amounts of the two compounds.

(Cont.)

# Na SODIUM

## SOLUBILITY OF SODIUM SULFATE IN PURE HYDROGEN PEROXIDE--Cont.

t°	Gms. Na <sub>2</sub> SO <sub>4</sub> per 100 gms. mixture	t°	Gms. Na <sub>2</sub> SO <sub>4</sub> per 100 gms. mixture	t°	Gms. Na <sub>2</sub> SO <sub>4</sub> per 100 gms. mixture
-2.17	1.19	- 5.52	10.23	+19.6	22.64
-2.87	2.56	- 6.77	13.51	29.1	23.59
-3.12	4.47	- 9.02	16.77	39.1	25.62
-4.27	6.92	-10.57			

## THE SYSTEM SODIUM SULFATE - SULFURIC ACID - WATER

S0 Pascal and Ero, 1919 at 5°, 14°, 23°, 36°, 56°, 75°, 97°; Faust and Esselmann, 1926 at 0°, 29.5°, 46°, 60°, 82.5°; Montemartini and Losana, 1928 at 12.5°; Luk'yanova, 1953 at 0°, 25°; D'Ans, 1906, 1909c, 1913 at 25° (data not in table below); Foote, 1919 at 12°, 25°.

A = Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	G = NaH <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub> ·1½H <sub>2</sub> O	M = NaHSO <sub>4</sub> ·5H <sub>2</sub> O
B = Na <sub>3</sub> H(SO <sub>4</sub> ) <sub>2</sub>	H = NaH <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub> ·H <sub>2</sub> O	N = NaH <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub>
C = Na <sub>3</sub> H(SO <sub>4</sub> ) <sub>2</sub> ·H <sub>2</sub> O	I = H <sub>2</sub> SO <sub>4</sub> ·H <sub>2</sub> O	O = Na <sub>2</sub> SO <sub>4</sub> ·7H <sub>2</sub> O
D = NaHSO <sub>4</sub> ·H <sub>2</sub> O	J = Na <sub>2</sub> SO <sub>4</sub> ·4.5H <sub>2</sub> SO <sub>4</sub>	P = Na <sub>3</sub> H(SO <sub>4</sub> ) <sub>2</sub>
E = NaHSO <sub>4</sub>	K = Na <sub>2</sub> SO <sub>4</sub> ·5.5H <sub>2</sub> SO <sub>4</sub>	Q = 2NaHSO <sub>4</sub> ·H <sub>2</sub> SO <sub>4</sub>
F = Na <sub>2</sub> SO <sub>4</sub>	L = H <sub>2</sub> SO <sub>4</sub>	*metastable

Sat. Sol. Wt. %			Solid Phase			Sat. Sol. Wt. %			Solid Phase			Sat. Sol. Wt. %			Solid Phase		
Na <sub>2</sub> SO <sub>4</sub>		H <sub>2</sub> SO <sub>4</sub>				Na <sub>2</sub> SO <sub>4</sub>		H <sub>2</sub> SO <sub>4</sub>				Na <sub>2</sub> SO <sub>4</sub>		H <sub>2</sub> SO <sub>4</sub>			
At 0° (L.)						At 0° (L.)--Cont.						At 0° (F. and E.)--Cont.					
4.2	-	A	3.86	60.84	D + E	11.5	20.5										
4.92	1.68	A	3.65	61.98	E	14.44	21.64										
5.50	3.58	A	4.89	62.32	E + H	20.01	21.69										
5.91	5.51	A	3.3	63.7	H	23.01	21.52										
7.82	11.75	A	2.87	64.67	H	28.3	22.07										
8.47	15.53	A	2.85	76.24	H	27.85	22.66										
8.98	17.50	A	2.57	80.01	H + I	26.25	23.81										
12.12	20.43	A	1.92	80.36	I	25.70	24.13										
13.64	21.38	A	1.62	88.85	I + H	22.95	26.08										
16.14	22.06	A	3.60	89.0	H*	18.67	29.35										
17.91	22.25	A	7.72	88.81	H*	16.45	30.74										
19.93	22.02	A	7.64	88.60	H*	13.88	32.73										
21.26	22.05	A	1.74	89.39	H + J	13.01	33.13										
25.74	21.93	A	1.69	90.78	J + K	9.62	34.59										
28.50	22.00	A + B	3.21	91.77	K*	7.66	37.21										
28.54	22.51	B	4.23	99.29	K*	3.98	43.31										
28.55	22.92	B	6.43	92.55	K*	2.11	57.5										
26.87	24.56	B	1.65	91.67	J	2.38	58.46										
26.65	25.07	B	1.68	93.39	J	2.79	60.00										
26.00	26.00	B + D	1.99	94.98	J	3.05	61.30										
23.29	26.92	D	3.91	95.36	J	3.44	62.60										
20.05	27.91	D	4.00	95.50	J + L	3.36	62.87										
17.35	29.57	D	2.0	97.0	L	0.0	69.90										
16.04	30.54	D															
6.52	42.58	D	At 0° (F. and E.)			At 5°											
3.37	51.50	D	5.98	6.74		13.94	8.75										
3.18	54.21	D	7.9	14.75		25.55	14.96										
3.41	58.71	D															

THE SYSTEM SODIUM SULFATE - SULFURIC ACID - WATER--Cont.

A =  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$   
 B =  $\text{Na}_3\text{H}(\text{SO}_4)_2$   
 C =  $\text{Na}_3\text{H}(\text{SO}_4)_2 \cdot \text{H}_2\text{O}$   
 D =  $\text{NaHSO}_4 \cdot \text{H}_2\text{O}$   
 E =  $\text{NaHSO}_4$   
 F =  $\text{Na}_2\text{SO}_4$

$$\begin{aligned} G &= \text{NaH}_3(\text{SO}_4)_2 \cdot 1.1 \text{H}_2\text{O} \\ H &= \text{NaH}_3(\text{SO}_4)_2 \cdot \text{H}_2\text{O} \\ I &= \text{H}_2\text{SO}_4 \cdot \text{H}_2\text{O} \\ J &= \text{Na}_2\text{SO}_4 \cdot 4.5 \text{H}_2\text{SO}_4 \\ K &= \text{Na}_2\text{SO}_4 \cdot 5.5 \text{H}_2\text{SO}_4 \\ L &= \text{H}_2\text{SO}_4 \end{aligned}$$

M =  $\text{NaHSO}_4 \cdot 5\text{H}_2\text{O}$   
 N =  $\text{NaH}_3(\text{SO}_4)_2$   
 O =  $\text{Na}_2\text{SO}_4 \cdot 7\text{H}_2\text{O}$   
 P =  $\text{Na}_3\text{H}(\text{SO}_4)_2$   
 Q =  $2\text{NaHSO}_4 \cdot \text{H}_2\text{SO}_4$   
 \*metastable

Sat. Sol. Wt. %			Sat. Sol. Wt. %			Sat. Sol. Wt. %		
Na <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	Solid Phase	Na <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	Solid Phase	Na <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	Solid Phase
At 5°--Cont.			At 23°			At 29.5°--Cont.		
33.30	16.70	A + F	29.29	10.11	A	34.02	15.60	F
25.74	25.05	B	35.52	13.37	A	34.37	17.31	F
16.23	33.60	B	34.05	13.56	A + F	33.49	19.10	P
4.95	45.90	B + D	34.65	19.38	F	33.19	19.49	P
4.19	48.60	D	30.08	26.61	P	32.69	21.45	P
3.96	58.78	E	9.42	43.76	P	32.38	22.35	P
0.95	70.80	E	6.23	56.09	D + E	30.86	24.98	P
0.19	81.70	G	2.78	63.93	E	29.79	27.35	P
3.02	88.70	G	7.54	64.06*	D	28.72	29.89	P
At 12.5°			1.84	79.40	G	28.32	30.60	P
9.46	0	A	14.74	83.89	N	27.81	32.53	P
19.26	11.86	A + M	3.95	87.29	G + N	26.87	32.64	P
30.40	18.73	F + M	At 25° (L.)			26.54	32.79	D
31.56	20.58	F + M	21.9	0.0	A	19.62	36.65	D
30.15	22.06	F + M	33.73	8.73	A + F	19.00	37.22	D
25.06	27.96	F + M + D	35.18	16.26	F + P	10.51	45.50	D
10.86	36.91	D	26.16	30.22	P + D	8.96	48.15	D
3.68	51.62	D	17.05	37.65	D	8.35	49.49	D
3.71	59.42	E	10.71	43.29	D	7.85	55.13	D + E
4.75	70.62	E + N	7.36	51.16	D	5.70	59.96	E
5.65	81.74	N	7.56	55.24	D + E	4.59	62.55	E
9.98	89.06	N	7.04	86.76	H	4.31	65.55	E
At 14°			15.63	83.48	H	12.7	82.91	E
25.9	0.0	O	5.65	90.92	J	9.3	84.25	E
34.15	9.5	O	6.82	92.71	J	At 36°		
19.81	7.13	A	At 25° (F.)			35.54	19.31	F
28.50	13.40	A	21.90	0.0	A	32.98	26.46	F
33.35	20.19	F	33.48	8.62	A + F	37.89	26.98*	F
28.58	24.54	P	35.36	16.27	F + P	17.61	42.34	D
22.77	29.97	P	27.02	30.58	P + D	12.53	53.07	D
17.74	33.88	P	6.54	56.25	D	6.05	65.41	E
5.63	48.12	D	At 29.5°			18.09	86.96	N
4.54	58.68	E	At 29.5°			6.69	86.20	N
8.68	58.68*	D	At 29.5°			At 46°		
2.09	63.78	E	32.22	3.06	A	32.4	3.47	F
1.20	70.76	E	32.89	3.99	F	32.54	6.27	F
0.35	81.66	G	32.84	5.11	F	32.52	6.8	F
0.32	81.68	G	32.60	6.99	F	33.01	10.8	F
3.44	87.92	N	32.42	8.94	F	34.08	14.4	F
3.64	88.30	N	32.51	10.05	F	34.17	14.9	F
5.95	91.69*	G	33.34	13.83	F	34.14	14.87	F
15.05	85.00	N	33.75	14.38	F	34.57	15.86	F

**Na SODIUM**

THE SYSTEM SODIUM SULFATE - SULFURIC ACID - WATER--Cont.

$$A = Na_2SO_4 \cdot 10H_2O$$
$$B = \text{Na}_3\text{H}(\text{SO}_4)_2$$
$$C = \text{Na}_3\text{H}(\text{SO}_4)_2 \cdot \text{H}_2\text{O}$$
$$D = \text{NaHSO}_4 \cdot \text{H}_2\text{O}$$
$$E = \text{NaHSO}_4$$
$$F = \text{Na}_2\text{SO}_4$$
$$G = \text{NaH}_2(\text{SO}_4)_{0.11} \cdot \text{H}_2\text{O}$$
$$H = NaH_2(SO_4)_2 \cdot H_2O$$
$$I = H_2SO_4 \cdot H_2O$$
$$J = \text{Na}_2\text{SO}_4 \cdot 4.5\text{H}_2\text{SO}_4$$
$$K = Na_2SO_4 \cdot 5.5H_2SO_4$$
$$L = H_2\bar{S}$$
$$M = \text{NaHSO}_4 \cdot 5\text{H}_2\text{O}$$
$$N = \text{NaH}_2(\text{SO}_4)_2$$
$$Q = \text{Na}_2\text{SO}_4 \cdot 7\text{H}_2\text{O}$$
$$P = \text{Na}_2\text{H}(\text{SO}_4)_2$$
$$Q = 2\text{NaHSO}_4 \cdot \text{H}_2\text{SO}_4$$

\*metastable

	Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
	Na <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>		Na <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>		Na <sub>2</sub> SO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	
	At 46°--Cont.			At 56°--Cont.			At 82.5°--Cont.		
SO	34.60	16.17	F	11.57	60.45	E	39.20	25.0	P
	36.00	18.08	F	8.44	62.72	E	40.63	28.86	P
	35.94	18.12	F	5.24	74.63	D	41.25	30.17	P
	35.63	19.18	F	5.68	76.54	G	42.25	32.15	P
	35.45	20.16	F	4.49	78.30	G	44.20	35.15	P
	34.97	21.32	F	21.54	78.46	N	45.37	36.14	P
	34.73	22.93	F	15.20	81.15	N	46.20	36.55	P
	34.52	23.04	F	9.30	83.25	N	39.02	41.04	E
	34.40	24.60	P				34.80	44.00	E
	33.59	27.2	P		At 60°		28.78	47.55	E
	33.25	28.48	P	32.27	4.66	F	23.62	50.64	E
	33.15	29.3	P	33.70	13.13	F	25.5	49.78	E
	33.07	30.18	P	34.26	14.71	F	20.84	53.9	E
	33.01	33.16	P	37.03	19.00	F	19.42	54.35	E
	33.27	33.44	P	36.86	22.1	P	16.45	56.99	E
	33.22	33.08	P	36.48	25.6	P	10.97	65.07	E
	33.25	35.36	D	37.0	29.87	P	11.9	65.5	E
	32.65	35.70	D	38.22	34.26	P	24.67	71.38	?
	30.95	36.5	D	33.04	41.77	P	10.56	71.44	?
	21.2	43.9	D	31.24	42.53	E	10.06	72.26	
20.5	44.52	D	17.72	51.25	E	21.43	73.00		
19.85	45.17	D	13.27	55.36	E	19.37	73.12		
17.71	48.5	D	8.22	63.75	E	11.47	75.44		
17.76	48.32	D	8.21	67.79	E	11.20	75.73		
17.13	49.6	D	11.33	73.65					
14.21	51.31	E	16.60	77.78					
12.41	52.65	E	15.93	78.6					
10.2	55.5	E	3.2	78.69	?	34.89	8.53	F	
9.93	56.0	E	3.3	79.32		44.34	15.03	F	
6.82	61.79	E	13.59	80.8		44.22	20.22	F	
6.4	62.46	E	5.14	81.01	E	44.37	24.02	P	
6.16	64.8					44.13	31.91	P	
6.04	65.59	E		At 75°		44.10	33.10	P	
4.51	67.76	E	41.80	23.10	F + P	48.29	34.20	P	
2.3	74.83	?	42.40	31.80	P	51.89	35.53	D	
7.5	72.16		20.10	55.20	D + E	37.78	42.97	E	
1.92	78.58		11.10	63.40	E	21.02	56.60	E	
13.22	80.44	?	12.30	69.80	E	15.88	61.92	E	
			13.40	77.40	N	15.60	65.00	E	
			24.90	75.30	N	20.43	68.00	E	
				At 82.5°		21.71	70.98	N	
34.63	8.47	F				29.43	71.16	N	
34.99	12.81	F				27.60	72.50	Q	
36.65	18.69	F	31.72	6.49	F	18.0	73.20*	E	
36.88	25.10	P	32.83	10.48	F				
40.51	33.21*	D	36.44	16.88	F				
19.86	51.15	D	38.63	19.73	F				
33.00	41.35	D	38.85	20.20	F				

THE SYSTEM  $\text{Na}_2\text{SO}_4 - \text{H}_2\text{SO}_4 - \text{H}_2\text{O}$ —Cont.

Results at low and high temperatures

(Pascal and Ero, 1919)

t°	Sat. Sol. Wt. %		Solid Phase	t°	Sat. Sol. Wt. %		Solid Phase
	$\text{Na}_2\text{SO}_4$	$\text{H}_2\text{SO}_4$			$\text{Na}_2\text{SO}_4$	$\text{H}_2\text{SO}_4$	
-45	1.6	42.8	$\left\{ \begin{array}{l} \text{Na}_3\text{H}(\text{SO}_4)_2 + \\ \text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O} \end{array} \right.$	120	49.00	32.67	$\text{Na}_3\text{H}(\text{SO}_4)_2$
-30	1.6	42.8	$\text{Na}_3\text{H}(\text{SO}_4)_2$	120	50.10	34.50	"
-30	2.30	37.10	"	120	53.20	36.50	$\text{NaHSO}_4$
-30	3.10	26.80*	"	120	32.26	51.20	"
-24	3.0	30.0	Ice	120	26.80	57.70	"
-24	7.5	35.0	$\left\{ \begin{array}{l} \text{Ice} + \\ \text{Na}_3\text{H}(\text{SO}_4)_2 + \\ \text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O} \end{array} \right.$	120	27.50	64.55	"
-21	7.5	40.0	$\text{NaHSO}_4 \cdot \text{H}_2\text{O}$	120	35.61	64.58	"
-1	7.5	40.0*	"	169.5	50.20	44.75	"
-17	3.0	24.25	Ice	159.5	47.23	48.67	"
-11	10.0	30.0	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$	160.5	45.00	49.20	"
-10	5.0	15.0	" + Ice	149.5	40.41	52.09	"
-9	3.0	12.5	Ice	91.5	45.00	38.50	$\text{NaHSO}_4 \cdot \text{H}_2\text{O}$
-7	10.0	22.5	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$	>145	45.00	33.00	$\text{Na}_2\text{SO}_4$
-6	4.0	45.0	$\text{Na}_3\text{H}(\text{SO}_4)_2$	>170	57.20	29.05	"
-3	9.1	32.1*	$\text{NaHSO}_4 \cdot \text{H}_2\text{O}$				
-3	10.25	10.9	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$				
-3	16.0	27.1	$\text{Na}_2\text{H}(\text{SO}_4)_2$				
-3	20.1	22.4	"				

\*metastable

Freezing points in the system  $\text{H}_2\text{SO}_4 + \text{Na}_2\text{SO}_4$  are given by Kendall and Landon, 1920; Cambi and Bozza, 1923; Gillespie and Oubridge, 1956. Results for sodium pyrosulfate + sodium bisulfate are given by Cambi and Bozza, 1923; for the system  $\text{H}_2\text{SO}_4 + \text{Na}_2\text{SO}_4 + \text{ZnSO}_4$  by Kleinert and Wurm, 1952.

Results for the system  $\text{Na}_2\text{SO}_4 + 2\text{HCl} \rightleftharpoons 2\text{NaCl} + \text{H}_2\text{SO}_4 (+ \text{H}_2\text{O})$  at 25° (1 atm. HCl) are given by Korf and Shchatrovskaya, 1940.

Results for the system  $\text{Na}_2\text{SO}_4 - \text{H}_3\text{BO}_3 - \text{H}_2\text{O}$  at 0, 10, 20, 25° are given by Palkin and Goloshchapov, 1939.



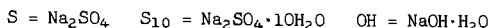
# Na SODIUM

## THE SYSTEM SODIUM SULFATE - SODIUM HYDROXIDE - WATER

### Results from 0° - 30°

(Windmaisser and Stockl, 1950)

Earlier determinations by D'Ans and Schreiner, 1910, at 25° are not in agreement with the more recent work. Additional data at 30° are given by Pischinger and Szufarski, 1958. Results in electrochemical cells at 25° are reported by Okuno, Sakai and Matsuura, 1942.



SO	Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
	Na <sub>2</sub> SO <sub>4</sub>	NaOH		Na <sub>2</sub> SO <sub>4</sub>	NaOH		Na <sub>2</sub> SO <sub>4</sub>	NaOH	
At 0°				At 10°, Cont.			At 25°, Cont.		
4.40	0.0	S <sub>10</sub>	2.44	25.37	S	17.86	7.79	S <sub>10</sub>	
3.37	1.20	S <sub>10</sub>	1.14	28.33	S	18.49	8.60	S <sub>10</sub>	
1.80	5.13	S <sub>10</sub>	0.49	31.85	S	18.61	8.92	S <sub>10</sub>	
1.50	8.52	S <sub>10</sub>	0.32	34.40	S	18.69	8.90	S <sub>10</sub> +S	
1.60	13.93	S <sub>10</sub>	0.24	49.30	S+ OH	18.40	9.03	S	
1.72	15.72	S <sub>10</sub>	0.0	51.50	OH	17.88	9.46	S	
3.40	20.90	S <sub>10</sub>				15.22	11.42	S	
4.22	21.71	S <sub>10</sub>	At 18°			11.05	14.36	S	
4.68	22.04	S <sub>10</sub>				7.90	17.23	S	
4.89	22.12	S <sub>10</sub> +S	14.04	0.0	S <sub>10</sub>	2.96	23.80	S	
4.11	22.51	S	11.91	2.23	S <sub>10</sub>	0.70	31.17	S	
2.76	24.50	S	10.58	3.56	S <sub>10</sub>	0.22	43.50	S	
0.67	30.56	S	10.22	4.48	S <sub>10</sub>	0.24	51.16	S+ OH	
0.20	41.14	S	9.50	6.43	S <sub>10</sub>	0.0	51.95	OH	
0.20	48.30	S+ OH	9.24	7.66	S <sub>10</sub>				
0.0	49.07	OH	9.00	8.57	S <sub>10</sub>				
			9.00	9.17	S <sub>10</sub>				
			9.50	11.67	S <sub>10</sub>				
			11.60	13.97	S <sub>10</sub> +S	29.41	0.0	S <sub>10</sub>	
8.38	0.0	S <sub>10</sub>	6.79	18.30	S	28.52	1.40	S <sub>10</sub>	
7.28	1.00	S <sub>10</sub>	3.43	21.89	S	28.37	1.57	S <sub>10</sub>	
6.00	2.44	S <sub>10</sub>	1.15	30.52	S	28.17	2.27	S <sub>10</sub>	
5.37	3.50	S <sub>10</sub>	0.22	37.31	S	28.21	2.50	S <sub>10</sub>	
4.49	6.09	S <sub>10</sub>	0.19	42.36	S	28.25	2.92	S <sub>10</sub> +S	
4.01	9.10	S <sub>10</sub>	0.18	45.45	S	28.21	2.93	S	
3.96	11.78	S <sub>10</sub>	0.19	51.27	S+ OH	27.83	3.09	S	
4.34	14.40	S <sub>10</sub>	0.0	51.43	OH	26.69	3.70	S	
5.32	16.81	S <sub>10</sub>				24.42	5.10	S	
6.93	18.10	S <sub>10</sub>	At 25°			18.75	8.61	S	
7.59	18.22	S <sub>10</sub> +S				7.96	17.00	S	
6.78	18.83	S	21.48	0.0	S <sub>10</sub>	4.62	21.20	S	
6.19	19.70	S	20.42	1.00	S <sub>10</sub>	0.30	38.82	S	
5.87	20.00	S	18.61	3.68	S <sub>10</sub>	0.26	45.00	S+ OH	
3.50	23.00	S	17.86	5.83	S <sub>10</sub>	0.0	53.52	OH	

### Results of Imkuna, 1949, at 50°

#### Sat. Sol. Wt. %

Na <sub>2</sub> SO <sub>4</sub>		NaOH	
15.98		8.73	
5.95		18.65	
0.55		34.34	

## THE SYSTEM SODIUM SULFATE - SODIUM HYDROXIDE - WATER--Cont.

Results from 50 - 140°

(Prihodko, 1932)

Solvent wt. % NaOH	Gms. Na <sub>2</sub> SO <sub>4</sub> per 100 gms. sat. sol.					
	50°	70°	90°	100°	120°	140°
5	21.0	19.89	18.9	18.7	18.1	17.9
15	8.9	8.4	8.2	7.7	7.4	7.8
25	2.7	2.5	2.37	2.1	1.9	1.9
35	1.2	1.05	0.95	0.82	0.82	0.85
45	0.35	0.32	0.308	0.30	0.29	0.31
55	0.13	0.126	0.123	0.107	0.11	0.111

30

Results at 70°

(Ravich and Elenevskaya, 1955)

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
NaOH	Na <sub>2</sub> SO <sub>4</sub>		NaOH	Na <sub>2</sub> SO <sub>4</sub>	
22.8	4.1	Na <sub>2</sub> SO <sub>4</sub>	56.6	0.5	3Na <sub>2</sub> SO <sub>4</sub> ·2NaOH
29.4	1.4	"	61.4	0.6	"
39.8	1.2	"	63.1	1.7	"
42.8	1.4	" + 3Na <sub>2</sub> SO <sub>4</sub> ·2NaOH	67.5	2.2	" + Na <sub>2</sub> SO <sub>4</sub> ·2NaOH
47.2	0.4	3Na <sub>2</sub> SO <sub>4</sub> ·2NaOH	71.0	0.3	Na <sub>2</sub> SO <sub>4</sub> ·2NaOH
48.6	1.0	"	72.6	0.2	"
56.4	0.4	"			

Results at 100°

(Green and Frattali, 1946)

Sat. Sol. Wt. %		Sat. Sol. Wt. %	
Na <sub>2</sub> SO <sub>4</sub>	NaOH	Na <sub>2</sub> SO <sub>4</sub>	NaOH
30.0	0.0	6.8	18.4
22.9	4.0	4.7	22.9
16.2	8.6	2.9	27.4
12.7	12.1	2.1	31.6
9.5	15.4	1.7	35.2

Results at 150°

(Ravich and Elenevskaya, 1955)

Sat. Sol. Wt. %	
NaOH	Na <sub>2</sub> SO <sub>4</sub>
23.6	6.8
38.6	3.5

Results at 200°

(Ravich and Elenevskaya, 1955)

Sat. Sol. Wt. %		Sat. Sol. Wt. %		Sat. Sol. Wt. %		Sat. Sol. Wt. %	
NaOH	Na <sub>2</sub> SO <sub>4</sub>	NaOH	Na <sub>2</sub> SO <sub>4</sub>	NaOH	Na <sub>2</sub> SO <sub>4</sub>	NaOH	Na <sub>2</sub> SO <sub>4</sub>
22.9	11.9	45.4	8.1	52.1	6.8	68.6	3.8
27.0	9.4	45.5	8.5	57.4	5.2	76.7	3.6
34.7	8.7	45.7	8.0	58.6	4.9	80.3	3.2
38.9	8.9	48.7	8.3	62.9	3.9		

## Na SODIUM

Results for the system  $\text{Na}_2\text{SO}_4 - \text{NaOH} - \text{H}_2\text{O}$  between  $150^\circ$  and  $350^\circ$  are given by Schroeder, Gabriel and Partridge, 1935, and Schroeder, Berk and Gabriel, 1937. For other data at high temperatures see Ravich and Borovaya, 1955.

### SOLUBILITY OF SODIUM SULFATE IN AQUEOUS AMMONIA SOLUTIONS (Guyer, Bieler and Orelli, 1940)

The data were read from curves drawn by the authors. The results are in gms.  $\text{Na}_2\text{SO}_4$  per 100 gms. solvent.

t°	% $\text{NH}_3$ in solvent				
	10	20	40	60	80
-30	-	1.4	0.8	0.8	0.7
-10	1.2	0.8	0.6	0.6	0.5
0	1.9	1.2	1.1	1.1	0.7
23	10	3.0	1.3	1.3	0.9

The solubility of sodium sulfate in aqueous ammonia solutions was determined by Belopolskii and Aleksandrov at  $5^\circ$ ,  $15^\circ$ , and  $25^\circ$  (1931), at  $0^\circ$  (1932) and the data at all four temperatures is given in (1943).

### SOLUBILITY OF SODIUM SULFATE IN AQUEOUS SOLUTIONS OF AMMONIA AT $35^\circ$ (Fedotieff and Kolosoff, 1923)

d of sat. sol.	Gms. per 100 cc. sat. sol.		Gms. per 100 gms. $\text{H}_2\text{O}$	
	$\text{Na}_2\text{SO}_4$	$\text{NH}_3$	$\text{Na}_2\text{SO}_4$	$\text{NH}_3$
1.202	28.76	4.84	33.23	5.65
1.169	25.39	6.08	29.71	6.49
1.137	21.98	6.59	25.83	7.75

### SOLUBILITY OF SODIUM SULFATE IN AQUEOUS SOLUTIONS OF SODIUM ACETATE AT $25^\circ$ (Fox, 1909)

Gms. per 100 Gms. Sat. Sol.			Gms. per 100 Gms. Sat. Sol.		
$\text{CH}_3\text{COONa}$	$\text{Na}_2\text{SO}_4$	Solid Phase	$\text{CH}_3\text{COONa}$	$\text{Na}_2\text{SO}_4$	Solid Phase
0	21.9	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$	12.58	13.50	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
4.10	17.72	"	16.26	11.50	"
7.71	16.48	"	20.68	8.10	"

THE SYSTEM SODIUM SULFATE - SODIUM CHLORATE - WATER AT 18°  
(Windmaisser and Stockl, 1951)

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
NaClO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	Solid Phase	NaClO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	Solid Phase
0.0	14.04	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	39.90	5.57	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
9.49	9.91	"	42.71	5.56	"
14.77	8.04	"	43.14	5.68	" + Na <sub>2</sub> SO <sub>4</sub>
20.96	6.79	"	44.60	5.28	NaClO <sub>3</sub> + "
25.31	6.14	"	44.09	5.71	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
29.97	5.67	"	46.88	2.12	NaClO <sub>3</sub>
34.80	5.50	"	48.86	0.0	"
40.00	5.54	"			

30

In a re-examination of the system Na<sub>2</sub>SO<sub>4</sub> - NaCl - H<sub>2</sub>O at 20°, Silber, 1957, 1958, reports finding a number of metastable hydrates: Na<sub>2</sub>SO<sub>4</sub>·6H<sub>2</sub>O, ·4H<sub>2</sub>O, ·3H<sub>2</sub>O, ·2H<sub>2</sub>O. The existence of ·5H<sub>2</sub>O and ·H<sub>2</sub>O are also considered "probable."

Sodium sulfate forms a discontinuous series of solid solutions with sodium selenate at 20° (Collet, 1949).

THE SYSTEM SODIUM SULFATE - SODIUM THIOSULFATE - WATER  
(Garrañ, 1926)

Saturation was obtained by constant agitation in a thermostat for from 3 to 24 hours. M. C. indicates mixed crystals and the formula following shows the major constituent; \* indicates metastable equilibrium.

d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	Na <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	
<u>Results at 0.8°</u>			
1.040	4.60	0.0	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
1.065	3.13	4.48	M.C. Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
1.105	2.31	9.63	"
1.159	1.88	16.03	"
1.190	1.87	19.62	"
1.247	1.56	25.63	"
-	1.34	30.07	"
1.312	1.27	32.26	"
1.324	1.58	33.91*	"
1.314	1.22	32.72	} M.C. Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O + M.C. Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O
1.317	1.15	32.72	
1.317	1.44	32.72	M.C. Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O
1.315	-	33.57	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O

(Cont.)

# Na SODIUM

## THE SYSTEM SODIUM SULFATE - SODIUM THIOSULFATE - WATER--Cont.

Gms. per 100 gms.  
sat. sol.

d of  
sat. sol.

$\text{Na}_2\text{SO}_4$

$\text{Na}_2\text{S}_2\text{O}_3$

Solid Phase

Results at 18°

1.130	14.11	0.0	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
1.150	12.31	4.01	M.C. $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
1.180	10.71	9.36	"
1.194	9.83	11.34	"
1.225	8.45	15.86	"
1.248	7.65	19.16	"
1.276	7.14	22.46	"
1.301	6.01	25.53	"
1.314	5.97	27.00	"
1.338	6.04	29.57	"
1.355	6.32	32.31	"
1.374	5.94	33.66	"
1.390	6.14	35.07	"
1.399	6.26	35.42	M.C. $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ + M.C. $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$
1.394	6.31	35.46	M.C. $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$
1.395	4.87	36.61	"
1.384	1.65	39.12	"
1.378	0.0	40.36	$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$

Results at 25°

1.204	21.60	0.0	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
1.215	19.74	3.48	M.C. $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
1.236	18.44	7.30	"
1.253	17.12	10.14	"
1.271	16.13	13.22	"
1.288	14.86	16.16	"
1.311	13.97	19.35	"
-	13.62	22.02	"
1.359	12.97	24.96	"
-	12.72	25.86	M.C. $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ + M.C. $\text{Na}_2\text{SO}_4$
-	12.72	26.85	
-	13.27	26.12*	
1.379	12.15	28.00	M.C. $\text{Na}_2\text{SO}_4$
-	10.28	30.31	"
1.401	7.73	34.72	"
-	6.06	38.07	"
-	4.53	41.86*	"
1.453	4.87	43.32*	"
-	5.59	38.83	M.C. $\text{Na}_2\text{SO}_4$ + M.C. $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$
-	5.66	38.67	
1.426	5.64	38.97	
1.420	5.42	38.85	
-	5.20	38.96	M.C. $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$
1.418	4.69	39.45	
1.412	3.13	40.92	"
1.411	2.01	41.53	"
1.410	0.23	43.52	"
-	0.0	43.50	$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$

(Cont.)

## THE SYSTEM SODIUM SULFATE - SODIUM THIOSULFATE - WATER--Cont.

d of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	Na <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	
<u>Results at 40°</u>			
-	32.37	0.0	Na <sub>2</sub> SO <sub>4</sub>
-	29.35	3.79	M.C. Na <sub>2</sub> SO <sub>4</sub>
1.326	24.79	9.06	"
1.334	18.58	16.73	"
-	14.76	22.95	"
1.367	11.14	28.06	"
-	10.40	30.44	"
1.383	8.13	34.35	"
-	5.90	39.74	"
1.444	4.28	43.06	"
1.484	2.46	48.78	"
	1.79	51.04*	"
	2.03	52.10*	"
1.496	2.27	49.38	M.C. Na <sub>2</sub> SO <sub>4</sub> + M.C. Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O
1.496	2.08	49.72	
1.494	2.24	49.73	
	2.09	49.97	M.C. Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5½H <sub>2</sub> O
	3.61	49.60*	
1.493	2.14	49.88	"
	2.45	49.98	"
-	1.58	50.15	"
1.492	0.67	50.49	"
1.488	0.0	51.23	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O

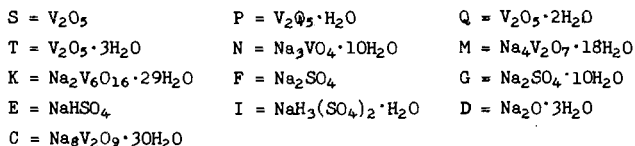
SO

THE SYSTEM SODIUM SULFATE - SODIUM VANADATE - WATER  
(Trujillo and Tejera, 1953)

Sat. Sol. Wt. %		density	Solid Phase
$\text{Na}_2\text{SO}_4$	$\text{NaVO}_3$		
0.0	12.80	1.084	$\text{NaVO}_3 \cdot 2\text{H}_2\text{O}$
3.40	9.62	1.088	"
5.30	7.50	1.090	"
8.88	5.18	1.091	"
10.05	4.60	1.108	"
12.00	3.76	1.120	"
13.15	3.22	1.129	"
14.27	3.15	1.138	"
16.05	2.65	1.167	"
19.28	1.93	1.179	"
19.89	1.53	1.185	"
20.86	1.48	1.186	$\text{NaVO}_3 \cdot 2\text{H}_2\text{O}$ + $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
21.54	0.53	1.192	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
21.72	0.36	1.194	"
21.85	0.0	1.196	"

# Na SODIUM

## THE SYSTEM SODIUM OXIDE - SULFUR TRIOXIDE - VANADIUM PENTOXIDE - WATER AT 25° (Makarov and Repa, 1940)



SO	Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
	Na <sub>2</sub> O	V <sub>2</sub> O <sub>5</sub>	SO <sub>3</sub>		Na <sub>2</sub> O	V <sub>2</sub> O <sub>5</sub>	SO <sub>3</sub>	
	17.04	3.35	5.95	F	2.78	2.20	34.20	P + Q + E
	12.66	3.02	11.50	G	2.50	1.41	25.36	Q + T + E
	12.89	4.34	10.00	G	8.20	3.92	19.74	E
	11.41	2.42	7.20	G + M	12.61	8.18	20.46	T + E + Q
	14.51	5.80	10.20	G + M + F	7.36	4.20	17.48	T + E
	10.40	1.03	5.04	M + F	6.98	3.00	20.05	T + E
	15.19	5.09	7.62	M + F	10.71	21.90	3.50	C
	14.00	1.16	2.80	M + F + N	9.68	18.40	3.02	C
	12.60	7.43	9.30	M + N	10.55	15.43	3.92	C + M
	15.15	14.01	7.90	M + N	4.62	11.38	0.24	C + S
	14.93	17.04	6.44	M + N	4.66	11.15	0.40	C + S
	9.44	3.41	11.25	M + G	2.80	5.35	1.00	M + S
	8.16	1.31	9.83	M + G	8.89	11.95	6.56	M + S
	9.24	3.57	10.84	M	2.49	2.42	3.55	T
	7.40	2.00	11.44	M	1.25	1.31	3.27	T
	8.87	2.93	9.65	M	18.41	7.62	6.40	N
	13.88	13.75	10.00	M	16.17	1.30	Trace	F + C
	9.21	3.38	14.96	M + G	14.12	16.15	5.25	N + M
	9.81	3.58	15.01	G + T + E	12.46	0.85	1.70	N + M
	6.75	2.15	11.20	M + S	15.60	4.63	3.73	N + F + C
	14.25	17.00	6.60	M	14.60	1.90	0.19	C + F
	18.30	21.80	6.72	M	19.98	1.42	Trace	C + F
	4.02	11.12	0.80	M + K + S	26.50	1.85	Trace	C + F + D
	2.76	8.46	58.00	S + I + E	10.00	6.42	2.60	N + C
	0.02	4.42	55.00	S + I	11.98	11.20	3.60	N + C
	2.19	4.01	53.40	E + I	18.70	13.75	3.50	N + C
	2.87	8.78	50.00	S + P + E	9.54	17.00	1.23	M + K

## THE SYSTEM SODIUM SULFATE - LITHIUM SULFATE - WATER (Campbell and Kartzmark, 1958)

The double salt is formed above 29.3°.

Sat. Sol. Wt. %		Wet Residue Wt. %		Solid Phase
Na <sub>2</sub> SO <sub>4</sub>	Li <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	Li <sub>2</sub> SO <sub>4</sub>	
Results at 25°				
-	25.5	-	-	Li <sub>2</sub> SO <sub>4</sub> ·H <sub>2</sub> O
8.0	23.8	0.9	76.7	"
9.9	22.4	13.2	60.8	Li <sub>2</sub> SO <sub>4</sub> ·H <sub>2</sub> O + solid solution
9.7	22.8	39.7	48.7	"

(Cont.)

## THE SYSTEM SODIUM SULFATE - LITHIUM SULFATE - WATER--Cont.

Sat. Sol. Wt. %		Wet Residue Wt. %		Solid Phase
Na <sub>2</sub> SO <sub>4</sub>	Li <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	Li <sub>2</sub> SO <sub>4</sub>	
Results at 25°, Cont.				
9.2	22.9	40.2	23.7	Homogeneous solid solution
11.3	20.8	49.0	22.5	"
14.2	15.7	47.0	14.5	"
15.9	12.9	56.8	11.0	"
21.9	7.8	59.4	4.0	"
22.0	7.0	67.0	1.3	Na <sub>2</sub> SO <sub>4</sub> + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
20.4	5.1	41.7	Trace	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
21.7	-	-	-	"

SO

## Results at 39.5°

-	25.0	-	-	Li <sub>2</sub> SO <sub>4</sub> ·H <sub>2</sub> O
5.8	22.6	1.8	70.0	"
9.0	23.4	27.5	43.0	Li <sub>2</sub> SO <sub>4</sub> ·H <sub>2</sub> O + double salt
9.3	22.7	22.3	50.6	"
12.2	20.1	41.5	38.5	Double salt
14.7	18.3	38.6	35.0	"
17.0	15.7	43.0	34.5	"
17.0	15.5	51.8	28.2	Double salt + solid solution
17.2	15.4	48.5	19.1	Solid solution
20.2	12.3	52.5	14.5	"
27.4	6.7	68.0	9.1	"
32.5	-	-	-	Na <sub>2</sub> SO <sub>4</sub> , anhydrous

## THE SYSTEM SODIUM SULFATE - NICKEL SULFATE - WATER

Results of Koppel; Wetzel, 1905, at 0° - 40°

t°	Gms. per 100 Gms. Solution		Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase
	NiSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	NiSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	
0	16.94	7.61	22.46	10.09	NiSO <sub>4</sub> ·7H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
5	17.99	10.85	25.28	15.24	
10	18.97	13.85	28.26	20.64	
20	18.76	17.21	29.31	26.87	
25	17.85	16.54	27.33	25.33	NiNa <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
30	16.74	15.34	24.64	22.58	
35	16.28	14.91	23.66	21.67	
40	15.35	14.49	21.88	20.65	
18.5	19.61	16.49	30.70	25.80	NiNa <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O + NiSO <sub>4</sub> ·7H <sub>2</sub> O
20	20.13	16.15	31.59	25.35	
25	21.20	14.77	33.11	23.06	
30	22.60	12.80	34.98	19.82	
35	23.62	10.78	36.01	16.43	NiNa <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
40	24.92	9.39	37.93	14.29	
18.5	16.80	18.93	26.14	29.45	
20	15.48	20.18	24.06	31.37	
25	10.92	24.12	16.81	37.13	NiNa <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub>
30	6.40	28.71	9.87	44.25	
35	4.54	31.65	7.13	49.59	
40	4.63	31.37	7.24	49.03	

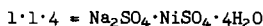


# Na SODIUM

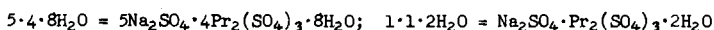
## THE SYSTEM SODIUM SULFATE - NICKEL SULFATE - WATER--Cont.

Results of Benrath and Benrath, 1929; Benrath, 1931, at 60° - 97°

SO	Gms. per 100 Gms. sat. sol.			Solid Phase	d. of sat. sol.	Gms. per 100 Gms. sat. sol.			Solid Phase
	Na <sub>2</sub> SO <sub>4</sub> NiSO <sub>4</sub>					Na <sub>2</sub> SO <sub>4</sub> NiSO <sub>4</sub>			
	<u>Results at 60°</u>					<u>Results at 97°</u>			
	29.51	4.37	Na <sub>2</sub> SO <sub>4</sub> + 1.1.4		1.237	30.50	0.0	Na <sub>2</sub> SO <sub>4</sub>	
	17.51	13.29	1.1.4		1.264	29.12	2.30	"	
	11.66	20.92	"		1.304	28.08	5.16	"	
	7.50	28.84	"		1.331	27.62	6.49	" + 1.1.4	
	4.52	34.40	" + NiSO <sub>4</sub> ·6H <sub>2</sub> O		1.304	22.71	9.54	1.1.4	
	0.0	36.20	Ni <sub>2</sub> SO <sub>4</sub> ·6H <sub>2</sub> O		1.310	21.13	10.94	"	
					1.331	16.45	16.33	"	
					1.403	10.25	26.00	"	
	4.29	36.10	1.1.4 + NiSO <sub>4</sub> ·6H <sub>2</sub> O		-	7.32	31.37	"	
					1.506	6.49	33.73	"	
					1.600	3.48	41.00	"	
					-	3.43	41.90	" + NiSO <sub>4</sub> ·6H <sub>2</sub> O	
	28.75	5.44	Na <sub>2</sub> SO <sub>4</sub> + 1.1.4		1.638	3.14	43.18	NiSO <sub>4</sub> ·6H <sub>2</sub> O	
	19.0	13.62	1.1.4		1.633	2.96	42.78	"	
	15.03	17.51	"		1.619	1.61	43.40	"	
	7.64	28.75	"		1.617	0.0	45.57	"	
	7.28	30.31	"						
	4.63	37.0	" + NiSO <sub>4</sub> ·6H <sub>2</sub> O						
	3.55	37.75	NiSO <sub>4</sub> ·6H <sub>2</sub> O						
	0.0	38.85	"						
						1.1.4 = Na <sub>2</sub> SO <sub>4</sub> ·NiSO <sub>4</sub> ·4H <sub>2</sub> O			

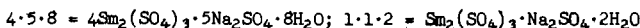


## THE SYSTEM SODIUM SULFATE - PRASEODYMIUM SULFATE - WATER AT 25° (Zambonini and Restanio, 1931)



Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
Pr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>			Pr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>		
-	9.45	5.4·8H <sub>2</sub> O		-	3.64	1.1.2H <sub>2</sub> O	
-	6.61	"		-	1.44	"	
-	5.24	"		2.36	0.01	"	

## THE SYSTEM SODIUM SULFATE - SAMARIUM SULFATE - WATER AT 25° (Restanio, 1934)



Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
Sm <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>			Sm <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>		
-	18.63	-		-	2.08	1.1.2	
-	12.95	4.5.8		0.26	0.50	"	
-	10.65	"		1.39	0.29	-	
-	8.40	1.1.2		1.41	0.28	-	

THE SYSTEM SODIUM SULFATE - THALLOUS SULFATE - WATER  
(Ricci and Fischer, 1952)

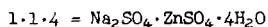
Results at 25°				Results at 45°			
Sat. Sol. Wt. %		den- sity	Solid Phase	Sat. Sol. Wt. %		den- sity	Solid Phase
Tl <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>			Tl <sub>2</sub> SO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>		
5.222	0.00	1.046	Tl <sub>2</sub> SO <sub>4</sub>	7.73	0.00	1.064	Tl <sub>2</sub> SO <sub>4</sub>
6.24	5.69	1.112	"	9.62	8.00	1.166	"
7.32	10.87	1.178	"	10.86	14.65	1.254	"
8.06	15.95	1.245	"	11.32	18.39	1.308	"
8.27	18.34	1.275	"	11.41	22.11	1.356	"
8.48	21.23	1.313	" + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	11.05	23.80	1.434	" + Na <sub>2</sub> SO <sub>4</sub>
8.42	21.34	1.315	" + "	11.04	28.78	1.435	" + " SO
6.59	21.50	1.290	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	10.95	28.75	1.434	Na <sub>2</sub> SO <sub>4</sub>
4.36	21.56	1.256	"	8.46	29.57	1.399	"
1.77	21.58	1.219	"	5.74	30.42	1.362	"
0.00	21.66	1.210	"	0.00	32.05	1.308	"

THE SYSTEM SODIUM SULFATE - ZINC SULFATE - WATER

For additional data see Shevchuk and Lepeshkov, 1956

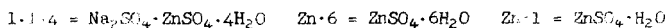
Results of Caven and Johnston, 1928

Results at 0°			Results at 25°		
Gm. Mols. per 1000 gms. H <sub>2</sub> O		Solid Phase	Gm. Mols. per 1000 gms. H <sub>2</sub> O		Solid Phase
ZnSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>		ZnSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	
0.0	0.331	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	0.0	1.972	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
0.128	0.347	"	0.543	2.023	"
0.414	0.366	"	1.226	2.087	" + 1.1.4
0.600	0.381	"	1.987	1.322	1.1.4
0.914	0.388	"	2.669	0.871	"
1.886	0.463	"	2.922	0.745	"
2.494	0.485	"	3.157	0.641	"
2.521	0.492	" + ZnSO <sub>4</sub> ·7H <sub>2</sub> O	3.463	0.551	" + ZnSO <sub>4</sub> ·7H <sub>2</sub> O
2.568	0.122	ZnSO <sub>4</sub> ·7H <sub>2</sub> O	3.504	0.255	ZnSO <sub>4</sub> ·7H <sub>2</sub> O
2.589	0.00	"	3.518	0.0	"



Results of Benrath and Benrath, 1929; Benrath, 1930

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
ZnSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	Solid Phase	ZnSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	Solid Phase
<u>Results at 50°</u>			<u>Results at 68°</u>		
6.48	28.19	Na <sub>2</sub> SO <sub>4</sub> + 1.1.4	39.82	4.05	Zn 1 + 1.1.4
41.47	2.77	Zn·6 + "			(Cont.)



# Na SODIUM

## THE SYSTEM SODIUM SULFATE - ZINC SULFATE - WATER--Cont.

Results of Benrath and Benrath, 1929; Benrath, 1930, Cont.

Gms. per 100 gms. sat. sol.		Solid Phase
ZnSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	
<u>Results at 75°</u>		
38.30	4.71	Zn·1 + 1·1·4
10.54	24.52	3·1 + "
6.54	27.75	" + Na <sub>2</sub> SO <sub>4</sub>
<u>Results at 80°</u>		
1.73	29.67	Na <sub>2</sub> SO <sub>4</sub>
6.45	27.55	3·1
8.19	26.19	"
11.38	23.80	" + 1·1·4
12.78	22.78	1·1·4
18.49	16.88	"
28.05	9.27	"
36.53	5.77	" + Zn·1
37.14	5.29	Zn·1
39.06	2.02	"
40.56	0.0	"

Gms. per 100 gms. sat. sol.		Solid Phase
ZnSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	
<u>Results at 97°</u>		
1.237	0.0	Na <sub>2</sub> SO <sub>4</sub>
1.279	3.36	"
1.301	5.67	"
1.315	6.17	" + 3·1
-	8.68	26.24
1.352	12.16	24.24
-	15.77	22.00
1.398	18.12	20.60
1.421	21.37	17.84
1.435	25.04	14.76
1.506	30.92	11.40
1.561	35.70	9.18
1.532	34.50	9.30
1.509	35.93	5.14
1.510	36.05	4.45
1.532	41.23	0.0
<u>Results at 100°</u>		
-	32.55	10.31
-	17.66	20.71
-	6.12	27.96

Zn·1 = ZnSO<sub>4</sub>·H<sub>2</sub>O

1·1·4 = Na<sub>2</sub>SO<sub>4</sub>·ZnSO<sub>4</sub>·4H<sub>2</sub>O

3·1 = 3Na<sub>2</sub>SO<sub>4</sub>·ZnSO<sub>4</sub>

Zn·6 = ZnSO<sub>4</sub>·6H<sub>2</sub>O

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Results of Koppel, Gumpert, 1905

t°	Gms. per 100 Gms. Solution		Gms. per 100 Gms. H <sub>2</sub> O		Mols. per 100 Mols. H <sub>2</sub> O		Solid Phase
	ZnSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	ZnSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	ZnSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	
0	27.19	5.33	40.30	7.90	4.50	1.01	ZnSO <sub>4</sub> ·7H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
5	27.85	6.27	42.28	9.52	4.71	1.21	
25	17.58	15.63	26.32	23.40	2.94	2.96	ZnNa <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
30	17.66	15.58	26.47	23.44	2.95	2.97	
35	17.59	15.70	26.36	23.52	2.94	2.98	ZnNa <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O + ZnSO <sub>4</sub> ·7H <sub>2</sub> O
40	17.75	15.72	26.68	23.63	2.98	2.99	
10	29.16	7.16	45.79	11.24	5.11	1.42	ZnNa <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O + ZnSO <sub>4</sub> ·6H <sub>2</sub> O
15	30.70	6.40	48.81	10.17	5.45	1.29	
20	32.51	5.36	52.34	8.62	5.84	1.09	ZnNa <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
25	34.36	4.41	56.15	7.22	6.27	0.91	
30	36.28	3.80	60.55	6.34	6.76	0.81	ZnNa <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
35	38.18	3.30	65.25	5.64	7.28	0.71	
38	38.83	2.90	66.64	4.98	7.44	0.63	ZnNa <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
40	38.26	2.78	64.89	4.71	7.24	0.60	
10	27.91	7.92	43.50	12.34	4.85	1.565	ZnNa <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
15	24.28	10.90	36.92	16.71	4.12	2.12	
20	19.14	14.58	28.77	21.95	3.21	2.79	ZnNa <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
25	13.31	19.94	19.93	29.87	2.22	3.785	
30	6.96	27.75	10.67	42.51	1.19	5.39	ZnNa <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O + Na <sub>2</sub> SO <sub>4</sub>
35	5.61	30.03	8.72	46.61	0.971	5.91	
40	5.96	28.65	9.16	43.83	1.02	5.555	

THE SYSTEM SODIUM SULFATE - AMMONIUM CARBONATE - WATER AT 32.5°  
(Belopolski and Urussov, 1935)

Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
Na <sub>2</sub> SO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>		Na <sub>2</sub> SO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	
33.62	0.0	-	S	25.90	14.80	-	S
32.64	1.81	-	S	24.57	18.54	-	S
31.70	3.52	-	S	24.16	19.21	0.10	S,C
30.53	5.19	-	S	23.26	19.94	1.13	C
29.80	7.15	-	S	22.60	21.25	1.03	C
28.00	10.44	-	S	21.41	23.80	1.45	C

S = Na<sub>2</sub>SO<sub>4</sub>C = NaHCO<sub>3</sub>

SO

THE SYSTEM Na<sub>2</sub>SO<sub>4</sub> - ETHANOL - WATER  
(Vener and Thompson, 1950)

Earlier results by Schreinemakers and deBaat, 1909, indicating an area of two-liquid separation, are given in a following table. Additional data are given by deBruyn, 1900, and Flatt and Jordan, 1933. DeBruyn includes data on the metastable Na<sub>2</sub>SO<sub>4</sub>·7H<sub>2</sub>O.

(Solid phase is anhydrous sodium sulfate unless otherwise indicated)

t°C	Wt. % Na <sub>2</sub> SO <sub>4</sub> in Sat. Sol.	d of Sat. Sol. G./Ml.	t°C	Wt. % Na <sub>2</sub> SO <sub>4</sub> in Sat. Sol.	d of Sat. Sol. G./Ml.
3.01 wt. % ethyl alcohol in solvent			10.35 wt. % ethyl alcohol in solvent		
25.00*	18.50	1.1684	25.00*	11.97	1.0867
30.00*	26.74	1.2535	30.00*	19.05	1.1532
35.00	29.10	1.2752	35.00	20.65	1.1669
40.00	28.69	1.2674	40.00	20.31	1.1605
45.00	28.29	1.2601	45.00	20.03	1.1548
50.00	27.91	1.2530	50.00	19.79	1.1495
55.00	27.60	1.2465	55.00	19.59	1.1447
60.00	27.34	1.2406	60.00	19.43	1.1400
65.00	27.12	1.2349	65.00	19.29	1.1353
70.00	26.90	1.2291	70.00	19.17	1.1307
75.00	26.70	1.2235	75.00	19.06	1.1261
6.62 wt. % ethyl alcohol in solvent			14.74 wt. % ethyl alcohol in solvent		
25.00*	15.38	1.1258	25.00*	8.56	1.0490
30.00*	22.87	1.2006	30.00*	14.79	1.1059
35.00	24.83	1.2177	35.00	16.04	1.1115
40.00	24.44	1.2125	40.00	15.85	1.1067
45.00	24.10	1.2060	45.00	15.69	1.1020
50.00	23.80	1.1998	50.00	15.54	1.0974
55.00	23.55	1.1941	55.00	15.42	1.0930
60.00	23.33	1.1885	60.00	15.31	1.0888
65.00	23.15	1.1834	65.00	15.25	1.0848
70.00	22.98	1.1783	70.00	15.19	1.0810
75.00	22.81	1.1733	75.00	15.15	1.0773

\* Solid phase Na<sub>2</sub>SO<sub>4</sub>·10H<sub>2</sub>O

(Cont.)

# Na SODIUM

## THE SYSTEM $\text{Na}_2\text{SO}_4$ - ETHANOL - WATER---Cont.

(Solid phase is anhydrous sodium sulfate unless otherwise indicated)

	19.88 wt. % ethyl alcohol in solvent			50.08 wt. % ethyl alcohol in solvent		
	t°C	Wt. % $\text{Na}_2\text{SO}_4$ in Sat. Sol.	d of Sat. Sol. G./ML.	t°C	Wt. % $\text{Na}_2\text{SO}_4$ in Sat. Sol.	d of Sat. Sol. G./ML.
SO	25.00*	6.00	1.0168	25.00*	0.510	0.9143
	30.00*	10.52	1.0553	30.00	0.593	0.9098
	35.00	11.36	1.0578	35.00	0.637	0.9061
	40.00	11.34	1.0541	40.00	0.680	0.9024
	45.00	11.33	1.0507	45.00	0.722	0.8986
	50.00	11.32	1.0473	50.00	0.760	0.8947
	55.00	11.32	1.0439	55.00	0.798	0.8905
	60.00	11.33	1.0405	60.00	0.832	0.8862
	65.00	11.34	1.0371	65.00	0.862	0.8818
	70.00	11.34	1.0337	70.00	0.886	0.8772
	75.00	11.36	1.0303	75.00	0.907	0.8727
24.95 wt. % ethyl alcohol in solvent				59.62 wt. % ethyl alcohol in solvent		
25.00*	3.902	0.9907		25.00	0.170	0.8878
30.00*	7.130	1.0149		30.00	0.187	0.8842
35.00	7.521	1.0144		35.00	0.201	0.8806
40.00	7.678	1.0121		40.00	0.216	0.8768
45.00	7.818	1.0097		45.00	0.230	0.8726
50.00	7.930	1.0069		50.00	0.241	0.8682
55.00	8.019	1.0038		55.00	0.252	0.8638
60.00	8.086	1.0007		60.00	0.262	0.8592
65.00	8.138	0.9977		65.00	0.269	0.8546
70.00	8.182	0.9945		70.00	0.277	0.8499
75.00	8.227	0.9916		75.00	0.286	0.8453
29.79 wt. % ethyl alcohol in solvent				79.67 wt. % ethyl alcohol in solvent		
25.00*	2.672	0.9710		25.00	0.002	0.8399
30.00*	4.513	0.9834		30.00	0.004	0.8356
35.00	4.822	0.9820		35.00	0.006	0.8312
40.00	5.032	0.9803		40.00	0.008	0.8266
45.00	5.229	0.9784		45.00	0.0011	0.8220
50.00	5.387	0.9760		50.00	0.0013	0.8175
55.00	5.519	0.9733		55.00	0.0015	0.8129
60.00	5.626	0.9704		60.00	0.0017	0.8083
65.00	5.704	0.9677		65.00	0.0018	0.8036
70.00	5.761	0.9635		70.00	0.0019	0.7990
75.00	5.817	0.9595		75.00	0.0021	0.7942
40.41 wt. % ethyl alcohol in solvent				* Solid phase $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$		
25.00*	1.155	0.9412				
30.00	1.615	0.9374				
35.00	1.741	0.9355				
40.00	1.854	0.9330				
45.00	1.969	0.9299				
50.00	2.070	0.9268				
55.00	2.160	0.9235				
60.00	2.237	0.9200				
65.00	2.303	0.9160				
70.00	2.360	0.9117				
75.00	2.413	0.9072				

(Cont.)

THE SYSTEM  $\text{Na}_2\text{SO}_4$  - ETHANOL - WATER--Cont.Transition points - Solid Phase  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$  +  $\text{Na}_2\text{SO}_4$ 

Wt. % $\text{C}_2\text{H}_5\text{OH}$ in solvent	t°	density	% $\text{Na}_2\text{SO}_4$ in Sat. Sol.
3.01	31.61	1.2821	29.46
6.62	31.23	1.2271	25.32
10.35	31.03	1.1752	21.23
14.74	30.94	1.1185	16.51
19.88	30.79	1.0619	11.54
24.95	30.67	1.0169	7.510
29.79	30.35	0.9843	4.690
40.41	28.81	0.9410	1.575
50.08	26.07	0.9132	0.554

50

Transition points  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O} \rightarrow \text{Na}_2\text{SO}_4$  in the presence of ethyl alcohol

(Vener and Thompson, 1950)

t°	Wt. % $\text{C}_2\text{H}_5\text{OH}$ in solvent	Gms. $\text{Na}_2\text{SO}_4$ per 100 gms. sat. sol.	density sat. sol.
32.38	0.0	33.27	1.3324
31.60	3.09	29.38	1.2808
31.01	11.33	20.14	1.1626
30.65	25.34	7.247	1.0139
30.00	33.17	3.356	0.9671
27.44	45.85	0.943	0.9257
25.17	52.25	0.409	0.9071
19.97	56.56	0.194	0.9009

THE SYSTEM  $\text{Na}_2\text{SO}_4$  - ETHANOL - WATER

(Schreinemakers and deBaat, 1909)

Between certain concentrations of the aqueous alcohol the liquid separates into two layers. The following results were obtained at 25°, 36° and 45°.

t°	Upper Layer			Lower Layer			Solid Phase
	$\text{H}_2\text{O}$	$\text{C}_2\text{H}_5\text{OH}$	Wt. % $\text{Na}_2\text{SO}_4$	$\text{H}_2\text{O}$	$\text{C}_2\text{H}_5\text{OH}$	Wt. % $\text{Na}_2\text{SO}_4$	
25	34.90	64.95	0.15	-	-	-	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
25	46.6	53.0	0.4	-	-	-	" + $\text{Na}_2\text{SO}_4$
25	49.0	50.5	0.5	-	-	-	$\text{Na}_2\text{SO}_4$
25	63.41	34.84	1.75	-	-	-	-
25	66.5	27.3	6.2	67.4	5.1	27.5	-
25	68.1	23.9	8.0	68.5	6.0	25.5	-
25	68.3	23.1	8.6	68.3	6.7	25.0	-
36	-	-	-	66.6	4.1	29.3	-
36	57.7	38.4	3.9	-	-	-	-
36	65.0	28.3	6.7	68.8	5.9	25.3	-
36	68.1	21.2	10.7	68.9	9.4	21.7	-
45	61.8	32.9	5.3	-	-	-	-
45	65.8	25.3	8.9	68.4	8.8	22.8	-
45	66.0	24.0	10.0	68.6	10.1	21.3	-

# Na SODIUM

## THE SYSTEM SODIUM SULFATE - SULFURIC ACID - ETHYL ALCOHOL (Dunncliff and Hoon, 1926)

The authors studied the action of alcohol upon sodium hydrogen sulfate and found that the maximum concentration of acid obtained in the liquid phase was 17.75 per cent. With quantities of salt necessary to yield higher concentrations it was impossible to separate the liquid phase and the "Rest." Hence the system could not be further investigated by this method. They then studied the action of alcoholic sulfuric acid solutions upon sodium sulfate and sodium hydrogen sulfate. The experimental results are not presented in a manner which can be easily understood.

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## SOLUBILITY OF SODIUM SULFATE IN AQUEOUS PROPYL ALCOHOL AT 20° (Linebarger, 1892)

Gms. C <sub>3</sub> H <sub>7</sub> OH per 100 Gms. Alcohol-Water Mixture	Gms. Na <sub>2</sub> SO <sub>4</sub> per 100 Gms. Sat. Solution	Gms. C <sub>3</sub> H <sub>7</sub> OH per 100 Gms. Alcohol-Water Mixture	Gms. Na <sub>2</sub> SO <sub>4</sub> per 100 Gms. Sat. Solution
42.20	1.99	56.57	0.55
49.77	1.15	60.64	0.44
55.65	0.72	62.81	0.38

## THE SYSTEM Na<sub>2</sub>SO<sub>4</sub> - ISOPROPYL ALCOHOL - WATER (Mills and Smith, 1957)

At and above 40°, two liquid phases are formed. In other experiments, only one phase was found at 23°.

Results at 40°		Results at 60°	
Wt. % i-C <sub>3</sub> H <sub>7</sub> OH	Wt. % H <sub>2</sub> O	Wt. % i-C <sub>3</sub> H <sub>7</sub> OH	Wt. % H <sub>2</sub> O
57.6	0.5	75.0	0.2
49.7	1.2	38.7	2.9
37.5	3.0	31.0	4.3
24.8	6.8	22.4	7.4
10.3	14.9	9.0	15.2
4.6	22.0	2.4	24.4
0.5	30.4	1.6	27.7
0.0	32.8	0.0	31.2

Tie-line data

{ 0.6	30.8
{ 65.3	0.5
{ 3.9	23.4
{ 46.2	1.8

Tie-line data

{ 1.2	28.3
{ 68.8	0.6
{ 5.0	20.3
{ 55.4	1.4

The effect of the addition of sodium sulfate (0.004 to 0.008 molar) on the mutual solubility of n-butyl alcohol and water is reported by Reber, McNabb, and Lucasse, 1942.

THE SYSTEM SODIUM SULFATE - TERTIARY BUTYL ALCOHOL - WATER AT 30°  
(Ginnings and Robbins, 1930)

The points on the binodal curve of this system were determined by observing the appearance or disappearance of clouding in mixtures of weighed amounts of  $\text{Na}_2\text{SO}_4$  and one of the liquids, upon addition of weighed amounts of the other. Tie lines, \*, were located by determining the  $\text{Na}_2\text{SO}_4$  in two layers in contact with each other and from these the plait point, PP, was found by plotting.

Gms. per 100 gms. homogeneous liquid			Gms. per 100 gms. homogeneous liquid			Gms. per 100 gms. homogeneous liquid		
$(\text{CH}_3)_3\text{COH}$		$\text{Na}_2\text{SO}_4$	$(\text{CH}_3)_3\text{COH}$		$\text{Na}_2\text{SO}_4$	$(\text{CH}_3)_3\text{COH}$		$\text{Na}_2\text{SO}_4$
93.0	-	*	28.8	3.4		10.2	9.5	
68.0	-	*	26.3	3.6		-	10.5 *	
66.0	-	*	24.9	3.9		8.1	11.4	
58.6	0.3		22.9	4.2		-	11.5 *	
50.0	-	*	21.5	4.6	*	6.7	13.3	
47.0	1.2		20.8	4.9		6.1	14.2	
42.2	1.6		19.5	5.3		5.5	15.2	
37.2	2.2		17.5	5.8		4.8	16.5	
37.0	2.5	PP	16.4	6.2		3.9	17.9	
33.7	2.6		14.3	6.9		3.0	19.8	
31.1	2.9		12.4	7.8		1.8	24.5 *	

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The plait point of this system at 25° was found by Ginnings, Herring and Webb, 1933, to have the composition 2.8 percent  $\text{Na}_2\text{SO}_4$  + 31.4 percent  $(\text{CH}_3)_3\text{COH}$  + 65.8 percent  $\text{H}_2\text{O}$ .

Results for the plait point of the system sodium alum, tertiary butyl alcohol and water at 25° are given as 5.4 percent  $\text{NaAl}(\text{SO}_4)_2$  + 26.9 percent  $(\text{CH}_3)_3\text{COH}$  + 67.7 percent  $\text{H}_2\text{O}$  by Ginnings, Herring and Webb, 1933.

100 gms. 95 percent alcohol dissolve about 1.4 gms.  $\text{NaHSO}_4$  at 25°. (U.S.P. VIII)

100 gms. 95 percent formic acid dissolve 30 gms.  $\text{NaHSO}_4$  at 19.3°. (Aschan, 1913)

SOLUBILITY OF SODIUM SULFATE IN ETHYLENE GLYCOL SOLUTIONS  
(Vener and Thompson, 1949)

Only one liquid phase was found in the system. The results are in gms. of  $\text{Na}_2\text{SO}_4$  per 100 gms. saturated solution, and the density is listed in each case. The authors plotted their data and read the results from the smooth curves. In the original, results are given for 5° intervals.

(Solvents)

No.	Density at 25°	Gms. $\text{C}_2\text{H}_4(\text{OH})_2$ per 100 gms. Solvent	No.	Density at 25°	Gms. $\text{C}_2\text{H}_4(\text{OH})_2$ per 100 gms. Solvent
8	1.0072	8.0	45	1.0564	45.5
12	1.0122	11.9	60	1.0739	60.6
16	1.0173	15.7	70	1.0846	69.8
25	1.0292	24.4	80	1.0935	78.8
32	1.0385	31.4	90	1.1034	90.3
40	1.0493	39.9	99	1.1096	99.2



## Na SODIUM

## SOLUBILITY OF SODIUM SULFATE IN ETHYLENE GLYCOL SOLUTIONS--Cont.

t°	Solvent					
	8	12	16	25	32	40
25	19.36 1.1918	18.37 1.1858	17.46 1.1807	15.82 1.1748	13.28 1.1589	9.036 1.1289
30	27.70 1.2780	25.69 1.2604	23.02 1.2357	17.13 1.1855	13.05 1.1538	8.947 1.1256
40	27.24 1.2673	24.76 1.2447	22.19 1.2219	16.59 1.1744	12.67 1.1445	8.820 1.1189
50	26.45 1.2520	24.08 1.2311	21.56 1.2093	16.15 1.1642	12.37 1.1357	8.707 1.1119
60	25.79 1.2390	23.53 1.2185	21.06 1.1975	15.83 1.1546	12.15 1.1270	8.610 1.1049
70	25.27 1.2264	23.08 1.2066	20.64 1.1864	15.57 1.1453	12.02 1.1184	8.530 1.0966
80	24.88 1.2141	22.74 1.1955	20.32 1.1753	15.36 1.1355	11.90 1.1095	8.461 1.0877
90	24.60 1.2033	22.45 1.1847	20.09 1.1651	15.19 1.1258	11.79 1.1012	8.399 1.0798
100	24.45 1.1953	22.21 1.1759	19.91 1.1556	15.03 1.1172	11.67 1.0942	8.340 1.0724

t°	Solvent					
	45	60	70	75	90	99
25	6.924 1.1171	3.263 1.1021	1.922 1.1014	1.143 1.1035	0.773 1.1113	0.540 1.1146
30	6.865 1.1135	3.256 1.0985	1.910 1.0981	1.133 1.0999	0.734 1.1071	0.514 1.1113
40	6.770 1.1068	3.242 1.0922	1.885 1.0911	1.111 1.0927	0.668 1.0994	0.458 1.1052
50	6.708 1.1003	3.219 1.0857	1.862 1.0844	1.085 1.0856	0.608 1.0916	0.402 1.0995
60	6.670 1.0932	3.194 1.0786	1.841 1.0771	1.059 1.0785	0.550 1.0839	0.351 1.0927
70	6.637 1.0850	3.174 1.0707	1.821 1.0695	1.032 1.0718	0.508 1.0769	0.309 1.0852
80	6.606 1.0764	3.155 1.0621	1.799 1.0614	1.005 -	0.481 -	0.276 -
90	6.579 1.0686	3.139 1.0542	1.779 1.0530	0.977 -	0.457 -	0.249 -
100	6.549 1.0609	3.120 1.0464	1.4755 1.0444	0.950 -	0.438 -	0.230 -

(Cont.)

## SOLUBILITY OF SODIUM SULFATE IN ETHYLENE GLYCOL SOLUTIONS--Cont.

Additional Determinations Above 100°

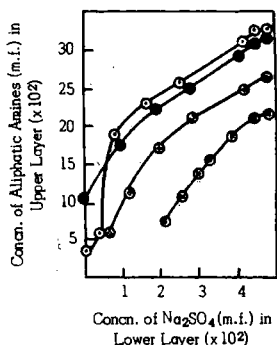
Solvent = 10.5 Wt. % Glycol	Solvent = 41.0 Wt. % Glycol	Solvent = 67.5 Wt. % Glycol
104.5° B.P.	107.1° B.P.	114.4° B.P.
104.3° 22.91	106.7° 7.915	113.9° 1.975
103.5° 22.92	105.6° 7.910	109.8° 1.997
99.8° 22.95	100.0° 7.914	98.8° 2.034
Solvent = 18.1 Wt. % Glycol	Solvent = 45.5 Wt. % Glycol	Solvent = 75.5 Wt. % Glycol
104.9° B.P.	108.3° B.P.	119.7° B.P.
104.5° 18.46	108.0° 6.624	119.2° 1.104
102.9° 18.46	106.6° 6.611	112.7° 1.132
96.4° 18.52	100.4° 6.644	100.0° 1.190
Solvent = 24.2 Wt. % Glycol	Solvent = 48.6 Wt. % Glycol	Solvent = 80.0 Wt. % Glycol
105.1° B.P.	108.9° B.P.	124.3° B.P.
104.8° 15.19	108.8° 5.528	123.5° 0.795
103.9° 15.19	106.3° 5.530	117.3° 0.791
99.7° 15.23	98.8° 5.554	99.3° 0.860
Solvent = 36.2 Wt. % Glycol	Solvent = 60.1 Wt. % Glycol	Solvent = 90.0 Wt. % Glycol
106.0° B.P.	111.3° B.P.	136.3° B.P.
105.8° 9.839	110.9° 3.188	135.1° 0.421
104.4° 9.836	108.9° 3.183	122.7° 0.414
101.8° 9.859	100.0° 3.201	100.0° .454

SO

B.P. = boiling point

THE SYSTEM  $\text{Na}_2\text{SO}_4$  - PYRIDINE - WATER

Binodal curves and plait points are given by Ginnings, Webb and Hinohara, 1933. Data for the conjugation curve in this system (at 30°) and in the system  $\text{Na}_2\text{SO}_4$  + 2 - picoline - water are given by Arakawa, Kawaguchi and Kato, 1958.

THE SYSTEM  $\text{Na}_2\text{SO}_4$  - ALIPHATIC AMINES - WATER AT 30°  
(Arakawa and Kawaguchi, 1958)

Compositions of the conjugate solutions are indicated for four primary aliphatic amines.

m.f. = mole fraction  
 ○ = heptylamine  
 ● = hexylamine  
 □ = amylamine  
 ● = butylamine

## Na SODIUM

### SOLUBILITY OF SODIUM SULFATE IN AQUEOUS SOLUTIONS OF URETHAN AT 25° (Palitzsch, 1928, 1929)

Gms. Mols. per 1000 gms. H <sub>2</sub> O		Solid Phase
Na <sub>2</sub> SO <sub>4</sub>	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>	
1.936	0.0	Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O
1.542	0.8273	"
0.184	16.17	Upper liquid layer
1.214	1.897	Lower liquid layer

### SOLUBILITY OF SODIUM SULFATE IN AN AQUEOUS SOLUTION OF UREA (Löwenherz, 1895)

SO

Solvent	t°	Gms. Na <sub>2</sub> SO <sub>4</sub> per 100 Gms. Sat. Sol.	The Corresponding Figure for the Solubility of Na <sub>2</sub> SO <sub>4</sub> in Pure Water Was Found to be:
100 gms. H <sub>2</sub> O + 12 gms. urea	20.86	22.36	-
" "	24.83	21.21	21.62
" "	28.32	26.50	26.48
" "	29.83	28.23	-
" "	31.90	-	32.34
" "	34.85	27.73	33.09
" "	39.92	27.19	32.58

100 gms. H<sub>2</sub>O dissolve 183.7 gms. sugar + 30.5 gms. Na<sub>2</sub>SO<sub>4</sub> at 31.25°, or 100 gms. sat. solution contain 52.2 gms. sugar + 9.6 gms. Na<sub>2</sub>SO<sub>4</sub>. (Köhler, 1897)

100 gms. 95% formic acid dissolve 16.5 gms. Na<sub>2</sub>SO<sub>4</sub> at 19°. (Aschan, 1913)

100 gms. of a saturated solution of Na<sub>2</sub>SO<sub>4</sub>·10H<sub>2</sub>O in glycerol of 95 percent purity (d<sub>25</sub> = 1.246) contain 7.52 gms. Na<sub>2</sub>SO<sub>4</sub>·10H<sub>2</sub>O at 25°. (Schnellbach and Rosin, 1929)

For data in the system Na<sub>2</sub>SO<sub>4</sub> - acetone - water at 35° see Int. Critical Tables, Vol. III, p. 410.

### SOLUBILITY OF SODIUM SULFATE IN SEVERAL ALCOHOLS (Kirn and Dunlap, 1931)

Alcohol	Formula	Gm. Mols. Na <sub>2</sub> SO <sub>4</sub> per 100 gm. Mols. Alcohol at:			
		20°	30°	40°	50°
Methanol	CH <sub>3</sub> OH	0.00555	0.00544	0.00523	0.00415
Ethanol	C <sub>2</sub> H <sub>5</sub> OH	0.00143	0.00154	0.00156	0.00114
Iso Propanol	CH <sub>3</sub> CHOHCH <sub>3</sub>	0.000886	0.000939	0.000928	0.000739

(Insoluble in Propanol, Butanol and Iso Butanol.)

Other data in methanol are given by Barber and Ali, 1950.

Melting point data are given for:

$\text{Na}_2\text{SO}_4 + \text{KCl}$	(Sackur, 1911-12)	
$\text{Na}_2\text{SO}_4 + \text{SrSO}_4$	(Calcagni, 1912-1912a)	
$\text{Na}_2\text{SO}_4 + \text{Na}_2\text{WO}_4$	(Boeke, 1907)(Belyaev, 1952)	
$\text{Na}_2\text{SO}_4 + \text{PbSO}_4$	(Perrier, 1940)(Belyaev, 1952)(Gladushchenko and Bergman, 1955)	
$\text{Na}_2\text{SO}_4 + \text{V}_2\text{O}_5$	(Illarionov, Ozerov and Kil'disheva, 1957)	
$\text{Na}_2\text{SO}_4 + \text{CdSO}_4$	(Bakumskaya and Bergman, 1956)	
$\text{Na}_2\text{SO}_4 + \text{Li}_2\text{SO}_4$	(Bakumskaya and Bergman, 1956)	
$\text{Na}_2\text{SO}_4 + \text{Li}_2\text{SO}_4 + \text{CdSO}_4$	(Bakumskaya and Bergman, 1956)	
$\text{Na}_2\text{SO}_4 + \text{BeSO}_4$	(Fedorov and Chang, 1957)	
$\text{Na}_2\text{SO}_4 + \text{NiSO}_4$	(Bol'shakov and Fedorov, 1956)	
$\text{Na}_2\text{SO}_4 + \text{CoSO}_4$	(Bol'shakov and Fedorov, 1956)	
$\text{Na}_2\text{SO}_4 + (\text{NH}_4)_2\text{SO}_4$	(Hilmy, 1953)	
$\text{Na}_2\text{SO}_4 + \text{Na}_2\text{SiO}_3$	(Bergman, Nesterova and Bychkova, 1955)	SO
$\text{Na}_2\text{SO}_4 + \text{Na}_2\text{O}$	(Kohlmeier and Lohrke, 1955)	
$\text{Na}_2\text{SO}_4 + \text{ZnSO}_4$	(Evseeva, 1953)	
$\text{Na}_2\text{SO}_4 + \text{PbMoO}_4 = \text{Na}_2\text{MoO}_4 + \text{PbSO}_4$		

#### SODIUM PHENYL SULFATE $\text{C}_6\text{H}_5\text{O}_4\text{SHa} \cdot 3\text{H}_2\text{O}$

100 gms. sat. solution in water contain 31.0 gms. of the compound at 17°. 100 gms. sat. solution in alcohol contain 7.0 gms. of the compound at 17°. (Burkhardt and Lapworth, 1926.)

#### SODIUM H-PHENYL $\beta$ AMINOCETHYL HYDROGEN SULFATE $\text{C}_6\text{H}_5\text{HH} \cdot \text{C}_2\text{H}_4\text{OSO}_3\text{Na} \cdot \text{H}_2\text{O}$

100 cc. sat. solution in water contain approx. 60 gms. of the compound at 15°. (Saunders, 1922.)

#### SODIUM ALKYL SULFATES

For results on sodium lauryl sulfate in water at 25° see Williams, Phillips and Mysels, 1955; for sodium dodecyl sulfate see Phillips and Mysels, 1955.

#### SODIUM THIOSULFATE $\text{Na}_2\text{S}_2\text{O}_3$

##### SOLUBILITY IN WATER

A large number of hydrates have been identified. The results of Young and Burke, 1904, 1906 (first table) are in good agreement with those of Picon, 1924 (second table). Young and Burke adopted a new system of naming the hydrates, based upon their mutual transition relations. These transitions occur in such a way that the members of one group undergo transition into members of the same group and not into members of another group. Those hydrates belonging to group (I) are called primary hydrates, those belonging to group (II) are called secondary and

# Na SODIUM

those belonging to the (III), (IV) and (V) groups are called tertiary, quaternary and quintary respectively.

Commercial sodium thiosulfate is the primary pentahydrate,  $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$  (I).

	Gms. Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> per 100 Gms.			Solid Phase	t°	Gms. Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> per 100 Gms.			Solid Phase
	Sat.		Water			Sat.		Water	
	Sol.					Sol.			
SO	0	33.40	50.15	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 5H <sub>2</sub> O(I)	14.3	-	-	-	" + Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 7H <sub>2</sub> O(III)
	10	37.37	59.66	"	0	57.42	134.8	-	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 7H <sub>2</sub> O(III)
	20	41.20	70.07	"					
	25	43.15	75.90	"	10	58.28	139.7	"	"
	35	47.71	91.24	"	20	59.28	145.6	"	"
	45	55.33	123.87	"	25	60.18	151.1	"	"
	48.17	-	-	" + Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 2H <sub>2</sub> O(I)	30	60.78	155	"	"
				Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 2H <sub>2</sub> O(I)	40	62.60	167.4	"	"
	0	52.73	111.60	"	47.5	64.68	183.1	"	"
				"	48.5	-	-	"	" + Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · H <sub>2</sub> O(III)
	10	53.94	117.10	"					Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · H <sub>2</sub> O(III)
	20	55.15	122.68	"	47.5	64.78	183.9	"	"
	25	56.03	127.43	"					"
	30	57.13	138.84	"	50	65.3	188.2	"	"
	40	59.38	146.20	"	55	66.45	198.1	"	"
	50	62.28	165.11	"	60	68.07	213.1	"	"
	60	65.68	191.30	"	61	-	-	"	" + Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>
	66.5	-	-	" + Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	0	57.63	136	-	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 4/3H <sub>2</sub> O(IV)
	0	41.96	72.30	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 5H <sub>2</sub> O(II)	10	58.49	140.9	"	"
	10	45.25	82.65	"	20	59.57	147.3	"	"
	20	49.38	97.55	"	25	60.35	152.2	"	"
	25	52.15	108.98	"	30	61.03	156.6	"	"
	30	56.57	130.26	"	40	62.95	169.9	"	"
	30.22	-	-	" + Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 4H <sub>2</sub> O(II)	50	65.45	189.5	"	"
				Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 4H <sub>2</sub> O(II)	55	67.07	203.7	"	"
	33.5	58.59	141.48	"	58	-	-	"	" + Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>
			"	0	57.63	136	-	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 2H <sub>2</sub> O(V)	
36.2	60.51	153.23	"	10	59.05	144.2	"	"	
36.6	62.80	168.82	"	20	61.02	156.5	"	"	
40.65	-	-	" + Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · H <sub>2</sub> O(II)	25	62.30	165.3	"	"	
			Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · H <sub>2</sub> O(II)	30	63.56	174.4	"	"	
0	60.47	153	"	35	65.27	188	"	"	
			"	27.5	-	-	"	" + Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · H <sub>2</sub> O(V)	
10	61.04	156.7	"					Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · H <sub>2</sub> O(V)	
20	62.11	163.9	"	30	63.34	172.80	"	"	
25	62.73	168.3	"					"	
30	63.56	174.4	"	40	64.75	183.70	"	"	
40	65.22	187.6	"	50	66.58	199.2	"	"	
50	66.82	201.4	"	55	67.59	208.5	"	"	
56.5	-	-	" + Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>					"	
0	46.14	85.67	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 6H <sub>2</sub> O(III and IV)	43	-	-	"	" + Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 1/2H <sub>2</sub> O(V)	
			"	25	64.21	179.4	-	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 1/2H <sub>2</sub> O(V)	
10	51.66	106.8	"					"	
13	54.96	122	"	40	64.99	185.6	"	"	
14.35	-	-	" + Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 4/3H <sub>2</sub> O(IV)	50	66.02	194.3	"	"	
			"	60	67.4	206.7	"	" (Cont.)	

t°	Gms. Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> per 100 Gms.			t°	Gms. Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> per 100 Gms.		
	Sat. Sol.	Water	Solid Phase		Sat. Sol.	Water	Solid Phase
70	69.06	223.2	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> · 1 1/2 H <sub>2</sub> O(V)	50	67.76	210.2	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>
70	-	-	" + Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	60	68.48	217.3	"
40	67.4	206.7	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	70	69.05	223.1	"
				80	69.86	231.8	"

## (Results of Picon, 1924)

This entire system has been reinvestigated by a method of determination involving the reheating of previously crystallized mixtures of accurately weighed amounts of the constituents, and observing the temperature of disappearance of the last crystal. The results are, with few exceptions, in very good agreement with the determinations of Young and Burke, 1904, 1906 (preceding table).

t°	Mol. % Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	t°	Mol. % Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	t°	Mol. % Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	t°	Mol. % Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>
Ice Curve		Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·6H <sub>2</sub> O (III) Curve		Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O (I) Curve		Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·2H <sub>2</sub> O (II) Curve	
- 1.8	0.85	-16.0	6.24	9.75	6.23	49.6	15.57
- 4.3	2.09	-13.0	6.56	12.7	6.43	56.7	16.81
- 6.8	3.40	- 9.5	7.00	15.7	6.87	59.0	17.40
- 8.6	4.14	- 3.0	8.02	18.4	7.01	61.3	18.23
-10.0	4.50	- 0.5	8.45	23.1	7.64	62.3	18.30
-10.6	4.71	+ 3.4	9.00	25.8	8.02	64.9	19.20
-14.0	5.70	8.0	10.00	31.0	8.59	65.0	19.20
-17.5	6.56	12.9	11.92	37.6	9.68	65.5	19.40
-22.5	7.25			41.5	10.97	66.0	19.51
Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·12H <sub>2</sub> O (II) Curve		Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O (II) Curve		45.5	12.50	66.5	19.68
-16.5	7.49	-14.0	6.34	46.9	13.46	66.8	19.71
-16.3	8.02	- 9.0	6.56	47.8	14.28	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·H <sub>2</sub> O (I) Curve	
Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·10H <sub>2</sub> O (I) Curve		- 2.9	7.03	48.0	15.02	46.2	17.06
-13.9	6.01	+ 2.5	7.56	48.2	15.72	51.9	18.08
-11.5	6.34	5.4	7.98	48.3	16.55	52.5	18.10
-10.5	6.56	14.5	8.98	48.6	17.35	59.0	19.20
- 9.5	7.0	20.8	10.00	48.0	17.80	59.5	19.34
- 9.0	7.25	25.5	10.98	48.0	18.15	61.4	19.75
- 8.6	7.49	28.1	11.92	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·4H <sub>2</sub> O (II) Curve		62.4	19.84
- 8.2	8.02	30.1	13.01	34.9	14.23	63.5	20.19
- 7.9	8.45	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O (I) Curve		37.9	15.00	65.4	20.48
		- 4.8	4.92	39.0	16.05	66.5	20.79
		- 3.4	4.94	40.0	16.74	66.8	20.86
		- 1.0	5.21	40.1	17.23	67.5	21.17
		+ 3.6	5.66			69.1	21.39
		4.5	5.73			69.5	21.64
		8.5	6.02				

(Cont.)

# Na SODIUM

(Results of Picon, 1924--Cont.)

t°	Mol. % Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	t°	Mol. % Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	t°	Mol. % Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	t°	Mol. % Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>
	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·H <sub>2</sub> O (I)		Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·½H <sub>2</sub> O (I)		Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>		Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>
	Curve		Curve		Curve		Curve
45.6	17.92	59.5	18.77	61.0	19.69	79.75	20.48
49.5	18.49	63.5	19.06	61.7	19.72	83.0	20.80
51.5	18.62	65.0	19.32	67.0	19.90	88.0	20.97
53.3	19.05	66.5	19.40	68.0	19.94	91.0	21.19
55.5	19.33	67.2	19.44	68.5	19.96	93.5	21.30
57.5	19.61	69.5	19.75	69.5	19.98	97.0	21.58
59.0	19.84	70.0	19.80	69.8	20.08	107.0	22.32
60.5	20.06	72.0	20.07	74.0	20.22	112.0	22.60
61.7	20.22	75.0	20.44	74.6	20.29	112.5	22.69
63.75	20.64	76.0	20.72	76.5	20.42	114.5	22.91
65.0	20.84	88.0	22.26				
70.0	21.86						
71.5	22.17						
72.0	22.26						
72.5	22.45						

## SOLUBILITY OF SODIUM THIOSULFATE IN WATER ABOVE 100° (Benrath, 1942)

t°	Gms. Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> per 100 gms. Sat. Sol.	t°	Gms. Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> per 100 gms. Sat. Sol.	t°	Gms. Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> per 100 gms. Sat. Sol.
111	71.4	136	73.4	171	77.7
125	72.4	148	74.6	179	79.1
130	72.8	159	76.3		

For solubilities of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> in water at high pressures see Mathiev, 1949.

Data for the conductivity and temperature coefficient of viscosity in the system Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> - H<sub>2</sub>O in solutions containing up to 77% Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> is given by Bak, 1939.

## THE SYSTEM Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> + CaCl<sub>2</sub> = 2NaCl + CaS<sub>2</sub>O<sub>3</sub> (+ H<sub>2</sub>O) AT 25° (Silberman and Ivanov, 1946)

Gms. per 100 gms. sat. sol.				Solid Phases
CaS <sub>2</sub> O <sub>3</sub>	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	CaCl <sub>2</sub>	NaCl	
0.0	32.98	0.0	9.86	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O + NaCl
20.33	30.19	-	-	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O + CaS <sub>2</sub> O <sub>3</sub> ·6H <sub>2</sub> O
19.70	26.42	-	4.62	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O + CaS <sub>2</sub> O <sub>3</sub> ·6H <sub>2</sub> O + NaCl
20.20	23.90	-	5.42	CaS <sub>2</sub> O <sub>3</sub> ·6H <sub>2</sub> O + NaCl
22.30	-	7.48	9.86	"
13.40	-	19.82	4.41	"
11.26	-	23.79	2.15	"
10.87	-	25.93	2.20	"

(Cont.)

THE SYSTEM  $\text{Na}_2\text{S}_2\text{O}_3 + \text{CaCl}_2 \rightleftharpoons 2\text{NaCl} + \text{CaS}_2\text{O}_3 (+ \text{H}_2\text{O})$  AT  $25^\circ$ --Cont.

Gms. per 100 gms. sat. sol.

$\text{CaS}_2\text{O}_3$	$\text{Na}_2\text{S}_2\text{O}_3$	$\text{CaCl}_2$	$\text{NaCl}$	Solid Phases
9.76	-	29.05	1.04	$\text{CaS}_2\text{O}_3 \cdot 6\text{H}_2\text{O} + \text{NaCl}$
8.64	-	31.35	0.73	$\text{CaS}_2\text{O}_3 \cdot 6\text{H}_2\text{O} + \text{CaS}_2\text{O}_3 \cdot \text{H}_2\text{O} + \text{NaCl}$
7.99	-	32.65	-	$\text{CaS}_2\text{O}_3 \cdot 6\text{H}_2\text{O} + \text{CaS}_2\text{O}_3 \cdot \text{H}_2\text{O}$
6.85	-	31.07	0.81	$\text{CaS}_2\text{O}_3 \cdot \text{H}_2\text{O} + \text{NaCl}$
6.32	-	32.10	0.90	"
0.98	-	44.2	0.85	$\text{CaS}_2\text{O}_3 \cdot \text{H}_2\text{O} + \text{CaCl}_2 \cdot 6\text{H}_2\text{O} + \text{NaCl}$
0.0	-	43.52	1.02	$\text{CaCl}_2 \cdot 6\text{H}_2\text{O} + \text{NaCl}$
1.03	-	45.01	-	$\text{CaS}_2\text{O}_3 \cdot 6\text{H}_2\text{O} + \text{CaCl}_2 \cdot 6\text{H}_2\text{O}$

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THE SYSTEM SODIUM THIOSULFATE - ETHYL ALCOHOL - WATER AT  $20^\circ$   
(Dolique, 1934)

Results determined by analysis of saturated solutions prepared by shaking together  $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ , and aqueous ethyl alcohol solutions containing various concentrations of  $\text{C}_2\text{H}_5\text{OH}$  by volume.

Vol. percent $\text{C}_2\text{H}_5\text{OH}$ in solvent used		Volume of liquid layers	d. of liquid layers	Gms. per 100 gms. liquid layer	
				$\text{Na}_2\text{S}_2\text{O}_3$	$\text{C}_2\text{H}_5\text{OH}$
10	(no separation)		1.344	36.70	4.0
20	Upper layer	7.9 cc	0.876	1.2	50.31
	Lower layer	92.1 cc	1.338	36.9	5.2
30	Upper layer	21.6 cc	0.899	1.128	51.6
	Lower layer	78.4 cc	1.338	36.90	4.8
40	Upper layer	34.8 cc	0.901	1.15	53.17
	Lower layer	65.2 cc	1.337	36.85	4.3
50	Upper layer	52.8 cc	0.898	1.10	56.7
	Lower layer	47.2 cc	1.342	36.85	4.3
60	Upper layer	73.8 cc	0.898	1.02	56.9
	Lower layer	26.2 cc	1.341	36.85	4.3
70	(no separation)		0.895	0.967	62.0
80	(no separation)		0.864	0.230	73.5
90	(no separation)		0.834	0.0146	85.7

Results determined by the synthetic method; that is by titrating known aqueous solutions of thiosulfate with known amounts of alcohol to appearance of clouding.



# Na SODIUM

## THE SYSTEM SODIUM THIOSULFATE - ETHYL ALCOHOL - WATER AT 20°--Cont.

Gms. per 100 Gms. homogeneous mixture			Gms. per 100 Gms. homogeneous mixture		
Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	H <sub>2</sub> O	C <sub>2</sub> H <sub>5</sub> OH	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	H <sub>2</sub> O	C <sub>2</sub> H <sub>5</sub> OH
28.31	62.85	8.83	4.85	53.37	41.76
24.82	63.0	11.87	3.90	51.10	45.00
16.77	61.64	21.59	3.18	40.22	47.60
7.73	57.23	35.04	1.93	43.81	54.26
6.72	55.96	37.18	0.93	36.56	62.51
6.10	55.44	38.46	0.92	31.94	67.12
5.84	54.76	39.40	0.41	29.00	70.58

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The plait point of the system sodium thiosulfate, tertiary butyl alcohol and water at 25° was found by Ginnings, Herring and Webb, 1933 to have the composition, 3.2 percent Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> + 33.6 percent (CH<sub>3</sub>)<sub>3</sub>COH + 63.2 percent H<sub>2</sub>O. The original results for the other points on the binodal curve are not given but only the values of constants calculated by means of an empirical equation.

The binodal curves and plait points of the systems:

sodium thiosulfate + allyl alcohol + water at 25°

and

sodium thiosulfate + pyridine + water at 25°

have been determined respectively by Ginnings and Dees, 1935, and Ginnings, Webb and Hinohara, 1933, but the experimental results are not given but only the values of a series of constants calculated by empirical equations.

Data for the lowering of the freezing-point of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>·5H<sub>2</sub>O by each of the following compounds: urea, glucose, cane sugar, NaCl, NaClO<sub>3</sub>, NaNO<sub>3</sub> and Na<sub>2</sub>SO<sub>4</sub> are given by Boutaric (1911).

An aqueous solution simultaneously saturated with sodium thiosulfate and urethan, contains 4.70 gm. mols. Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> + 0.132 gm. mols. NH<sub>2</sub>COOC<sub>2</sub>H<sub>5</sub> per 1000 gms. H<sub>2</sub>O at 25°. (Palitzsch, 1928, 1929.)

100 gms. alcohol dissolve 0.0025 gm. Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> and 0.0034 gm. Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>·5H<sub>2</sub>O at room temperature. (Bödtker, 1897.)

100 gms. alcohol of 0.941 Sp. Gr. dissolve 33.3 gms. sodium thiosulfate at 15.5°.

SODIUM HYPOSULFITE  $\text{Na}_2\text{S}_2\text{O}_4$   
(HYDROSULFITE)

SO

SOLUBILITY IN WATER  
(Jellinck, 1911)

The pure sample was prepared by salting out the commercial product with NaCl. It is very easily oxidized to  $\text{Na}_2\text{S}_2\text{O}_5$  and must be kept in an indifferent atmosphere or a vacuum. A special apparatus was required for the freezing-point determinations (ice curve) and for the solubility determinations. Great difficulty was experienced in obtaining concordant results with a given sample of  $\text{Na}_2\text{S}_2\text{O}_4$ .

t°	Gms. Na <sub>2</sub> S <sub>2</sub> O <sub>4</sub> per 100 Gms. H <sub>2</sub> O	Solid Phase	t°	Gms. Na <sub>2</sub> S <sub>2</sub> O <sub>4</sub> per 100 Gms. H <sub>2</sub> O	Solid Phase
-0.107	0.394	Ice	* - 4.58	19	Ice + Na <sub>2</sub> S <sub>2</sub> O <sub>4</sub> ·2H <sub>2</sub> O
-1.10	4	"	+20	.22 (+5% error)	Na <sub>2</sub> S <sub>2</sub> O <sub>4</sub> ·2H <sub>2</sub> O
-2.21	9	"	† 52	27.8	" + Na <sub>2</sub> S <sub>2</sub> O <sub>4</sub>
-3.15	13	"	20	24.1	Na <sub>2</sub> S <sub>2</sub> O <sub>4</sub> (unstable)
-4.17	17	"			

\*eutectic

†transfer point

The binodal curves and plait points of the system  $\text{Na}_2\text{S}_2\text{O}_4$  - pyridine - water is given by Ginnings, Webb and Hinohara, 1933, but the authors do not give their experimental results but only the values of arbitrary constants calculated by means of empirical equations.

At 25° 1.34 gms.  $\text{Na}_2\text{S}_2\text{O}_4$  dissolve in 100 gms. of ethylene glycol.

At 25° 0.37 gms.  $\text{Na}_2\text{S}_2\text{O}_4$  dissolve in 100 gms. of propylene glycol. (Palit, 1947)

SODIUM PYROSULFITE  $\text{Na}_2\text{S}_2\text{O}_5$

SO

SOLUBILITY OF SODIUM PYROSULFITE IN WATER  
(Foerster, Brosch and Norberg-Schulz, 1924)

The determinations were made with exceptional care. Equilibrium was approached from above and below. A new preparation of the salt was used for each determination and the composition of the solid phase was determined by analysis in each case. In order to reduce the free sulfur dioxide present, the volume of air space above the saturated solution was kept at a minimum. The two hydrates give solubility curves which are almost parallel. The metastable hexahydrate is very easy to obtain and its equilibrium with the solutions can be readily followed.

# Na SODIUM

## SOLUBILITY OF SODIUM PYROSULFITE IN WATER--Cont.

t°	Gms. Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub> per 100 gms. sat. sol.	Solid Phase	t°	Gms. Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub> per 100 gms. sat. sol.	Solid Phase
-0.56	1.435	Ice	-5.0	26.15	Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub> ·7H <sub>2</sub> O
-2.28	6.40	"	0.0	31.10	"
-3.19	9.00	"	+1.2	32.45	"
-5.24	14.64	"	5.5 <sup>t</sup>	-	" + Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub>
-7.84	20.92	"	0.0	37.47 <sup>u</sup>	Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub>
-9.74 <sup>e</sup>	24.20	" + Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub> ·6H <sub>2</sub> O	8.6	38.65	"
-8.5	24.75	Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub> ·6H <sub>2</sub> O	15.0	39.20	"
-4.2	28.10	"	22.8	39.77	"
-2.2	30.25	"	25	(39.75) <sup>a</sup>	"
0.0	32.90	"	31.4	40.79	"
+1.8	35.40	"	35	(40.55) <sup>a</sup>	"
3.0	37.10	"	40.2	41.60	"
3.8 <sup>t</sup>	-	" + Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub>	59.0	44.27	"
-9.05 <sup>e</sup>	23.50	Ice + Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub> ·7H <sub>2</sub> O	71.4	45.62	"
-9.0	23.77	Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub> ·7H <sub>2</sub> O	85.0	47.89	"
-7.5	24.50	"	97.2	49.06	"

eutectic    <sup>t</sup>transfer point    <sup>u</sup>unstable    <sup>a</sup>Data of Arai, 1927

# SO SODIUM DITHIONATE Na<sub>2</sub>S<sub>2</sub>O<sub>6</sub>

## SOLUBILITY OF SODIUM DI THIONATE IN WATER (Ishikawa and Oku, 1927)

t°	d. of sat. sol.	Gms. Na <sub>2</sub> S <sub>2</sub> O <sub>6</sub> per 100 gms. H <sub>2</sub> O	Solid Phase
- 1.36	-	5.72	Na <sub>2</sub> S <sub>2</sub> O <sub>6</sub> ·8H <sub>2</sub> O
- 0.73	-	5.94	"
- 0.49	-	6.04	"
0.0	-	6.27	" + Na <sub>2</sub> S <sub>2</sub> O <sub>6</sub> ·6H <sub>2</sub> O
+ 1.0	-	6.62	Na <sub>2</sub> S <sub>2</sub> O <sub>6</sub> ·6H <sub>2</sub> O
3.0	1.054	7.49	"
5.0	1.056	8.47	"
7.5	1.068	9.82	"
9.1	-	10.80	" + Na <sub>2</sub> S <sub>2</sub> O <sub>6</sub> ·2H <sub>2</sub> O
10.0	-	11.34 <sup>m</sup>	"
0	1.0565	7.83 <sup>m</sup>	Na <sub>2</sub> S <sub>2</sub> O <sub>6</sub> ·2H <sub>2</sub> O
5	-	9.34 <sup>m</sup>	"
10	1.0773	11.12	"
20	1.0984	15.12	"
30	1.1216	19.63	"
40	1.1460	24.69	"
50	1.1705	30.17	"
60	1.1920	36.07	"
70	1.2191	42.48	"
80	1.2425	49.26	"
90	1.2711	56.29	"
100	1.2981	64.74	"

m = metastable

## SOLUBILITY OF SODIUM DI THIONATE IN WATER--Cont.

Data of de Baat (1926), in fair agreement:

t°	0	12	20	30
Gms. $\text{Na}_2\text{S}_2\text{O}_3$ per 100 gms. sat. sol.	6.44	10.63	13.39	17.32

THE SYSTEM  $\text{Na}_2\text{S}_2\text{O}_6$  -  $\text{SrS}_2\text{O}_6$  -  $\text{H}_2\text{O}$  AT 30°  
(de Baat, 1926)

Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
$\text{Na}_2\text{S}_2\text{O}_6$	$\text{SrS}_2\text{O}_6$		$\text{Na}_2\text{S}_2\text{O}_6$	$\text{SrS}_2\text{O}_6$	
17.32	0.0	$\text{Na}_2\text{S}_2\text{O}_6 \cdot 2\text{H}_2\text{O}$	6.91	12.24	$\text{SrS}_2\text{O}_6 \cdot 4\text{H}_2\text{O}$
14.52	5.55	"	0.0	14.90	"
13.06	10.09	" + $\text{SrS}_2\text{O}_6 \cdot 4\text{H}_2\text{O}$			

SODIUM POLYTHIONATES  $\text{K}_2\text{S}_3\text{O}_6$  (tri)  
 $\text{Na}_2\text{S}_4\text{O}_6$  (tetra)  
 $\text{Na}_2\text{S}_5\text{O}_6$  (penta)

SO

THE SYSTEM SODIUM TRITHIONATE - SODIUM TETRATHIONATE - WATER  
(Kurenacker and Laszlo, 1938)

Results at 0°

Results at 20°

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
$\text{Na}_2\text{S}_3\text{O}_6$	$\text{Na}_2\text{S}_4\text{O}_6$		$\text{Na}_2\text{S}_3\text{O}_6$	$\text{Na}_2\text{S}_4\text{O}_6$	$\text{Na}_2\text{S}_5\text{O}_6$	
37.8	0.0	$\text{S}_3$	52.952.9	0.0	0.0	$\text{S}_3$
37.6	0.4	"	52.2	0.6	0.0	"
36.6	3.9	"	46.7	6.4	0.4	"
36.7	5.6	"	43.1	12.7	0.7	"
34.4	16.2	"	40.0	17.8	1.1	"
32.8	20.8	" + $\text{S}_4$	38.8	19.3	1.6	" + $\text{S}_4$
30.9	21.0	$\text{S}_4$	34.0	21.6	2.8	$\text{S}_4$
28.6	22.4	"	25.3	27.3	2.2	"
20.6	26.9	"	21.3	30.5	3.4	"
16.6	28.2	"	12.1	37.9	2.3	"
11.9	33.7	"	9.8	40.4	3.2	"
2.9	39.8	"	5.1	45.8	2.0	"
0.0	41.3	"	1.4	49.7	0.5	"
59.0(30°)	0.0	$\text{S}_3$	0.0	50.4	-	"
			0.0	55.0(30°)	-	"

 $\text{S}_3 = \text{Na}_2\text{S}_3\text{O}_6 \cdot 3\text{H}_2\text{O}$ ;  $\text{S}_4 = \text{Na}_2\text{S}_4\text{O}_6 \cdot 2\text{H}_2\text{O}$

# Na SODIUM

## THE SYSTEM SODIUM TETRATHIONATE - SODIUM PENTATHIONATE - WATER (Kurténacker and Laszlo, 1938)

Results at 0°				Results at 20°			
Gms. per 100 Gms. sat. sol.		Solid Phase		Gms. per 100 Gms. sat. sol.		Solid Phase	
Na <sub>2</sub> S <sub>4</sub> O <sub>6</sub>	Na <sub>2</sub> S <sub>5</sub> O <sub>6</sub>			Na <sub>2</sub> S <sub>4</sub> O <sub>6</sub>	Na <sub>2</sub> S <sub>5</sub> O <sub>6</sub>		
27.8	12.5	Na <sub>2</sub> S <sub>4</sub> O <sub>6</sub> ·2H <sub>2</sub> O		22.0	8.8	Na <sub>2</sub> S <sub>4</sub> O <sub>6</sub> ·2H <sub>2</sub> O	
23.5	17.9	"		34.6	10.9	"	
22.5	19.8	" + Na <sub>2</sub> S <sub>5</sub> O <sub>6</sub> ·2H <sub>2</sub> O		33.0	13.3	"	
17.5	21.2	Na <sub>2</sub> S <sub>5</sub> O <sub>6</sub> ·2H <sub>2</sub> O		28.0	19.6	"	
14.8	22.1	"		25.2	23.3	" + Na <sub>2</sub> S <sub>5</sub> O <sub>6</sub> ·2H <sub>2</sub> O	
6.5	27.2	"		21.4	23.2	Na <sub>2</sub> S <sub>5</sub> O <sub>6</sub> ·2H <sub>2</sub> O	
4.5	29.2	"		15.3	29.8	"	
0.0	32.9	"		1.9	49.2	"	
				0.0	52.0	"	

# SOM SODIUM SULFAMATE NaSO<sub>3</sub>NNH<sub>2</sub>

## SOLUBILITY OF SODIUM SULFAMATE IN WATER (Laning and Van der Meulen, 1947)

t°	Gms. NaSO <sub>3</sub> NNH <sub>2</sub> per 100 gms. H <sub>2</sub> O	Solid Phase	t°	Gms. NaSO <sub>3</sub> NNH <sub>2</sub> per 100 gms. H <sub>2</sub> O	Solid Phase
0	79.9	NaSO <sub>3</sub> NNH <sub>2</sub> ·H <sub>2</sub> O	38.3	165.2	NaSO <sub>3</sub> NNH <sub>2</sub> ·H <sub>2</sub> O + NaSO <sub>3</sub> NNH <sub>2</sub>
20	113.0	"	40	168.6	NaSO <sub>3</sub> NNH <sub>2</sub>
25	123.8 (1)	"	45	175.1	"
	123.5 (2)	"	50	182.2	"
30	135.9	"	55	191.3	"
35	151.4	"			

(1) Ricci and Selikson, 1947

(2) Ricci and Selikson, 1952

Melting points in the system sodium sulfamate - sodium nitrate are given by Laning and Van der Meulen, 1948.

# SODIUM FLUOANTIMONATE NaSbF<sub>6</sub>

At 2°, a saturated solution in HF is 0.2 molar. (Clifford and Morris, 1957)

SODIUM ANTIMONITES  $x\text{Na}_2\text{O} \cdot y\text{Sb}_2\text{O}_3$ 

SbO

THE SYSTEM  $\text{NaOH} - \text{Sb}_2\text{O}_3 - \text{H}_2\text{O}$  AT  $20^\circ$   
(Scholder and Merbeth, 1958)

Gms. per 100 ml. sat. sol.		Solid Phase	Gms. per 100 ml. sat. sol.		Solid Phase
NaOH	$\text{Sb}_2\text{O}_3$		NaOH	$\text{Sb}_2\text{O}_3$	
1.32	0.0341	$\text{Sb}_2\text{O}_3$	21.0	1.225	$\text{Na}_2\text{Sb}_4\text{O}_7$ (m)
3.28	0.0790	"	28.8	1.250	" (m)
3.52	0.0917	"	36.5	1.274	"
5.08	0.0942	"	44.2	1.330	"
5.60	0.1576	"	44.4	1.313	"
7.96	0.1884	"	50.9	1.415	"
9.12	0.1924	"	56.1	1.520	"
7.32(!)	0.2428	"	62.4	1.778	"
10.5	0.4268	$\text{Na}_2\text{Sb}_6\text{O}_{10} \cdot 2\text{H}_2\text{O}$	63.2	1.819	"
13.0	0.4870	"	63.3	1.954	"
14.4	0.4993	"	64.2	2.478	"
15.8	0.549	"	64.8	2.656	$\text{NaSbO}_2$
19.7	0.659	"	66.4	2.421	"
20.9	0.686	"	70.4	1.989	"
21.0	0.687	"	74.7	1.646	"
28.2	0.980	"			
28.6	0.983	"			(m) metastable
28.7	0.971	"			
31.7	1.119	"			
33.1	1.266	"			

SODIUM DIHYDRO PYROANTIMONATE  $\text{Na}_2\text{H}_2\text{Sb}_2\text{O}_7$ 

SbO

100 gms. sat. solution of sodium dihydro pyroantimonate in water contain 0.0564 gms.  $\text{Na}_2\text{H}_2\text{Sb}_2\text{O}_7$  at  $18^\circ$ , 0.0738 gm. at  $25^\circ$  and 0.1018 gm. at  $33.5^\circ$ . (Tomula, 1921)

SODIUM SULFOANTIMONATE  $\text{Na}_3\text{SbS}_4$ 

SbO

SOLUBILITY IN WATER  
(Donk, 1908)

t°	Gms. $\text{Na}_2\text{SbS}_4$ per 100 gms.		Solid Phase	t°	Gms. $\text{Na}_2\text{SbS}_4$ per 100 gms.		Solid Phase
	Sat. Sol.				Sat. Sol.		
- 0.1	0.5		Ice	15	19.3		$\text{Na}_2\text{SbS}_4 \cdot 9\text{H}_2\text{O}$
- 0.65	4.0		"	30	27.1		"
- 0.9	5.7		"	38	32.0		"
- 1.26	7.8		"	49.6	38.9		"
- 1.45	9.2		"	59.6	45.0		"
- 1.75	11.2		"	69.6	50.7		"
0	11.8		$\text{Na}_2\text{SbS}_4 \cdot 9\text{H}_2\text{O}$	79.5	57.1		"

# Na SODIUM

## SOLUBILITY OF SODIUM SULFOANTIMONATE IN AQUEOUS SOLUTIONS OF SODIUM HYDROXIDE AT 30° (Donk, 1908)

Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
Na <sub>3</sub> SbS <sub>4</sub>	NaOH		Na <sub>3</sub> SbS <sub>4</sub>	NaOH	
27.1	0	Na <sub>3</sub> SbS <sub>4</sub> ·9H <sub>2</sub> O	16.4	42.6	Na <sub>2</sub> SbS <sub>4</sub> ·9H <sub>2</sub> O
13.0	9.9	"	17.7	47.2	" + NaOH·H <sub>2</sub> O
5.9	24.8	"	9.1	49.5	NaOH·H <sub>2</sub> O
10.5	32.9	"	0	54.3	

SbO

## THE SYSTEM Na<sub>3</sub>SbS<sub>4</sub> - Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> - H<sub>2</sub>O (Donk, 1908)

Results at 0°			Results at 30°		
Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
Na <sub>3</sub> SbS <sub>4</sub>	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>		Na <sub>3</sub> SbS <sub>4</sub>	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	
11.8	0	Na <sub>3</sub> SbS <sub>4</sub> ·9H <sub>2</sub> O	19.9	7.7	Na <sub>3</sub> SbS <sub>4</sub> ·9H <sub>2</sub> O
4.4	4.9	"	12.5	16.4	"
0.8	14.6	"	4.2	37.7	"
0.1	27.3	"	1	43.8	"
0	33.6	" + Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O	1	47.0	"
0	33.6	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O	1	47.8	" + Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O
			0	45.8	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> ·5H <sub>2</sub> O

## SOLUBILITY OF SODIUM SULFOANTIMONATE IN AQUEOUS METHYL ALCOHOL (Donk, 1908)

Results at 0°			Results at 30°		
Gms. per 100 Gms. Sat. Sol.		Solid Phase	Gms. per 100 Gms. Sat. Sol.		Solid Phase
Na <sub>3</sub> SbS <sub>4</sub>	CH <sub>3</sub> OH		Na <sub>3</sub> SbS <sub>4</sub>	CH <sub>3</sub> OH	
8.6	3.4	Na <sub>3</sub> SbS <sub>4</sub> ·9H <sub>2</sub> O	27.1	0	Na <sub>3</sub> SbS <sub>4</sub> ·9H <sub>2</sub> O
2.8	15.5	"	12.8	18.1	"
2.1	23.1	"	5.8	33.1	"
0.3	50.3	"	0.1	65.7	"
0.1	57.0	"	0.1	84.2	"
0.05	81.7	"	1.2	91.2	"
0.2	92.0	"	3.9	94.0	"
2.0	95.9	"			

SOLUBILITY OF SODIUM SULFOANTIMONATE IN AQUEOUS ETHYL ALCOHOL  
(Donk, 1908)

Results at 0°		Results at 30°		Results at 65°	
Gms. per 100 Gms. Sat. Sol.		Gms. per 100 Gms. Sat. Sol.		Gms. per 100 Gms. Sat. Sol.	
Na <sub>3</sub> SbS <sub>4</sub>	C <sub>2</sub> H <sub>5</sub> OH	Na <sub>3</sub> SbS <sub>4</sub>	C <sub>2</sub> H <sub>5</sub> OH	Na <sub>3</sub> SbS <sub>4</sub>	C <sub>2</sub> H <sub>5</sub> OH
11.8	0	19.3	5.0	47.9	0
8.2	3.7	14.6	10.3	39.3	4.7
3.2	12.7	6.4	24.8	36.5	8*
0.9	29.0	1.2	46.0	4.1	54.1*
0	60.8	0	76.2	0	81

SbO

\*Two liquid layers separate between these concentrations of alcohol. The composition of several of these conjoined layers is as follows:

Gms. per 100 Gms. Alcoholic Layer		Gms. per 100 Gms. Aqueous Layer	
Na <sub>3</sub> SbS <sub>4</sub>	C <sub>2</sub> H <sub>5</sub> OH	Na <sub>3</sub> SbS <sub>4</sub>	C <sub>2</sub> H <sub>5</sub> OH
4.1	54.1	36.5	8
10.2	40.4	27.8	14.3
14.1	33.5	24.1	18.8
-	0	18	27.2

The solid phase in contact with each of the above solutions is Na<sub>3</sub>SbS<sub>4</sub>·9H<sub>2</sub>O.

SODIUM SELENITE Na<sub>2</sub>SeO<sub>3</sub>

SeO

SOLUBILITY OF SODIUM SELENITE IN WATER  
(Janitski, 1932)

t°	Gms. Na <sub>2</sub> SeO <sub>3</sub> per 100 gms. sat. sol.	Solid Phase	t°	Gms. Na <sub>2</sub> SeO <sub>3</sub> per 100 gms. sat. sol.	Solid Phase
-20.5	38.8	Ice + Na <sub>2</sub> SeO <sub>3</sub> ·8H <sub>2</sub> O	+16.3	45.48	Na <sub>2</sub> SeO <sub>3</sub> ·5H <sub>2</sub> O
-15	40.0			46.12	
-10	41.58	"		47.28	"
- 8.7	-	" + Na <sub>2</sub> SeO <sub>3</sub> ·5H <sub>2</sub> O		48.27	"
- 8.0	42.9*	"		49.40	"
-28.1	41.6*	Ice + Na <sub>2</sub> SeO <sub>3</sub> ·5H <sub>2</sub> O		50.00*	"
-20.6	41.88*			-	
-15	42.11*	Na <sub>2</sub> SeO <sub>3</sub> ·5H <sub>2</sub> O			" + Na <sub>2</sub> SeO <sub>3</sub>
-10.5	42.13*	"		46.8	48.76
- 6.8	42.4	"		54.4	48.14
- 0.5	43.9	"		67.6	47.15
				89.1	45.93
				103.3	45.30

In a later paper Janickis and Gutamanite, 1936, give results for the freezing-points of aqueous solutions of Na<sub>2</sub>SeO<sub>3</sub>·8H<sub>2</sub>O.



# Na SODIUM

## SeO SODIUM ACID SELENITES $\text{Bi}(\text{NaHSO}_3)$ , Pyro ( $\text{Na}_2\text{Se}_2\text{O}_5$ )

### SOLUBILITY OF SODIUM ACID SELENITES IN WATER (Janitzki, 1932)

Gms. Na <sub>2</sub> Se <sub>2</sub> O <sub>5</sub> per 100 gms. t°                      sat. sol.                      Solid Phase			Gms. Na <sub>2</sub> Se <sub>2</sub> O <sub>5</sub> per 100 gms. t°                      sat. sol.                      Solid Phase		
-9.3	31.66 (33.66)	Ice+NaHSO <sub>3</sub> ·3H <sub>2</sub> O	40.1	64.27	NaHSO <sub>3</sub>
0	38.45	NaHSO <sub>3</sub> ·3H <sub>2</sub> O	50.0	65.98	"
+8.1	43.97	"	59.9	67.40	"
14.6	49.19	"	79.2	72.26	"
20.0	54.02	"	89.0	74.76	"
25.4	60.32	"	93.0	75.8	" + Na <sub>2</sub> Se <sub>2</sub> O <sub>5</sub>
27.1	62.52	" + NaHSO <sub>3</sub>	96	76.05	Na <sub>2</sub> Se <sub>2</sub> O <sub>5</sub>
28.8	62.88	NaHSO <sub>3</sub>	101.4	76.61	"
32.0	63.14	"	109.5	77.57	"

The freezing-points of aqueous solutions of  $\text{NaHSO}_3 \cdot 3\text{H}_2\text{O}$  are given by Janickis and Gutmanaitis, 1936.

## SeO SODIUM TETRA SELENITE $\text{NaH}_3(\text{SeO}_3)_2$

### SOLUBILITY OF SODIUM TETRA SELENITE IN WATER (Janitzki, 1932)

Gms. NaH <sub>3</sub> (SeO <sub>3</sub> ) <sub>2</sub> per 100			Gms. NaH <sub>3</sub> (SeO <sub>3</sub> ) <sub>2</sub> per 100		
t°	gms. sat. sol.	Solid Phase	t°	gms. sat. sol.	Solid Phase
-7.5	36.5	Ice + NaH <sub>3</sub> SeO <sub>3</sub>	32.0	58.17	NaH <sub>3</sub> SeO <sub>3</sub>
-6.9	37.12	NaH <sub>3</sub> SeO <sub>3</sub>	51.3	67.42	"
-0.7	41.50	"	69.6	75.88	"
13.5	48.83	"	79.2	80.93	"
22.8	53.42	"	83.0	83.95	"

The freezing-points of aqueous solutions of  $\text{NaH}_3(\text{SeO}_3)_2$  are given by Janickis and Gutmanaitis, 1936.

SODIUM SELENATE  $\text{Na}_2\text{SeO}_4$ 

SeO

## SOLUBILITY IN WATER

(Funk, 1900a; Meyer and Aulich, 1928; from 76° to 777°, Smits and Mazee, 1928)

t°	Gms. $\text{Na}_2\text{SeO}_4$ per 100 Gms. Solution	Solid Phase	t°	Gms. $\text{Na}_2\text{SeO}_4$ per 100 Gms. Solution	Solid Phase
0	11.74	$\text{Na}_2\text{SeO}_4 \cdot 10\text{H}_2\text{O}$	76	43.0	$\text{Na}_2\text{SeO}_4$
15	25.01	"	86	42.2	"
18 <sup>a</sup>	29.00	"	107	41.8	"
25.2	36.91	"	232	41.8	"
27	39.18	"	262	42.2	"
30	44.05	"	269	42.6	"
31.8	-	" + $\text{Na}_2\text{SeO}_4$	274	43.0	"
35.2	45.47	$\text{Na}_2\text{SeO}_4$	333	46.1	"
39.5	45.26	"	372	48.7	"
50	44.49	"	777 <sup>m</sup>	100.0	"
75	42.83	"			
100	42.14	"			

<sup>a</sup>density at 18° = 1.315<sup>m</sup>melting point

THE SYSTEM SODIUM SELENATE - HYDROGEN PEROXIDE - WATER AT 20°  
(Pani and Terrey, 1955)

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
$\text{Na}_2\text{SeO}_4$	$\text{H}_2\text{O}_2$		$\text{Na}_2\text{SeO}_4$	$\text{H}_2\text{O}_2$	
30.11	0.0	$\text{Na}_2\text{SeO}_4 \cdot 10\text{H}_2\text{O}$	38.50	21.03	$\text{Na}_2\text{SeO}_4 \cdot \text{H}_2\text{O} \cdot \frac{1}{2}\text{H}_2\text{O}_2$
33.76	1.15	"	37.51	24.91	"
36.56	4.19	"	36.85	28.82	"
39.63	7.10	"	36.53	32.73	"
40.27	8.28	"	37.12	36.14	"
41.88	9.24	$\text{Na}_2\text{SeO}_4 \cdot \text{H}_2\text{O} \cdot \frac{1}{2}\text{H}_2\text{O}_2$	36.64	39.99	"
40.08	14.36	"	37.35	40.99	"
39.04	18.54	"	36.89	42.55	"
			39.71	46.47	"

## Na SODIUM

### THE SYSTEM SODIUM SELENATE - SODIUM HYDROXIDE - WATER (Windmaisser and Stockl, 1951)

Results at 18°			Results at 25°		
Sat. Sol.	Wt. %	Solid Phase	Sat. Sol.	Wt. %	Solid Phase
Na <sub>2</sub> SeO <sub>4</sub>	NaOH		Na <sub>2</sub> SeO <sub>4</sub>	NaOH	
28.04	0.0	Na <sub>2</sub> SeO <sub>4</sub> ·10H <sub>2</sub> O	37.11	0.0	Na <sub>2</sub> SeO <sub>4</sub> ·10H <sub>2</sub> O
27.71	0.41	"	36.07	0.45	"
25.93	2.20	"	36.48	0.71	"
24.12	4.50	"	35.80	1.78	"
23.32	6.41	"	35.39	2.65	"
23.12	7.19	"	35.15	3.44	"
23.08	7.83	"	35.11	3.87	"
23.20	8.81	"	35.10	4.01	"
23.91	9.66	"	35.10	4.30	"
25.10	10.43	"	35.25	4.60	"
25.92	10.70	"	35.85	5.30	"
27.47	11.04	"	36.58	5.40	"
27.80	11.06	" + Na <sub>2</sub> SeO <sub>4</sub>	36.76	5.20	" + Na <sub>2</sub> SeO <sub>4</sub>
27.76	11.10	" + "	35.84	5.70	Na <sub>2</sub> SeO <sub>4</sub>
27.80	11.12	Na <sub>2</sub> SeO <sub>4</sub>	35.53	5.89	"
27.30	11.29	"	33.69	7.02	"
26.41	11.80	"	31.70	8.21	"
24.22	12.91	"	29.22	9.60	"
18.58	16.80	"	25.58	12.00	"
12.02	21.46	"	21.23	14.62	"
6.60	26.13	"	11.20	21.62	"
2.50	30.98	"	6.19	26.02	"
0.88	36.13	"	2.09	31.90	"
0.31	41.70	"	0.62	37.86	"
0.20	51.20	" + NaOH·H <sub>2</sub> O	0.27	51.10	" + NaOH·H <sub>2</sub> O
0.0	51.43	NaOH·H <sub>2</sub> O	0.0	52.49	NaOH·H <sub>2</sub> O

## SeO SODIUM NEODYMIUM SELENATE NaNd(SeO<sub>4</sub>)<sub>2</sub>·2N<sub>2</sub>O

100 gms. H<sub>2</sub>O dissolve about 7 gms. of the salt (? anhydrous) at 0° and 7 gms. at 20°. (Meyer, Julius and Kittlemann, 1931.)

## SiO SODIUM SILICATES

### THE SYSTEM Na<sub>2</sub>O - SiO<sub>2</sub> - H<sub>2</sub>O

The system has been studied by a number of investigators, with only occasional agreement. Considerable difficulty has been encountered in obtaining equilibrium in the viscous, highly alkaline solutions. Separation of the solid and liquid phases is difficult and a variety of techniques have been employed. Many of the phases exist metastably and have been mistaken for other, stable solids. Although it is difficult to determine the correctness of any given data, Wills (1950) has reviewed the system critically, and has tabulated the "most probable" composite curve at 25°. This is given below; several isotherms at other temperatures follow this table, and are presented without detailed comment.

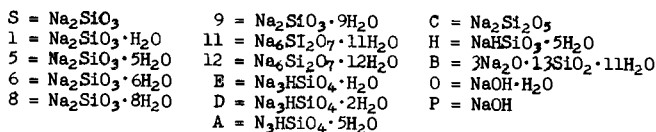
THE SYSTEM  $\text{Na}_2\text{O} - \text{SiO}_2 - \text{H}_2\text{O}$ --Cont."Most Probable" Isotherm at  $25^\circ$  (Wills, 1950)

- References: (1) Harman, 1927  
 (2) Sprauer and Pearce, 1940  
 (3) Lange and von Stackelberg, 1948

Sat. Sol. Wt. %		Ref.	Solid Phase	SiO
$\text{Na}_2\text{O}$	$\text{SiO}_2$			
19.32	31.33	(1)	$\text{Na}_2\text{SiO}_3 \cdot 9\text{H}_2\text{O}$	
14.11	19.65	(1)	"	
9.65	10.1	(2)	"	
9.37	8.74	(1)	"	
8.68	2.93	(2)	"	
9.45	2.22	(1)	"	
12.7	1.82	(3)	"	
17.8	1.46	(2)	"	
18.2	1.42	(3)	"	
19.5	1.45	(3)	"	
21.1	1.50	(3)	"	
22.9	1.64	(3)	"	
24.9	1.88	(3)	"	
26.5	2.14	(3)	"	
27.9	2.59	(3)	"	
23.0	1.6		" + $\text{Na}_2\text{SiO}_3 \cdot 5\text{H}_2\text{O}$	
25.5	2.0		" + $\text{Na}_2\text{SiO}_3 \cdot 6\text{H}_2\text{O}$	
20.6	2.18	(2)	$\text{Na}_2\text{SiO}_3 \cdot 6\text{H}_2\text{O}$	
20.7	2.39	(2)	"	
21.8	1.97	(2)	"	
22.9	1.98	(2)	"	
24.2	2.04	(2)	"	
27.52	1.84	(1)	"	
28.8	2.49	(3)	"	
30.3	2.50	(3)	"	
33.02	2.92	(1)	"	
22	2.0		" + $\text{Na}_2\text{SiO}_3 \cdot 5\text{H}_2\text{O}$	
23.3	1.59	(3)	$\text{Na}_2\text{SiO}_3 \cdot 5\text{H}_2\text{O}$	
24.6	1.51	(3)	"	
26.2	1.39	(3)	"	
27.3	1.54	(3)	"	
32.4	2.43	(3)	"	
27.7	1.4		" + $\text{Na}_3\text{HSiO}_4 \cdot 5\text{H}_2\text{O}$	
26.5	1.9		$\text{Na}_2\text{SiO}_3 \cdot 6\text{H}_2\text{O} + \text{Na}_3\text{HSiO}_4 \cdot 5\text{H}_2\text{O}$	
26.4	2.07	(2)	$\text{Na}_3\text{HSiO}_4 \cdot 5\text{H}_2\text{O}$	
27.2	1.55	(2)	"	
27.8	0.76	(3)	"	
27.9	1.01	(2)	"	
28.9	0.75	(2)	"	
29.2	0.47	(3)	"	
33.0	0.34	(2)	"	
36.7	0.30	(2)	"	
37.1	0.38	(2)	"	
38	0.6		" + $\text{Na}_3\text{HSiO}_4 \cdot 2\text{H}_2\text{O}$	
35.4	1.6	(2)	$\text{Na}_3\text{HSiO}_4 \cdot 2\text{H}_2\text{O}$	
41.0	0.34	(2)	"	
44.78	0.85	(1)	"	

THE SYSTEM  $\text{Na}_2\text{O} - \text{SiO}_2 - \text{H}_2\text{O}$ --Cont.Results at Other Temperatures

- (3) Lange and von Stackelberg, 1948  
 (4) Becker and Jue, 1950  
 (5) Leidenroth, 1939 as quoted by Wills, 1950  
 (6) Baker, Jue and Wills, 1950 (selected data)



SiO

Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
$\text{Na}_2\text{O}$	$\text{SiO}_2$			$\text{Na}_2\text{O}$	$\text{SiO}_2$			$\text{Na}_2\text{O}$	$\text{SiO}_2$		
At 0° (3)				At 10° (4), Cont.				At 14° (3), Cont.			
10.4	0.27		9	24.82	1.06	6m		20.2	0.91		5
13.0	0.21		9	24.65	1.05	6+5		20.9	1.08		5
14.7	0.34		9	24.28	1.07	5m		26.1	1.08		5
17.9	0.40		9	24.65	1.06	5		27.4	1.17		5
19.6	0.48		9	25.22	1.04	5		25.9	1.34		11
21.8	0.40		9	25.92	1.02	5		26.9	1.27		11
22.3	0.45		9	26.72	1.06	5m		28.0	0.79		11
24.8	0.84		9	27.15	1.04	5m		28.8	0.45		11
23.9	0.74		6	26.43	1.04	5+H		29.7	0.43		11
24.2	0.81		6	26.45	1.00	H		30.5	0.29		11
				26.85	0.935	H		30.9	0.21		11
				27.74	0.66	H		34.7	0.20		11
				29.05	0.30	H		34.8	0.16		11
				29.95	0.28	H					
				32.8	0.12	H		At 20° (5)			
				34.20	0.14	H					
				36.58	0.13	H		3.0	1.44		9
				38.0	0.13	H		2.7	1.06		9
				38.3	0.13	H+O		2.6	0.94		9
				38.45	0.0	O		2.5	0.57		9
								2.8	0.36		9
				At 14° (3)				2.9	0.32		9
								4.1	0.21		9
				10.9	0.33	9		6.4	0.18		9
				11.8	0.34	9		8.6	0.26		9
				12.9	0.56	9		9.0	0.29		6
				19.3	0.60	9		9.5	0.35		6
				21.0	0.65	9		9.5	0.34		6
				21.5	0.95	9		9.7	0.37		6
				22.2	1.08	9		10.2	0.35		6
				23.7	1.25	6		10.5	0.35		6
				25.4	1.41	6		10.8	0.37		6
				25.8	1.14	6		11.0	0.36		6
				26.0	1.46	6		11.4	0.38		6
				26.3	1.18	6		11.7	0.43		6
				26.3	1.21	6		12.1	0.28		12
				18.9	0.94	5		12.4	0.22		12

Cont.



# Na SODIUM

## THE SYSTEM $\text{Na}_2\text{O} - \text{SiO}_2 - \text{H}_2\text{O}$ --Cont.

### Results at Other Temperatures--Cont.

(6) Baker, Jue and Wills, 1950 (selected data)

S =  $\text{Na}_2\text{SiO}_3$       D =  $\text{Na}_3\text{HSiO}_4 \cdot 2\text{H}_2\text{O}$       E =  $\text{Na}_3\text{HSiO}_4 \cdot \text{H}_2\text{O}$       P = NaOH

	Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
	Na <sub>2</sub> O		SiO <sub>2</sub>		Na <sub>2</sub> O		SiO <sub>2</sub>		Na <sub>2</sub> O		SiO <sub>2</sub>	
	At 90° (6)											
SiO	34.47	5.76	S	35.0	5.50	S+D	57.00	0.18	E			
	33.70	2.56	S	41.30	1.34	D	46.75	0.49	E			
	30.83	0.44	S	37.30	2.70	D	40.85	0.93	E			
	25.74	2.39	S	35.30	4.52	D	40.00	1.54	E			
	23.30	10.80	S	34.60	7.45	D	57.5	0.0	P			
	24.28	23.70	S	40.0	1.50	D+E						

## THE SYSTEM $\text{Na}_2\text{O} - \text{SiO}_2 - \text{H}_2\text{O}$ AT HIGH TEMPERATURES

t°		Reference
250, 300, 350	-	Tuttle and Friedman, 1948
400, 450	several	Friedman, 1950
250, 300, 350	-	Belyankin, 1949

### SOLUBILITY OF SODIUM SILICATE ( $\text{Na}_2\text{SiO}_3 \cdot 9\text{H}_2\text{O}$ ) IN AQUEOUS SODIUM HYDROXIDE AND SODIUM CHLORIDE SOLUTIONS (Vesterberg, 1912)

Solid phase  $\text{Na}_2\text{SiO}_3 \cdot 9\text{H}_2\text{O}$  in each case.

Solvent	t°	d <sub>17</sub> of Sat. Sol.	Gms. per 100 cc. Sat. Sol.			
			$\text{Na}_2\text{O}$	$\text{SiO}_2$	$= \text{Na}_2\text{SiO}_3 \cdot 9\text{H}_2\text{O}$	NaCl
Approx. 0.5 n NaOH	17.5	1.129	6.942	5.419	= 25.56	-
Approx. 0.5 n NaCl	17.5	1.150	7.347	7.172	33.83	2.297
Saturated NaCl Solution	19	1.258	4.563	4.376	20.64	27.91

Data for the solubility of  $\text{Na}_2\text{SiO}_3$  in aqueous NaCl (0-20%) and in aqueous  $\text{NaHCO}_3$  (0-7.5%) solutions was determined by Denisov and Belova, 1953. The solubility decreases in NaCl solutions and increases in aqueous  $\text{NaHCO}_3$ .

Data for the solubility of  $\text{Na}_2\text{SiO}_3$  in aqueous  $\text{Na}_2\text{CO}_3$  (1-20%) solutions was determined by Denisov and Bleshinshii, 1953. The solubility increases in more alkaline solutions.

Results for the rate of solution of vitreous sodium silicate glasses of different grain sizes were obtained by Matveev, 1949.

For data on the solubilities of clay, carbonates and argillaceous minerals in 0.1N HCl, 0.5 N acetic acid and other solutions, see Zalmazov and Shishova, 1950.

Melting points are given for:

$\text{Na}_2\text{SiO}_3 + \text{Na}_2\text{WO}_4$	(Van Klooster, 1910-11)
$\text{Na}_2\text{SiO}_3 + \text{SrSiO}_3$	(Wallace, 1901)
$\text{Na}_2\text{SiO}_3 + \text{PbSiO}_3 + \text{SiO}_2$	(Krakau, Mukhin and Heinrich, 1937)
$\text{Na}_2\text{SiO}_3 - \text{Na}_2\text{TiO}_3 - \text{TiO}_2$	(Belyaev and Sigida, 1958)

## SODIUM ALUMINOSILICATES

For data in aluminate solutions at 50° and 70° in which the ratio of each component was varied see Ni and Ponomarev, 1956.

## SODIUM STANNATE $\text{Na}_2\text{Sn}(\text{OH})_6$

SNO

### SOLUBILITY OF SODIUM STANNATE IN WATER (Zocher, 1920)

t°	Gms. $\text{Na}_2\text{Sn}(\text{OH})_6$ per 100 gms. sat. sol.	Solid Phase,	t°	Gms. $\text{Na}_2\text{Sn}(\text{OH})_6$ per 100 gms. sat. sol.	Solid Phase
- 5	31.8	$\text{Na}_2\text{Sn}(\text{OH})_6$	- 5	32.4	$\text{Na}_2\text{Sn}(\text{OH})_6 \cdot \text{H}_2\text{O}$
0	31.5	"	0	33.2	"
+21	30.4	"	+21	35.4	"
25	30.3	"	25	36.5	"
35	29.4	"	35	37.5	"
45	26.6	"	45	39.2	"
			50	41.1	"

### SOLUBILITY OF SODIUM STANNATE IN WATER (Reiff and Toussaint, 1939)

t°	Gms. per 100 cc. sat. sol.		Solid Phase
	$\text{Na}_2[\text{Sn}(\text{OH})_6]$	free NaOH	
0	52.0	0.0	$\text{Na}_2\text{Sn}(\text{OH})_6$
20	46.0	0.2	"
25	43.5	1.0	"
40	41.5	1.5	"
60	37.0	2.5	$\text{Na}_2[\text{Sn}(\text{OH})_2] + \text{Sn}(\text{OH})_4$
80	33.0	5.0	" + "
100	30.0	7.0	" + "
120	27.0	10.0	" + "



## Na SODIUM

### SOLUBILITY OF SODIUM STANNATE IN AQUEOUS SOLUTIONS OF SODIUM HYDROXIDE AND OF SODIUM CARBONATE (Reiff and Toussaint, 1939)

The following approximate results were taken from the authors diagram:

t°	Gms. Na <sub>2</sub> [Sn(OH) <sub>6</sub> ] per 100 cc. sat. solution in Aqueous:				
	5 Percent NaOH	10 Percent NaOH	20 Percent NaOH	30 Percent NaOH	10 Percent Na <sub>2</sub> CO <sub>3</sub>
0	35	22.5	7	0.5	40
20	31	19	5.5	0.6	35.5
40	26	16	4.5	0.7	31
60	23	13.5	4.0	1.0	29
80	21	11.5	3.5	1.2	26.5
100	19.5	11.0	4.0	1.5	24.5
120	18.5	11.5	5.5	2.0	23.0

### SOLUBILITY OF SODIUM STANNATE IN AQUEOUS 1.97 NORMAL SOLUTION OF VARIOUS SODIUM SALTS AT 18° (Reiff and Toussaint, 1939)

Gms.		Gms.	
Na <sub>2</sub> [Sn(OH) <sub>6</sub> ]		Na <sub>2</sub> [Sn(OH) <sub>6</sub> ]	
Aqueous 1.97	per 100	Aqueous 1.97	per 100
Normal Solution of:	cc. sat. sol.	Normal Solution of:	cc. sat. sol.
CH <sub>3</sub> COONa	20.7	Na <sub>2</sub> SO <sub>3</sub>	35.0
NaOH	25.0	Na <sub>2</sub> WO	35.0
NaF	28.8	NaNO <sub>3</sub>	35.3
NaClO <sub>4</sub>	30.1	NaBr	37.0
NaCl	31.5	Na <sub>2</sub> CrO <sub>4</sub>	37.5
NaI	33.0	Na <sub>2</sub> SO <sub>4</sub>	38.0
Na <sub>2</sub> CO <sub>3</sub>	34.8		

## SODIUM TANTALATE NaTaO<sub>3</sub>

### SOLUBILITY IN WATER (Lapitskii, Stepanov and Pehelkina, 1955)

t°	Moles NaTaO <sub>3</sub> per liter	Mg. NaTaO <sub>3</sub> per 100 ml
0	0.0000469	1.18
25	0.0000546	1.38
50	0.000110	2.75
75	0.000219	5.50
100	0.000239	11.03

## SODIUM TELLURIDE Na<sub>2</sub>Te

Fusion-point data for the system Na<sub>2</sub>Te + Te are given by Kraus and Glass, 1929.

SODIUM TELLURITE  $\text{Na}_2\text{TeO}_3$ 

TeO

THE SYSTEM  $\text{Na}_2\text{TeO}_3$  - ETHANOL - WATER AT 25°  
(Vorob'eva and Lavut, 1957)

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase	
C <sub>2</sub> H <sub>5</sub> OH	Na <sub>2</sub> TeO <sub>3</sub>		C <sub>2</sub> H <sub>5</sub> OH	Na <sub>2</sub> TeO <sub>3</sub>		
95.70	-	Na <sub>2</sub> TeO <sub>3</sub> ·xH <sub>2</sub> O	Two-Liquid Region			
91.52	-	Na <sub>2</sub> TeO <sub>3</sub> ·5H <sub>2</sub> O				
88.58	0.10	"	{	61.07	1.68	Na <sub>2</sub> TeO <sub>3</sub> ·5H <sub>2</sub> O
85.50	0.10	"		3.25	40.77	"
77.09	0.20	"	{	43.45	6.48	None
72.75	0.20	"		7.18	36.35	"
70.64	0.50	"	{	29.11	15.46	"
62.43	1.00	"		15.15	27.27	"
2.98	41.74	"	{	28.12	16.82	"
0.0	44.97	"		17.45	24.72	"

SODIUM TELLURATE  $\text{Na}_2\text{TeO}_4$ 

100 gms.  $\text{H}_2\text{O}$  dissolve 0.77 gm.  $\text{Na}_2\text{TeO}_4$  at 18°, and 2 gms. at 100°. Solid phase  $\text{Na}_2\text{TeO}_4 \cdot 2\text{H}_2\text{O}$ .

100 gms.  $\text{H}_2\text{O}$  dissolve 1.43 gms.  $\text{Na}_2\text{TeO}_4$  at 18°, and 2.5 gms. at 50°. Solid phase  $\text{Na}_2\text{TeO}_4 \cdot \text{H}_2\text{O}$ .

SODIUM TITANATE  $\text{Na}_2\text{TiO}_3$ 

TiO

Melting points are given for:

$\text{Na}_2\text{TiO}_3 + \text{NaF}$  (Sholokovich, 1955)  
 $\text{Na}_2\text{TiO}_3 + \text{Na}_2\text{SO}_4, + \text{Na}_2\text{CrO}_4, + \text{Na}_2\text{MoO}_4, + \text{Na}_2\text{WO}_4,$   
 $+ \text{NaCl}, + \text{NaVO}_3, + \text{Na}_4\text{P}_2\text{O}_7$  (Sholokovich and Barkova, 1956)  
 $\text{Na}_2\text{TiO}_3 + \text{Li}_2\text{TiO}_3$  (Belyaev and Sigida, 1957)  
 $\text{Na}_2\text{TiO}_3 + \text{PbWO}_4, \text{PbMoO}_4$  (Belyaev, 1954)

SODIUM URANATES  $x\text{Na}_2\text{O} \cdot y\text{UO}_3$ 

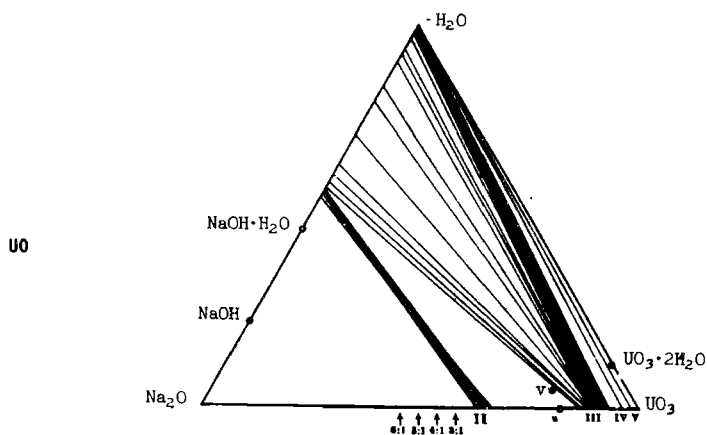
UO

THE SYSTEM SODIUM OXIDE - URANIUM TRIOXIDE - WATER  
(Ricci and Loprest, 1954)

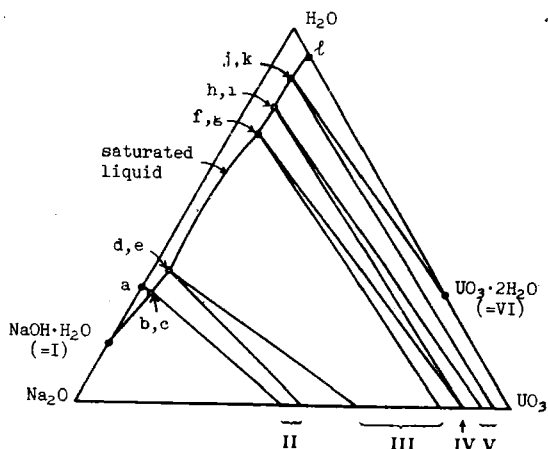
Only one pure solid sodium uranate phase ( $\text{Na}_2\text{O} \cdot 6\text{UO}_3$ ) was found after an extensive investigation at 50°. Three separate series of solid solutions exist, some hydrated, but none of simple composition; all solid phases are incongruently soluble. Data are also given at 75°, and confirm the findings at the lower temperature.

Na SODIUM

THE SYSTEM SODIUM OXIDE - URANIUM TRIOXIDE - WATER--Cont.



System  $\text{Na}_2\text{O}-\text{UO}_3-\text{H}_2\text{O}$ :  
tie-line relations at  $50^\circ$ ;  $u = \text{Na}_2\text{UO}_4$ ,  $v = \text{Na}_2\text{UO}_4 \cdot \text{H}_2\text{O}$  or  $2\text{NaOH} \cdot \text{UO}_3$



Schematic diagram of the phase relations at  $50^\circ$ .

Data for the system  $\text{Na}_2\text{O}-\text{UO}_2-\text{CO}_2-\text{H}_2\text{O}$  at  $26^\circ$  are given by Blake, et al., 1956.

SODIUM PERURANATE  $\text{Na}_4\text{UO}_8$ 

SOLUBILITY IN VARIOUS SOLVENTS AT 25°  
(Ratner, Gurevich and Polozhenskaya, 1957)

Solid phase  $\text{Na}_4\text{UO}_8 \cdot 9\text{H}_2\text{O}$ 

$\text{Na}_4\text{UO}_8 \cdot 9\text{H}_2\text{O}$			$\text{Na}_4\text{UO}_8 \cdot 9\text{H}_2\text{O}$		
Solvent	Gm./l.	Mol./l.	Solvent	Gm./l.	Mol./l.
$\text{H}_2\text{O}$		37.3	$\text{NaOH}$	0.1N	29.2
$\text{HNO}_3$	0.1N	50.0		0.2	19.6
	0.2	61.0		0.3	15.1
	0.3	73.5		0.4	12.1
	0.4	80.5		0.5	8.74
	0.5	95.0		0.75	5.64
	0.56	102.0		1.0	4.25
	0.9	145.0		2.0	2.0
	1.0	161.5		3.25	1.35
	1.5	191.2	$\text{NaNO}_3$	0.2	28.4
	2.0	233.0		0.3	25.8
	3.0	263.0		0.5	18.1
$\text{NaC}_2\text{H}_3\text{O}_2$	0.5	12.45		1.0	11.2
	1.0	5.50		1.5	8.3
	1.5	3.12	$\text{NaHCO}_3$	0.1	43.5
	2.0	2.30		0.5	64.3
$\text{Na}_2\text{CO}_3$	0.1	33.6		1.0	80
	0.5	21.0		1.5	113
	1.0	16.9		2.0	137
	2.0	14.17			0.576

UO

SOLUBILITY OF  $\text{Na}_4\text{UO}_8 \cdot 9\text{H}_2\text{O}$  AT VARIOUS TEMPERATURES  
(Ratner, Gurevich and Polozhenskaya, 1957)

Solvent	0°	25°	40°	58°	60°	78°	80°
$\text{H}_2\text{O}$ g./l.	20.85	37.3	53.3	-	103.5	208.0	-
mol./l.	0.085	0.156	0.244	-	0.435	0.875	-
$\text{NaOH}$ 0.5N g./l.	6.4	8.74	26.8	52.8	-	-	170.8
mol./l.	0.026	0.036	0.11	0.22	-	-	0.72
1.0N g./l.	4.10	4.25	12.2	35.2	-	107.0	-
mol./l.	0.017	0.018	0.051	0.148	-	0.45	-
$\text{HNO}_3$ 0.5N g./l.	95.0	95.0	124.0	128.0	-	212.0	-
mol./l.	0.399	0.399	0.521	0.538	-	0.89	-
1.0N g./l.	160.0	161.5	162.5	180.5	-	-	270.0
mol./l.	0.673	0.679	0.684	0.759	-	-	1.113

# Na SODIUM

## VO SODIUM VANADATES $x\text{Na}_2\text{O} \cdot y\text{V}_2\text{O}_5$

### THE SYSTEM SODIUM OXIDE - VANADIUM PENTOXIDE - WATER

30° - Kiehl and Manfredo, 1937; 20° - Menzel and Muller, 1953; 25°, 75° - Makarov and Repa, 1940.

#### Results of Menzel and Muller, 1953, at 20°

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
Na <sub>2</sub> O	V <sub>2</sub> O <sub>5</sub>	Solid Phase	Na <sub>2</sub> O	V <sub>2</sub> O <sub>5</sub>	Solid Phase
2.67	7.38	NaVO <sub>3</sub> ·2H <sub>2</sub> O	10.67	12.07	$\psi\text{-Na}_3\text{VO}_4 \cdot 12\text{H}_2\text{O}$
2.40	7.00 <sup>a</sup>	"	10.79	11.96	"
3.35	8.46	"	10.83	11.94	"
6.18	12.46	"	10.91	11.75	"
12.47	22.60	"	10.12	10.26	"
13.61	24.08	" + Na <sub>4</sub> V <sub>2</sub> O <sub>7</sub> ·18H <sub>2</sub> O	8.33	7.53	"
11.68	19.43	Na <sub>4</sub> V <sub>2</sub> O <sub>7</sub> ·18H <sub>2</sub> O	8.22	7.12	"
10.44	16.55	"	8.08	6.68	"
9.39	14.28	"	8.00	6.07	"
8.39	12.18	"	7.72	5.62	"
8.12	11.86 <sup>a</sup>	"	7.24	3.83	"
8.19	11.49	"	7.24	2.48	"
8.98	11.54	"	7.79	1.71	"
9.79	11.77	"	9.01	1.11	"
10.57	12.27	"	9.71	0.69	"
10.60	12.17	"	15.94	0.28	"
11.10	12.38	" + $\psi\text{-Na}_3\text{VO}_4 \cdot 12\text{H}_2\text{O}$	16.06	0.26	"
			16.94	0.25	"
			18.91	0.22	$\psi\text{Na}_3\text{VO}_4 \cdot 8\text{H}_2\text{O}$
			25.93	0.10	-

<sup>a</sup>Solubility of pure salt in water

#### Results of Kiehl and Manfredo, 1937, at 30°

d. of sat. sol.	Gms. Mols. per 100 Gms. mols. sat. sol.		Solid Phase
	V <sub>2</sub> O <sub>5</sub>	Na <sub>2</sub> O	
0.996	0.010	-	V <sub>2</sub> O <sub>5</sub> ·xH <sub>2</sub> O
0.9955	0.004	0.002	V <sub>2</sub> O <sub>5</sub> ·xH <sub>2</sub> O·xyH <sub>2</sub> O
0.9979	0.03	0.026	" "
1.039	0.46	0.24	" "
1.163	1.73	1.30	" "
1.236	2.54	1.55	V <sub>2</sub> O <sub>5</sub> + Na <sub>4</sub> V <sub>6</sub> O <sub>17</sub> ·12H <sub>2</sub> O
1.219	2.34	1.58	Na <sub>4</sub> V <sub>6</sub> O <sub>17</sub> ·12H <sub>2</sub> O
1.208	2.22	1.68	" + NaVO <sub>3</sub> ·2H <sub>2</sub> O
1.187	1.95	1.53	NaVO <sub>3</sub> ·2H <sub>2</sub> O
1.148	1.57	1.37	"
1.110	1.21	1.23	"
1.151	1.50	1.69	"
1.265	2.36	3.19	"
1.418	3.60	5.50	"
1.536	4.57	7.55	" + Na <sub>4</sub> V <sub>2</sub> O <sub>5</sub> ·18H <sub>2</sub> O
1.460	3.76	6.47	Na <sub>4</sub> V <sub>2</sub> O <sub>5</sub> ·18H <sub>2</sub> O

(Cont.)

## THE SYSTEM SODIUM OXIDE - VANADIUM PENTOXIDE - WATER--Cont.

## Results of Kiehl and Manfredo, 1937, at 30°--Cont.

d. of sat. sol.	Gms. Mols. per 100 Gms. mols. sat. sol.		Solid Phase
	V <sub>2</sub> O <sub>5</sub>	Na <sub>2</sub> O	
1.363	2.56	4.93	Na <sub>4</sub> V <sub>2</sub> O <sub>5</sub> ·18H <sub>2</sub> O
1.352	2.32	4.46	"
1.367	2.31	5.08	"
1.379	2.42	5.60	" + Na <sub>3</sub> VO <sub>4</sub> ·12H <sub>2</sub> O
1.278	1.55	4.19	Na <sub>3</sub> VO <sub>4</sub> ·12H <sub>2</sub> O
1.228	1.12	3.54	"
1.172	0.67	2.97	"
1.151	0.40	2.87	"
1.151	0.22	3.19	"
1.153	0.21	3.26	"
1.165	0.14	3.66	"
1.183	0.11	4.04	"
1.208	0.08	4.76	"
1.312	0.06	7.55	" + Na <sub>3</sub> VO <sub>4</sub> ·7H <sub>2</sub> O
1.337	0.04	8.39	Na <sub>3</sub> VO <sub>4</sub> ·7H <sub>2</sub> O
1.411	0.03	10.94	"
1.478	0.06	13.39	"
1.472	0.08	13.99	" + Na <sub>3</sub> VO <sub>4</sub> ·2 <sup>1</sup> / <sub>2</sub> H <sub>2</sub> O
1.519	0.08	15.23	Na <sub>3</sub> VO <sub>4</sub> ·2 <sup>1</sup> / <sub>2</sub> H <sub>2</sub> O
1.557	0.08	16.96	"
1.549	0.00	16.81	"

VO

## Data Makarov and Repa, 1940

Gms. per 100 Gms. Sat. Sol.		Solid Phase
Na <sub>2</sub> O	V <sub>2</sub> O <sub>5</sub>	
<u>Results at 25°</u>		
0.0	0.04	V <sub>2</sub> O <sub>5</sub> ·3H <sub>2</sub> O
2.94	8.28	V <sub>2</sub> O <sub>5</sub>
4.56	21.87	"
5.08	22.00	"
6.58	23.06	V <sub>2</sub> O <sub>5</sub> + Na <sub>2</sub> V <sub>6</sub> O <sub>16</sub> ·20H <sub>2</sub> O
7.36	19.06	Na <sub>2</sub> V <sub>6</sub> O <sub>16</sub> ·20H <sub>2</sub> O
8.27	20.49	"
8.94	21.33	Na <sub>2</sub> V <sub>6</sub> O <sub>16</sub> ·20H <sub>2</sub> O + Na <sub>4</sub> V <sub>2</sub> O <sub>7</sub> ·18H <sub>2</sub> O
10.02	21.40	Na <sub>4</sub> V <sub>2</sub> O <sub>7</sub> ·18H <sub>2</sub> O
12.87	21.09	"
14.05	23.33	"
13.80	20.04	"
13.60	16.72	Na <sub>4</sub> V <sub>2</sub> O <sub>7</sub> ·18H <sub>2</sub> O + Na <sub>3</sub> VO <sub>4</sub> ·10H <sub>2</sub> O
13.09	15.29	Na <sub>3</sub> VO <sub>4</sub> ·10H <sub>2</sub> O
14.52	12.30	"
16.18	10.58	Na <sub>3</sub> VO <sub>4</sub> ·10H <sub>2</sub> O + Na <sub>8</sub> V <sub>2</sub> O <sub>9</sub> ·30H <sub>2</sub> O
9.98	8.79	Na <sub>8</sub> V <sub>2</sub> O <sub>9</sub> ·30H <sub>2</sub> O
7.95	3.76	"
8.48	2.21	"

(Cont.)

## Na SODIUM

## THE SYSTEM SODIUM OXIDE - VANADIUM PENTOXIDE - WATER--Cont.

Data Makarov and Repa, 1940--Cont.

Gms. per 100 Gms. Sat. Sol.		Solid Phase
Na <sub>2</sub> O	V <sub>2</sub> O <sub>5</sub>	
<u>Results at 25°, Cont.</u>		
12.17	1.32	Na <sub>8</sub> V <sub>2</sub> O <sub>9</sub> ·30H <sub>2</sub> O
20.21	1.81	Na <sub>8</sub> V <sub>2</sub> O <sub>9</sub> ·26H <sub>2</sub> O
27.44	2.24	Na <sub>8</sub> V <sub>2</sub> O <sub>9</sub> ·26H <sub>2</sub> O + Na <sub>2</sub> O·3H <sub>2</sub> O
41.04	0.0	Na <sub>2</sub> O·3H <sub>2</sub> O
11.78	15.38	Na <sub>2</sub> VO <sub>4</sub> ·10H <sub>2</sub> O
12.84	7.73	"
13.69	7.37	"
14.58	5.09	"
28.11	2.34	Na <sub>3</sub> VO <sub>4</sub> ·10H <sub>2</sub> O + Na <sub>2</sub> O·3H <sub>2</sub> O
17.00	1.24	Na <sub>8</sub> V <sub>2</sub> O <sub>9</sub> ·26H <sub>2</sub> O
<u>Results at 75°</u>		
0.0	0.09	V <sub>2</sub> O <sub>5</sub>
4.58	20.12	"
6.98	31.80	"
7.29	33.32	V <sub>2</sub> O <sub>5</sub> + Na <sub>4</sub> V <sub>2</sub> O <sub>7</sub>
8.82	19.50	Na <sub>4</sub> V <sub>2</sub> O <sub>7</sub>
12.74	23.76	"
13.20	25.30	"
17.95	30.05	"
22.70	34.00	"
20.06	27.98	"
20.29	22.12	Na <sub>4</sub> V <sub>2</sub> O <sub>7</sub> + Na <sub>3</sub> VO <sub>4</sub>
18.18	22.60	Na <sub>3</sub> VO <sub>4</sub>
17.93	17.19	"
16.15	15.85	"
16.13	17.94	"
18.38	7.05	"
20.69	7.31	Na <sub>3</sub> VO <sub>4</sub> + Na <sub>8</sub> B <sub>2</sub> O <sub>9</sub> ·12H <sub>2</sub> O
21.48	6.40	Na <sub>8</sub> V <sub>2</sub> O <sub>9</sub> ·12H <sub>2</sub> O
19.57	6.00	"
22.27	4.14	"
26.02	2.48	"
39.50	4.00	Na <sub>8</sub> V <sub>2</sub> O <sub>9</sub> ·12H <sub>2</sub> O + Na <sub>2</sub> O·H <sub>2</sub> O
31.56	2.44	Na <sub>2</sub> O·H <sub>2</sub> O

SODIUM METAVANADATE  $\text{NaVO}_3$ SOLUBILITY IN WATER  
(MacAdam and Pierle, 1912)

Considerable time was required for attainment of equilibrium. The two solid phases appear to exist for the whole range of temperature and the conditions for the transformation of one into the other were not ascertained.

t°	Gms. $\text{NaVO}_3$ per 100 Gms. $\text{H}_2\text{O}$	Solid Phase	t°	Gms. $\text{NaVO}_3$ per 100 Gms. $\text{H}_2\text{O}$	Solid Phase
25	21.10	$\text{NaVO}_3$	12.5	7.87	?
40	26.23	"	25	15.3	$\text{NaVO}_3 \cdot 2\text{H}_2\text{O}$
60	32.97	"		(12.96) <sup>a</sup>	"
75	38.83	"	40	30.2	"
			60	68.4	"
				(69.3) <sup>b</sup>	?

<sup>a</sup>Trujillo and Tejera, 1953;

d = 1.084

<sup>b</sup>Andreev, 1957

THE SYSTEM SODIUM VANADATE - SODIUM CHLORIDE - WATER  
(Andreev, 1957)

Results at 12.5°			Results at 60°		
Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
$\text{NaVO}_3$	$\text{NaCl}$		$\text{NaVO}_3$	$\text{NaCl}$	
7.29	0.0	$\text{NaVO}_3$	40.94	0.0	$\text{NaVO}_3$
3.35	2.18	"	28.19	5.71	"
0.28	7.65	"	25.43	5.61	"
0.05	15.44	"	12.58	12.49	"
0.02	26.27	" + $\text{NaCl}$	9.22	10.18	"
0.0	26.32	$\text{NaCl}$	4.04	23.22	"
			1.87	25.21	"
			0.03	26.68	" + $\text{NaCl}$
			0.0	27.10	$\text{NaCl}$

SODIUM ORTHOVANADATE  $\text{Na}_3\text{VO}_4$ SOLUBILITY IN WATER  
(Menzel and Muller, 1953)

Sat. Sol. Wt. %				Sat. Sol. Wt. %			
t°	$\text{Na}_2\text{O}$	$\text{V}_2\text{O}_5$	Total	t°	$\text{Na}_2\text{O}$	$\text{V}_2\text{O}_5$	Total
$\text{Na}_4\text{V}_2\text{O}_7 \cdot 18\text{H}_2\text{O} + \psi\text{-Na}_3\text{VO}_4 \cdot 12\text{H}_2\text{O}$				Solid Phase $\psi\text{-Na}_3\text{VO}_4 \cdot 12\text{H}_2\text{O}$ -- Cont.			
0.0	4.62	3.70	8.32	20.0	8.33	7.53	15.86
				25.0	9.63	8.52	18.15
Solid Phase $\psi\text{-Na}_3\text{VO}_4 \cdot 12\text{H}_2\text{O}$				30.0	10.72	9.66	20.38
2.8	5.38	4.74	10.12	40.0	12.53	11.49	24.02
13.8	7.25	6.47	13.72	50.0	15.76	13.80	29.56



# Na SODIUM

## SOLUBILITY IN WATER--Cont.

t°	Sat. Sol. Wt. %			t°	Sat. Sol. Wt. %		
	Na <sub>2</sub> O	V <sub>2</sub> O <sub>5</sub>	Total		Na <sub>2</sub> O	V <sub>2</sub> O <sub>5</sub>	Total
Solid Phase $\psi$ -Na <sub>3</sub> VO <sub>4</sub> ·12H <sub>2</sub> O--Cont.				Solid Phase O-Na <sub>3</sub> VO <sub>4</sub> ·7H <sub>2</sub> O			
51.5	17.11	15.24	32.35	52.1	17.30	15.15	32.45
51.7	16.98	15.09	32.07	52.3	16.92	14.88	31.80
51.8	16.79	14.89	31.68	52.5	17.25	14.58	31.83
				53.0	16.84	14.92	31.76
Solid Phase O-Na <sub>3</sub> VO <sub>4</sub> ·12H <sub>2</sub> O				57.2	17.54	15.34	32.88
				60.0	17.22	15.37	32.59
51.9	17.08	15.34	32.42	70.0	19.25	16.94	36.19
				80.2	21.28	17.67	38.95
Solid Phase $\psi$ -Na <sub>3</sub> VO <sub>4</sub> ·10H <sub>2</sub> O							
52.0	16.75	14.77	31.52				

Fusion-point data for mixtures of Na<sub>2</sub>O + V<sub>2</sub>O<sub>5</sub> are given by Canneri, 1928.

Melting points in the system NaVO<sub>3</sub>-V<sub>2</sub>O<sub>5</sub> are given by Illarionov, Ozerov and Kil'disheva, 1957.

# WO SODIUM TUNGSTATE Na<sub>2</sub>WO<sub>4</sub>

## SOLUBILITY IN WATER (Funk, 1908)

Mols.				Mols.			
Gms.		Na <sub>2</sub> WO <sub>4</sub>		Gms.		Na <sub>2</sub> WO <sub>4</sub>	
Na <sub>2</sub> WO <sub>4</sub> per		per		Na <sub>2</sub> WO <sub>4</sub> per		per	
100 Gms.		100 Mols.		100 Gms.		100 Mols.	
t°	Solution	H <sub>2</sub> O	Solid Phase	t°	Solution	H <sub>2</sub> O	Solid Phase
-5	30.60	2.70	Na <sub>2</sub> WO <sub>4</sub> ·10H <sub>2</sub> O	-3.5	41.67	4.37	Na <sub>2</sub> WO <sub>4</sub> ·2H <sub>2</sub> O
-4	31.87	2.86	"	+0.5	41.73	4.39	"
-3.5	32.98	3.01	"	18	42.0	4.40	"
-2	34.52	3.23	"	21	42.27	4.48	"
0	36.54	3.52	"	43.5	43.98	4.81	"
+3	39.20	3.95	"	80.5	47.65	5.57	"
5	41.02	4.26	"	100	49.31	5.95	"

Sp. Gr. of sat. solution at 18° = 1.573. For Sp. Gr. determinations of aqueous solutions at 20°, see Pawlewski, 1900.

SODIUM PARATUNGSTATE  $5\text{Na}_2\text{O} \cdot 12\text{WO}_3 \cdot 28\text{H}_2\text{O}$ 

WO

SOLUBILITY OF SODIUM PARATUNGSTATE IN WATER  
(Vallance, 1931; Rosenheim and Wolff, 1930)

The original results in each case were plotted and the following figures taken from the curves. The solid phase was  $5\text{Na}_2\text{O} \cdot 12\text{WO}_3 \cdot 28\text{H}_2\text{O}$  in each case.

t°	Gms. $5\text{Na}_2\text{O} \cdot 12\text{WO}_3$ per 100 gms. sat. sol.		t°	Gms. $5\text{Na}_2\text{O} \cdot 12\text{WO}_3$ per 100 gms. sat. sol.	
	(V)	(R & W)		(V)	(R & W)
0	2.1	2.10	50	26.5	21.0
10	4.2	4.2	60	35.0	28.0
20	7.5	7.5	70	43.0	35.0
25	9.0	9.0	80	52.0	-
30	11.4	10.7	90	61.0	-
40	18.0	15.0	100	70.0	-

Melting points are given for:

$\text{Na}_2\text{WO}_4 + \text{WO}_3$	(Parravano, 1909; Van Liempt, 1925; Hoermann, 1929)
$\text{Na}_2\text{WO}_4 + \text{WO}_3 + \text{W}$	(Brimm, Brantly, Lorenz and Jellinek, 1951)
$\text{Na}_2\text{WO}_4 + \text{PbWO}_4$	(Belyaev, 1952)

SODIUM ZINCATE  $\text{Na}_2\text{ZnO}_2$ 

ZnO

THE SYSTEM  $\text{Na}_2\text{O} - \text{ZnO} - \text{H}_2\text{O}$  AT 30°  
(Goudriaan, 1919, 1920)

See data following for other results

Especially carefully purified materials were used. The solid phases were determined by the rest method of Schreinemakers. At the zinc hydroxide end of the curve crystallized  $\text{Zn}(\text{OH})_2$  was used as solid phase and about two weeks allowed for the attainment of final equilibrium.

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Na}_2\text{O}$	$\text{ZnO}$	
11.8	2.6	ZnO
17.4	5.0	"
23.7	11.3	"
27.3	16.0	"
27.8	16.5	" + $\text{Na}_2\text{O} \cdot \text{ZnO} \cdot 4\text{H}_2\text{O}$
28.0	14.9	$\text{Na}_2\text{O} \cdot \text{ZnO} \cdot 4\text{H}_2\text{O}$
30.1	13.2	"
31.8	11.7	"
33.2	11.2	"
34.7	10.4	"

(Cont.)

# Na SODIUM

## THE SYSTEM $\text{Na}_2\text{O} - \text{ZnO} - \text{H}_2\text{O}$ AT $30^\circ$ --Cont.

Gms. per 100 gms. sat. sol.

	$\text{Na}_2\text{O}$	$\text{ZnO}$	Solid Phase
	36.1	10.2	$\text{Na}_2\text{O} \cdot \text{ZnO} \cdot 4\text{H}_2\text{O}$
	39.2	9.7	" + $\text{Na}_2\text{O} \cdot 3\text{H}_2\text{O}$
	39.4	9.0	$\text{Na}_2\text{O} \cdot 3\text{H}_2\text{O}$
	39.6	7.2	"
	40.7	2.0	"
	40.5	1.6	"
	40.9	1.1	"
	41.9	0.0	"
ZnO	24.6	12.5	ZnO
	19.9	15.2	$\text{Zn}(\text{OH})_2$
	13.7	7.2	"
	10.1	4.7	"
	4.6	1.0	"
	4.5	0.4	ZnO

Other determinations of the equilibrium in this system, differing more or less from the above, are given by Müller, Müller and Fauvel, 1927, and by Scholder and Hendrich, 1939. These latter investigators found that at  $20^\circ$  the solid phase at concentrations of NaOH between 1 and 13.4 normality, was ZnO. At concentrations between 13.5 and 19.6 normality it was  $\text{Na}[\text{Zn}(\text{OH})_3]$  and at concentrations between 19.6 and 20.1 it was  $\text{Na}_2[\text{Zn}(\text{OH})_4]$ . Above 20.1 normality the solid phase consisted of mixtures of  $\text{Na}[\text{Zn}(\text{OH})_4]$  and  $\text{NaOH} \cdot \text{H}_2\text{O}$ . At concentration of NaOH between 7.3 and 13.3 normality there are also present rhombic  $\text{Zn}(\text{OH})_2$  and  $\text{Na}_3[\text{Zn}(\text{OH})_3] \cdot 3\text{H}_2\text{O}$  as metastable solid phases. Less complete results at  $30^\circ$ ,  $40^\circ$  and  $100^\circ$  are also given.

More recent data by Urazov, Lipshits and Lovchikov, 1956 agree with those of Scholder and Hendrich, 1939. At  $25^\circ$ , Urazov found  $\text{Zn}(\text{OH})_2$  stable in solutions containing up to 11.4%  $\text{Na}_2\text{O}$ ; from 11.4 to 24.76%  $\text{Na}_2\text{O}$ , ZnO was the saturating phase; and from 24.76 to 29.54%  $\text{Na}[\text{Zn}(\text{OH})_3]$ . At  $75^\circ$  the phases are 0-32%  $\text{Na}_2\text{O}$  (ZnO); 32.2-44.8%  $\text{Na}[\text{Zn}(\text{OH})_3]$ ; 44.8-55%  $\text{Na}_2\text{Zn}(\text{OH})_4$ . At the boiling point maximum solubility of ZnO (23.5%) is in 56% NaOH. The solid phase at this point is  $4[2\text{ZnO} \cdot \text{Na}_2\text{O}] \cdot 3\text{H}_2\text{O}$ .

## SODIUM FLUOZIRCONATE $5\text{NaF} \cdot \text{ZrF}_4$

100 gms.  $\text{H}_2\text{O}$  dissolve 0.387 gm. at  $18^\circ$ , and 1.67 gms. at  $100^\circ$ . (Marignac, 1861)

NIOBIMUM CARBIDE

C

Continuous solid solutions are formed with titanium and zirconium carbides. (Koval'skii and Umanskii, 1946)

NIOBIMUM CHLORIDE  $NbCl_5$

C1

SOLUBILITY IN TITANIUM CHLORIDE  
(Tarasenkov and Komandin, 1940)

	25°	50°	100°
Gms. $NbCl_5$ per 100 gms. sat. sol.	0.24	0.58	1.32

Melting point data are given for:

$NbCl_5 + AlCl_3$	(Morozov, Korshunov and Simonich, 1956)
$NbCl_5 + AlCl_3 + NaCl$	(Morozov, Korshunov and Simonich, 1956)
$NbCl_5 + NaCl$	(Morozov and Korshunov, 1956)
$NbCl_5 + ZrCl_4$	(Morozov and Korshunov, 1956)
$NbCl_5 + TiCl_4 + FeCl_3$	(Morozov and Toptygin, 1957)
$NbCl_5 + TaCl_5 + AlCl_3$	(Morozov, 1956)
$NbCl_5 + FeCl_3$	(Morozov, 1956)
$NbCl_5 + FeCl_3 + AlCl_3$	(Morozov, 1956)

NIOBIMUM FLUORIDE  $NbF_5$

F

Data for the partition of  $NbF_5$  between aq. HF solutions (1-20 N) and diethylether are given by Bock and Herrmann, 1956.

31.8 gms.  $NbF_5$  are dissolved in 100 gms. of sat. sol. in bromine trifluoride at 25°. (Sheft, Hyman and Katz, 1953)

NIOBIMUM OXIDE  $Nb_2O_5$

G

SOLUBILITY OF  $Nb_2O_5$  IN DILUTE ACID SOLUTIONS  
(D. I. Kurbatov and N. V. Demenev, 1956)

In aq.  $H_2SO_4$

At 20°		At 65°	
Gms. $H_2SO_4$ per liter	Gms. $Nb_2O_5$ per liter	Gms. $H_2SO_4$ per liter	Gms. $Nb_2O_5$ per liter
68	0.047	-	-
88	0.060	-	-
150	0.090	159	0.275

(Cont.)

# Nb NIOBIUM

## SOLUBILITY OF $Nb_2O_5$ IN DILUTE ACID SOLUTIONS--Cont.

In aq.  $H_2SO_4$

At 20°		At 65°	
Gms. $H_2SO_4$ per liter	Gms. $Nb_2O_5$ per liter	Gms. $H_2SO_4$ per liter	Gms. $Nb_2O_5$ per liter
200	0.120	278	0.420
300	0.180	350	0.740
400	0.250	405	1.210
500	0.410	479	2.400
544	0.600	500	2.960
600	1.320	557	3.430
640	2.100	587	4.270
700	3.200	644	4.320
760	4.500	663	4.940
800	5.400	737	6.200
840	6.200	866	6.900
880	7.200	876	7.500
900	7.600	-	-

In aq.  $HCl$  at 20°

In aq.  $HNO_3$  at 20°

Gms. $HCl$ per liter	Gms. $Nb_2O_5$ per liter	Gms. $HNO_3$ per liter	Gms. $Nb_2O_5$ per liter
66	0.072	143	0.071
110	0.129	327	0.075
182	0.259	450	0.074
230	0.469	567	0.075
295	1.433	630	0.088
330	2.041	730	0.250
451	4.836	800	0.366

Data for the solubility of niobic acid in aqueous solutions of  $\alpha$  hydroxy acids, dibasic acids and amines are given by Fairbrother and Taylor, 1956

For data on the solubility of freshly roasted  $Nb_2O_5$  in  $H_2O$ , dil.  $HCl$  and dil.  $H_2SO_4$  see Lapitsky, Pospelova and Artamonova, 1956.

## Br NEODYMIUM BROMIDE $NdBr_3$

0.94 gms.  $NdBr_3$  dissolve in 100 gms. ethylene diamine at 30°. (Moeller and Zimmerman, 1953)

NEODYMIUM BROMATE  $\text{Nd}(\text{BrO}_3)_3$ 

BrO

SOLUBILITY OF NEODYMIUM BROMATE IN WATER  
(James, Fogg, McIntire, Evans and Donovan, 1927)

t°	Gms. $\text{Nd}(\text{BrO}_3)_3$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{Nd}(\text{BrO}_3)_3$ per 100 gms. sat. sol.	Solid Phase
0	30.52	$\text{Nd}(\text{BrO}_3)_3 \cdot 9\text{H}_2\text{O}$	25	46.06	$\text{Nd}(\text{BrO}_3)_3 \cdot 9\text{H}_2\text{O}$
5	34.01	"	30	48.77	"
10	37.19	"	35	51.48	"
15	40.30	"	40	53.70	"
20	43.04	"	45	56.90	"

NEODYMIUM ACETATE  $\text{Nd}(\text{CH}_3\text{COO})_3 \cdot \text{H}_2\text{O}$ 

CH

100 gms. sat. sol. of neodymium acetate in water contain 20.76 gms.  $\text{Nd}(\text{CH}_3\text{COO})_3$  at 25°. Constant agitation was employed for obtaining saturation. (Meyer and Miller, 1920)

100 ml. sat. sol. of neodymium acetate in ethylenediamine contain 7.81 gms.  $\text{Nd}(\text{CH}_3\text{COO})_3$  at 30°. (Muniyappan and Anjaneyalu, 1957)

NEODYMIUM GLYCOLATE  $\text{Nd}(\text{C}_2\text{H}_3\text{O}_3)_3$ 

One liter  $\text{H}_2\text{O}$  dissolves 4.609 gms. salt at 20°. (Jantsch and Grünkraut, 1912-13)

NEODYMIUM LACTATE  $\text{Nd}(\text{C}_3\text{H}_5\text{O}_3)_3 \cdot 2\frac{1}{2}\text{H}_2\text{O}$ 

One liter of sat. solution of neodymium lactate in water contains 24.775 gms.  $\text{Nd}(\text{C}_3\text{H}_5\text{O}_3)_3 \cdot 2\frac{1}{2}\text{H}_2\text{O}$  at 20°. Saturation was secured by constant agitation. (Jantsch, 1926)

## NEODYMIUM BENZENE SULFONATES

[See also Vol. I, p. 1001 under DIDYMIUM]

## SOLUBILITY IN WATER

Sulfonate and Formula	t°	Gms. Anhydrous Salt per 100 gms. $\text{H}_2\text{O}$	Authority
Neodymium m Nitrobenzene Sulfonate $\text{Nd}[\text{C}_6\text{H}_4(\text{NO}_2)\text{SO}_3]_3 \cdot 6\text{H}_2\text{O}$	15	46.1	(Holmberg, 1907)
Neodymium Bromonitrobenzene Sulfonate $\text{Nd}[\text{C}_6\text{H}_3\text{Br}(\text{NO}_2)(\text{SO}_3)]_3 \cdot 8\text{H}_2\text{O}$	25	7.25	(Katz & James, 1913)

# Nd NEODYMIUM

## NEODYMIUM SORBATE $Nd(C_6H_7O_2)_3$

A saturated solution in water at 20° contains 0.001720 moles  $Nd(C_6H_7O_2)_3$  per liter.

## NEODYMIUM SODIUM ETHYLENEDIAMINE TETRAACETATE $NdNaC_2H_4N_2(COO)_4$

At 25°, 0.072 moles of (anhydrous) salt are dissolved in 1000 gms. sat. sol. in water. (Moeller, Moss and Marshall, 1955)

### C

## NEODYMIUM ACETYL ACETONATE $Nd[CH(COCH_3)_2]_3$

### SOLUBILITY OF NEODYMIUM ACETYLACETONATE IN VARIOUS SOLVENTS (Erametza and Hamala, 1958)

Solvent	t°	Gms. $Nd_2O_3$ per liter sat. sol.	Solvent	t°	Gms. $Nd_2O_3$ per liter sat. sol.
$CCl_4$	20	0.53	acetylacetone	20	1.66
$CHCl_3$	20	2.2		30	1.8
acetone	20	3.6		40	2.0
$CH_3OH$	20	87.0		60	2.4
$C_2H_5OH$	20	3.4		75	3.1
$C_4H_9OH$	20	2.8			

## NEODYMIUM CAMPHOCARBONATE $Nd(C_{11}H_{15}O_3)_3$

### SOLUBILITY OF NEODYMIUM CAMPHO CARBONATE IN SEVERAL SOLVENTS AT 15° (Picon, 1931)

Solvent	Gms. $Nd(C_{11}H_{15}O_3)_3$ per 100 cc sat. sol.	Solvent	Gms. $Nd(C_{11}H_{15}O_3)_3$ per 100 cc sat. sol.
Water	0.7	Benzene	50.+
Methyl Alcohol	16.7	Chloroform	50.+
Ethyl Alcohol	15.3	$CCl_4$	50.+
Ethyl Ether	4.9	Carbon DiSulfide	100
Ethyl Acetate	5.9	Olive Oil	2.6
Acetone	6.3		

## NEODYMIUM COBALTICYANIDE $2Nd[Co(CN)_6] \cdot 9H_2O$

1000 gms. aq. 10% HCl ( $d_{15} = 1.05$ ) dissolve 4.19 gms. salt at 25°. (James and Willand, 1916)

NEODYMIUM FERROCYANIDE  $\text{Nd}_4[\text{Fe}(\text{CN})_6]_3$ 

Data for the formation of this salt in systems of  $\text{Nd}(\text{NO}_3)_3$  + alkali ferrocyanides are given by Tananaev and Levina, 1957.

NEODYMIUM OXALATE  $\text{Nd}_2(\text{C}_2\text{O}_4)_3 \cdot 10\text{H}_2\text{O}$ 

CO

## SOLUBILITY IN WATER AT 25°

- 0.0053 mg./equiv (0.49 mg.)  $\text{Nd}_2(\text{C}_2\text{O}_4)_3$  per liter (electrolytic det'n.)  
 (Rimbach and Schubert, 1909)  
 0.00148 gm.  $\text{Nd}_2(\text{C}_2\text{O}_4)_3$  per liter (gravimetric)  
 (Sarver and Brinton, 1927)  
 0.00198 gm.  $\text{Nd}_2(\text{C}_2\text{O}_4)_3$  per liter (electrolytic)  
 (Sarver and Brinton, 1927)  
 0.000973 gm.  $\text{Nd}_2(\text{C}_2\text{O}_4)_3$  per liter (radiotracers)  
 (Crouthamel and Martin, Jr., 1951)

SOLUBILITY OF NEODYMIUM OXALATE IN AQUEOUS SOLUTIONS OF ACIDS AT 25°  
 (Sarver and Brinton, 1927)

The determinations were made with very great care. The mixtures were constantly rotated for several days.

Concentration of Aq. Solvent in Normality	Gms. $\text{Nd}_2(\text{C}_2\text{O}_4)_3$ per 100 gms. sat. sol.	Concentration of Aq. Solvent in Normality	Gms. $\text{Nd}_2(\text{C}_2\text{O}_4)_3$ per 100 gms. sat. sol.
0.1008 HCl	0.0076	0.2482 $\text{HNO}_3$	0.0238
0.2576 "	0.0217	1.992 "	0.4287
0.5004 "	0.0442	4.054 "	1.353
1.018 "	0.1260	2.000 "+0.1 (COOH) <sub>2</sub>	0.1138
1.484 "	0.2222	3.03 "+0.1 "	0.4606
2.000 "	0.3318	2.00 "+0.5 "	0.0195
5.200 "	1.5330	3.03 "+0.5 "	0.0811
0.978 "+0.1 (COOH) <sub>2</sub>	0.0082	4.00 "+0.5 "	0.2528
2.000 "+0.1 "	0.0747	4.00 "+sat. "	0.0972
2.865 "+0.1 "	0.2167	6.00 "+sat. "	0.3413
3.965 "+0.1 "	0.5570	0.086 $\text{H}_2\text{SO}_4$	0.0091
0.978 "+0.5 "	0.0020	0.419 "	0.0415
2.000 "+0.5 "	0.0112	0.958 "	0.1037
2.865 "+0.5 "	0.0352	1.846 "	0.2237
3.965 "+0.5 "	0.1047	2.612 "	0.3702
1.484 "+sat. "	0.0033		
4.000 "+ " "	0.0775		
6.000 "+ " "	0.1814		
6.200 "+ " "	0.1785		



# NEODYMIUM

## SOLUBILITY OF NEODYMIUM OXALATE IN AQUEOUS SOLUTIONS OF ACIDS AT 90° (Neckers and Kremers, 1928)

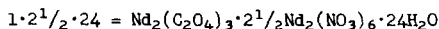
The mixtures were shaken frequently during thirty-six hours.

Concentration of Aq. Solvent		Gms. Nd <sub>2</sub> O <sub>3</sub> per 100 cc. sat. sol.
Normality HNO <sub>3</sub>	Percent (COOH) <sub>2</sub> ·2H <sub>2</sub> O	
1.25	-	0.8707
2.50	-	1.9571
5.00	-	6.7788
1.25	5.0	0.0915
2.50	5.0	0.6760
5.00	5.0	5.1263

CO

## THE SYSTEM NEODYMIUM OXALATE - NEODYMIUM NITRATE - WATER AT 25° (James and Robinson, 1913)

The mixtures were constantly agitated at constant temperature for twelve weeks.



Gms. per 100 Gms. Sat. Sol.		Solid Phase
Nd <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub>	Nd <sub>2</sub> (NO <sub>3</sub> ) <sub>6</sub>	
0.18	6.46	Nd <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> ·11H <sub>2</sub> O
0.54	12.23	"
0.76	17.78	"
0.85	22.67	"
0.96	27.43	"
1.28	31.36	"
1.38	35.26	"
1.66	38.70	"
1.88	42.13	"
1.96	44.82	"
2.07	47.64	"
2.54	50.52	"
2.89	52.82	"
3.17	54.67	"
2.21	56.48	probably 1.2½·24
1.44	59.68	Nd <sub>2</sub> (NO <sub>3</sub> ) <sub>6</sub> (?H <sub>2</sub> O)
1.33	59.67	"
1.21	59.70	"
0.96	59.75	"
-	60.46	"

## APPROXIMATE SOLUBILITY OF NEODYMIUM OXALATE IN AMINE OXALATE SOLUTIONS (Grant and James, 1917)

100 cc. aq. 20% methyl amine oxalate dissolve 0.027 gm. neodymium oxalate. 100 cc. aq. 20% ethyl amine oxalate dissolve 0.107 gm. neodymium oxalate. 100 cc. aq. 20% triethyl amine oxalate dissolve 0.065 gm. neodymium oxalate.

NEODYMIUM CHLORIDE  $\text{NdCl}_3$ SOLUBILITY OF NEODYMIUM CHLORIDE IN WATER  
(Friend and Hall, 1940)The solid phase is  $\text{NdCl}_3 \cdot 6\text{H}_2\text{O}$  throughout

t°	Gms. $\text{NdCl}_3$ per 100 Gms. Sat. Sol.	t°	Gms. $\text{NdCl}_3$ per 100 Gms. Sat. Sol.	t°	Gms. $\text{NdCl}_3$ per 100 Gms. Sat. Sol.
0	49.19	40	(50.41) <sup>a</sup>	72.0	54.61
10	49.33	45.8	51.88	80.0	56.04
	(49.16) <sup>a</sup>	54.8	52.51	87.0	56.75
13	(49.67) <sup>b</sup>	55	(51.11) <sup>a</sup>	91.7	57.19
15.4	49.34	55.4	52.90	93.5	57.41
20	(49.49) <sup>a</sup>	59.0	53.33	97.6	58.29
26.2	49.61	64.0	53.88	98.3	58.15
30	(49.91) <sup>a</sup>	68.0	54.39	100	(58.3) <sup>b</sup>
33.0	50.69				

<sup>a</sup>Williams, Fogg and James, 1926<sup>b</sup>Matignon, 1906, 1909SOLUBILITY OF NEODYMIUM CHLORIDE IN AQUEOUS HYDROCHLORIC ACID  
(Williams, Fogg and James, 1926)

t°	Gms. $\text{NdCl}_3$ per 100 gms. sat. sol. in aq. HCl of d = 1.1051	Solid Phase
10	26.16	$\text{NdCl}_3 \cdot 6\text{H}_2\text{O}$
20	26.57	"
30	27.92	"
40	29.83	"
55	31.94	"

SOLUBILITY OF NEODYMIUM TRICHLORIDE AND OF NEODYMIUM OXIDE IN AQUEOUS  
SOLUTIONS OF AMMONIUM CHLORIDE AT 15°, 30°, 50° AND 100°  
(Prandtl and Rauchenberger, 1920)

The results are given only in the form of small scale diagrams and it is stated that the numerical data will be published in full in the dissertation of Johanna Rauchenberger, University of München, 1920. The equilibrium  $\text{Nd}(\text{OH})_3 + 3\text{NH}_4\text{Cl} \rightleftharpoons \text{NdCl}_3 + 3\text{NH}_3 + 3\text{H}_2\text{O}$  was approached by the authors from both sides. The composition of the basic chlorides obtained by shaking the oxide with 1.0n  $\text{NH}_4\text{Cl}$  at different temperatures, and drying over soda lime, was approximately as follows:

At 15°

At 30°

At 50°



100 gms. abs. alcohol dissolve 44.5 gms. (anhydrous)  $\text{NdCl}_3$  at 20°. Saturation was obtained by spontaneous evaporation of the solution over  $\text{H}_2\text{SO}_4$ . (Matignon, 1906)

100 gms. anhydrous pyridine dissolve 1.8 gms. anhydrous  $\text{NdCl}_3$  at about 15°. Saturation obtained by daily agitation of the solution for some weeks. (Matignon, 1906)

## Nd NEODYMIUM

Melting points in the systems  $\text{NdCl}_3 - \text{NaCl}$ ,  $\text{NdCl}_3 - \text{CaCl}_2$  and  $\text{NdCl}_3 - \text{NaCl} - \text{CaCl}_2$  are given by Morozov, Shevtsova and Kiyukina, 1957.

### NEODYMIUM HEXA ANTIPYRINE PERCHLORATE $[\text{Nd}(\text{COC}_{10}\text{H}_{12}\text{O}_2)_6](\text{ClO}_4)_3$

100 cc. sat. solution of neodymium hexa antipyrine perchlorate in water contain 0.98 gm.  $[\text{Nd}(\text{COC}_{10}\text{H}_{12}\text{O}_2)_6](\text{ClO}_4)_3$  at 20°. (Wilke-Dörfurt and Schliephake, 1925.)

### NEODYMIUM CHROMATE $\text{Nd}_2(\text{CrO}_4)_3 \cdot 8\text{H}_2\text{O}$

100 gms. sat. solution of neodymium chromate in water contain 0.027 gm.  $\text{Nd}_2(\text{CrO}_4)_3$  at 25°. (Britton, 1924.)

## I NEODYMIUM IODIDE $\text{NdI}_3$

At 30°, 2.53 gms.  $\text{NdI}_3$  dissolve in 100 gms. ethylene diamine. (Moeller and Zimmerman, 1953.)

### NEODYMIUM MOLYBDATE $\text{Nd}_2(\text{MoO}_4)_3$

One liter  $\text{H}_2\text{O}$  dissolves 0.0186 gm. salt at 28° and 0.0308 gm. at 75°. The mixtures were frequently stirred at constant temperature during only two hours. (Hitchcock, 1895.)

## NO NEODYMIUM NITRATE $\text{Nd}(\text{NO}_3)_3$

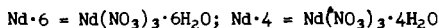
[See also Vol. I, p. 1000 under DIDYMIUM]

### SOLUBILITY OF $\alpha$ AND $\beta$ NEODYMIUM NITRATES IN WATER (Friend, 1935)

t°	Gms. $\text{Nd}(\text{NO}_3)_3$ per 100		Solid Phase	t°	Gms. $\text{Nd}(\text{NO}_3)_3$ per 100		Solid Phase
	Gms. Sat. Sol.				Gms. Sat. Sol.		
0	55.97		$\text{Nd}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O} \alpha$	27.2	59.17		$\text{Nd}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O} \beta$
13.2	57.37		"	29.4	59.18		"
18.2	58.03		"	37.2	60.95		"
23.0	59.59		"	42.4	61.91		"
25. (1)	60.46		"	50.0	64.86		"
26.2	60.69		"	57.2	67.00		"
				66.2	73.13		"
(1) James and Robinson, 1913				67.5 <sup>m</sup>	75.34		"

m = melting point

SOLUBILITY OF NEODYMIUM NITRATE IN AQUEOUS SOLUTIONS OF NITRIC ACID  
(Quill and Robey, 1937)



Results at 25°				Results at 50°			
d. of sat. sol.	Gms. per 100 Gms. Sat. Sol.		Phase	d. of sat. sol.	Gms. per 100 Gms. Sat. Sol.		Phase
	$\text{HNO}_3$	$\text{Nd}(\text{NO}_3)_2$			$\text{HNO}_3$	$\text{Nd}(\text{NO}_3)_2$	
-	0.0	59.0	Nd·6	1.963	0.0	66.26	Nd·6
1.741	6.20	53.31	"	1.948	2.14	64.62	"
-	6.36	52.15	"	1.901	6.92	60.34	"
-	18.28	40.79	"	1.885	10.41	57.74	"
-	43.95	23.64	"	1.997	11.93	59.47	" + Nd·4 NO
-	44.63	24.08	"	-	22.67	51.24	Nd·4
1.595	49.20	23.47	Nd·4	1.819	26.83	47.36	"
1.572	56.65	19.11	"	-	46.55	32.49	"
				-	45.46	34.97	"

A study of the systems  $\text{Nd}(\text{NO}_3)_3 - \text{M}_4\text{Fe}(\text{CN})_6 - \text{H}_2\text{O}$  at 25°, where M = Na, Li, K, Rb, Cs indicated the presence of only the compound  $\text{Li}_4\text{Fe}(\text{CN})_6$  in the lithium system; and of the double ferrocyanides  $\text{M NdFe}(\text{CN})_6$  in the other systems. (Tananaev and Levina, 1957)

## NEODYMIUM DOUBLE NITRATES

SOLUBILITIES IN WATER  
(Prandtl and Ducru, 1926)

Salt	t°	d of sat. sol.	Gms. per 100 gms. sat. sol.		
			$\text{Nd}_2\text{O}_3$	Other metal oxide	Double salt
Neodymium Cobalt Nitrate $2\text{Nd}(\text{NO}_3)_3 \cdot 3\text{Co}(\text{NO}_3)_2 \cdot 24\text{H}_2\text{O}$	15	1.65	14.0	9.28 (CoO)	68.3
	30	1.68	14.84	9.84	72.4
	45	1.72	15.71	10.43	76.6
	60	1.77	16.63	11.16	81.1
Neodymium Magnesium Nitrate $2\text{Nd}(\text{NO}_3)_3 \cdot 3\text{Mg}(\text{NO}_3)_2 \cdot 24\text{H}_2\text{O}$	15	1.52	14.45	5.17 (MgO)	66.0
	30	1.55	15.20	5.49	69.5
	50	1.59	16.34	5.78	74.4
	70	1.64	17.47	6.29	79.8
Neodymium Manganese Nitrate $2\text{Nd}(\text{NO}_3)_3 \cdot 3\text{Mn}(\text{NO}_3)_2 \cdot 24\text{H}_2\text{O}$	15	1.66	15.24	9.50 (MnO)	73.8
	30	1.70	15.99	10.15	77.4
	45	1.75	17.05	10.68	82.6
	60	1.82	18.37	11.48	89.0
Neodymium Nickel Nitrate $2\text{Nd}(\text{NO}_3)_3 \cdot 3\text{Ni}(\text{NO}_3)_2 \cdot 24\text{H}_2\text{O}$	15	1.63	14.01	9.13 (NiO)	68.4
	30	1.66	14.66	9.73	71.5
	45	1.69	15.41	10.12	75.1
	60	1.74	16.36	10.89	79.8
Neodymium Zinc Nitrate $2\text{Nd}(\text{NO}_3)_3 \cdot 3\text{Zn}(\text{NO}_3)_2 \cdot 24\text{H}_2\text{O}$	15	1.65	14.00	10.15 (ZnO)	69.1
	30	1.69	14.88	10.79	73.5
	50	1.75	15.86	11.53	78.3
	70	1.81	17.15	12.33	84.6

## Nd NEODYMIUM

SOLUBILITY IN AQUEOUS  $\text{HNO}_3$  OF  $d_{16} = 1.325$  (= 51.59 GMS.  $\text{HNO}_3$  PER 100 CC.)  
AT  $16^\circ$   
(Jantsch, 1912)

Double Salt	Formula	Gms. Hydrated Double Salt per 100 Gms. Sat. Sol.
Neodymium Magnesium Nitrate	$[\text{Nd}(\text{NO}_3)_6]_2\text{Mg}_3 \cdot 24\text{H}_2\text{O}$	97.7
" Nickel "	" $\text{Ni}_3$ "	116.6
" Cobalt "	" $\text{Co}_3$ "	151.6
" Zinc "	" $\text{Zn}_3$ "	177
" Manganese "	" $\text{Mn}_3$ "	296

The distribution coefficient of a mixture of rare earth nitrates containing 12.5% neodymium nitrate between methyl n-hexyl ketone and water at room temperature was found to be less than 0.0012, with 33.0% of anhydrous salt in the aqueous phase. (Rothchild; Templeton, and Hall, 1948.)

Data for the distribution of  $\text{Nd}(\text{NO}_3)_3$  between tri n-butyl phosphate and aqueous  $\text{HNO}_3$  are given by Knapp, Smutz and Spedding, 1956 and by Weaver, Kappelmann and Topp, 1953.

100 cc. of a saturated solution of  $\text{Nd}(\text{NO}_3)_3$  in ethyl ether, prepared by frequent agitation and allowing to stand over night at about  $20^\circ$ , contain 0.20 gm.  $\text{Nd}_2\text{O}_3$ . A saturated ethereal solution prepared as above but using neodymium nitrate which had been dehydrated at  $150^\circ$ , contain 2.67 gm.  $\text{Nd}_2\text{O}_3$  per 100 cc. of solution. (Wells, 1930.)

### DISTRIBUTION OF NEODYMIUM NITRATE BETWEEN WATER AND n-HEXYL ALCOHOL AT $25^\circ$

Gms. $\text{Nd}_2\text{O}_3$ per 100 gms. Sat. Sol.		Gms. $\text{Nd}_2\text{O}_3$ per 100 gms. Sat. Sol.	
Aqueous Phase	Alcohol Phase	Aqueous Phase	Alcohol Phase
30.45	5.59	25.2	1.16
29.80	5.10	23.0	0.60
29.23	4.32	22.3	.52
28.80	3.78	21.25	.35
27.7	2.64	19.8	.25
		18.2	.15

Data for the distribution of  $\text{Nd}(\text{NO}_3)_2$  between aqueous  $\text{NH}_4\text{SCN}$  solutions and 1 butanol (or 1-pentanol) are reported by Asselin, Audrieth and Comings, 1950.

- O NEODYMIUM OXIDE  $\text{Nd}_2\text{O}_3$   
OH NEODYMIUM HYDROXIDE  $\text{Nd}(\text{OH})_3$

One liter sat. solution of neodymium oxide in water contain 0.00000575 gm. mol.  $\text{Nd}_2\text{O}_3$  at  $29^\circ$ . (Bush, 1927)

Korenmsn, 1955 in a review of rare earth Ksp values, lists  $5 \times 10^{-24}$  for  $\text{Nd}(\text{OH})_3$ .

SOLUBILITY OF NEODYMIUM HYDROXIDE IN DILUTE ACIDS AND BASE AT 25°  
(Tobias and Garrett, 1958)

In Aqueous HCl		In Aqueous HClO <sub>4</sub>		In Aqueous NaOH	
Initial HCl moles/1000 g. H <sub>2</sub> O	Final Nd g. atoms/1000 g. H <sub>2</sub> O	Initial HClO <sub>4</sub> moles/1000 g. H <sub>2</sub> O	Final Nd g. atoms/1000 g. H <sub>2</sub> O	Initial OH moles/1000 g. H <sub>2</sub> O	Final Nd(OH) <sub>3</sub> moles/1000 g. H <sub>2</sub> O
0.1004	0.0335	0.0998	0.0329	0.0607	0.0000198
0.0502	0.0167	0.01051	0.00340	0.1800	0.0000055
0.0100	0.00335	0.00210	0.00070	0.5273	{ 0.0000142
0.0050	0.00167				{ 0.0000082
0.0010	0.00033				{ 0.0000430
0.0005	0.00017			1.0125	{ 0.0000347

Data for the precipitation of Nd<sub>2</sub>O<sub>3</sub> and other rare earth oxides from ammonium acetate solutions is given by Perey, 1949.

NEODYMIUM HYPOPHOSPHATE Nd<sub>4</sub>(P<sub>2</sub>O<sub>6</sub>)<sub>3</sub>

PO

SOLUBILITY IN HYDROCHLORIC ACID SOLUTIONS  
(Moeller and Quinty, 1952)

N HCl	moles Nd <sub>4</sub> (P <sub>2</sub> O <sub>6</sub> ) <sub>3</sub> per liter	N HCl	moles Nd <sub>4</sub> (P <sub>2</sub> O <sub>6</sub> ) <sub>3</sub> per liter
0.05	0.000011	0.30	0.00200
0.10	0.000048	1.00	0.001446
0.20	0.000160	2.00	0.003470

NEODYMIUM DIMETHYL PHOSPHATE Nd<sub>2</sub>[(CH<sub>3</sub>)<sub>2</sub>PO<sub>4</sub>]<sub>6</sub>

100 gms. H<sub>2</sub>O dissolve 56.1 gms. Nd<sub>2</sub>[(CH<sub>3</sub>)<sub>2</sub>PO<sub>4</sub>]<sub>6</sub> at 25° and about 22.3 gms. at 95°. (Morgan and James, 1914.)

NEODYMIUM SULFATE Nd<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>

[See also Vol. I, p. 1001 under DIOXYMIUM] SO

The results of Friend, 1930; Meyer, R. J. (private communication to Landoldt and Bornstein Tabellen) and Jackson and Reinacker, 1930, were plotted and the following values taken from the average curve. The previous results of Muthmann and Rohg, 1898, are not in good agreement with the later determinations.

## Nd NEODYMIUM

## SOLUBILITY OF NEODYMIUM SULFATE IN WATER--Cont.

t°	Gms. Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> per 100 gms.		Solid Phase	t°	Gms. Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> per 100 gms.		Solid Phase
	sat. sol.				sat. sol.		
0	11.5		Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·15H <sub>2</sub> O	50	3.2		Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·8H <sub>2</sub> O <sup>a</sup>
10	8.8		Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·8H <sub>2</sub> O <sup>a</sup>	60	2.7		"
20	6.6		"	70	2.4		"
25	5.8		"	85	2.0		"
	5.29 <sup>a</sup>		"	87	1.2		Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·8H <sub>2</sub> O <sup>β</sup>
30	5.0		"	95	1.15		"
40	3.9		"	100	1.2		"

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<sup>a</sup>Spedding and Jaffe, 1954

Data for the solubility of Nd<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> in water from 110° to 295° were determined by Lock, 1957.

## Results for Aqueous Acids:

0.33 normal H<sub>2</sub>SO<sub>4</sub>    1.0 normal H<sub>2</sub>SO<sub>4</sub>    4.0 normal H<sub>2</sub>SO<sub>4</sub>    8.0 normal H<sub>2</sub>SO<sub>4</sub>

t°	Gms. Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> per 100 gms.		t°	Gms. Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> per 100 gms.		t°	Gms. Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> per 100 gms.	
	sat. sol.			sat. sol.			sat. sol.	
0	10.04	0.2	9.89	0.2	4.56	11.0	1.62	
30.4	5.71	15.4	7.0	14.8	3.92	30.4	2.04	
46.4	4.79	30.4	6.10	30.4	3.61	46.4	2.19	
81.0	3.54	79.2	4.41	46.4	3.78			
89.6	2.15	90.0	3.41	59.0	3.62			
		96.8	2.69					

THE SYSTEM NEODYMIUM SULFATE - POTASSIUM SULFATE - WATER AT 25°  
(Zambonini and V. Cagliotti, 1924)

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>			Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>		
2.76	0.00		1·1·1	0.18	3.01		1·3·2
2.02	0.15		"	0.17	3.40		" + 1·4·1
1.69	0.30		"	0.08	4.06		1·4·1
1.62	0.47		" + 2·3·8	0.08	4.94		"
1.13	0.54		2·3·8	0.07	6.20		1·4·2
0.26	1.75		"	0.04	8.52		"
0.17	2.61		"	0.04	10.01		"
0.17	2.80		" + 1·3·2	0.04	10.85		1·5·2
0.18	2.98		" "	0.00	11.18		" + K <sub>2</sub> SO <sub>4</sub>
1·1·2 = Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·K <sub>2</sub> SO <sub>4</sub> ·2H <sub>2</sub> O				2·3·8 = 2Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·3K <sub>2</sub> SO <sub>4</sub> ·8H <sub>2</sub> O			
1·3·2 = Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·3K <sub>2</sub> SO <sub>4</sub> ·2H <sub>2</sub> O				1·4·1 = Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·4K <sub>2</sub> SO <sub>4</sub> ·H <sub>2</sub> O			
1·4·2 = Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·4K <sub>2</sub> SO <sub>4</sub> ·2H <sub>2</sub> O				1·5·2 = Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·5K <sub>2</sub> SO <sub>4</sub> ·2H <sub>2</sub> O			

THE SYSTEM NEODYMIUM SULFATE - AMMONIUM SULFATE - WATER AT 25°  
(Zambonini, and Stolfi, 1927)

Gms. per 100 gms. sat. sol.

 $\text{Nd}_2(\text{SO}_4)_3$        $(\text{NH}_4)_2\text{SO}_4$ 

Solid Phase

4.50	0.77	$\text{Nd}_2(\text{SO}_4)_3 \cdot 8\text{H}_2\text{O} + \text{Nd}_2(\text{SO}_4)_3 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 8\text{H}_2\text{O}$
3.17	0.77	"
2.58	1.00	$\text{Nd}_2(\text{SO}_4)_3 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 8\text{H}_2\text{O}$
1.16	2.78	"
0.58	12.86	"
0.58	16.21	"
0.58	24.25	"
0.58	26.98	"
0.58	29.18	"
0.58	35.18	"
0.58	37.55	"
0.58	40.88	"
0.58	43.90	$\text{Nd}_2(\text{SO}_4)_3 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 8\text{H}_2\text{O} + (\text{NH}_4)_2\text{SO}_4$

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THE SYSTEM NEODYMIUM SULFATE - SODIUM SULFATE - WATER AT 25°  
(Zambonini and Carobbi, 1925a)

Gms. per 100 gms.  
sat. sol.Gms. per 100 gms.  
sat. sol.
 $\text{Nd}_2(\text{SO}_4)_3$        $\text{Na}_2\text{SO}_4$ 

Solid Phase

 $\text{Nd}_2(\text{SO}_4)_3$        $\text{Na}_2\text{SO}_4$ 

Solid Phase

2.37	0.57	$\text{Nd}_2(\text{SO}_4)_3 \cdot 8\text{H}_2\text{O}$	-	8.11	4.5.8
1.11	0.14	" + 1.1.2	-	8.97	" + 3.4.6
0.28	0.49	1.1.2	-	10.98	3.4.6
0.14	1.24	"	-	13.16	"
-	3.11	"	-	14.54	" + 2.3.5
-	5.02	"	-	16.92	2.3.5
-	6.00	4.5.8	-	17.61	"
-	7.72	"	-	17.95	" + $\text{Na}_2\text{SO}_4$

1.1.2 =  $\text{Nd}_2(\text{SO}_4)_3 \cdot \text{Na}_2\text{SO}_4 \cdot 2\text{H}_2\text{O}$       4.5.8 =  $4\text{Nd}_2(\text{SO}_4)_3 \cdot 5\text{Na}_2\text{SO}_4 \cdot 8\text{H}_2\text{O}$ 3.4.6 =  $3\text{Nd}_2(\text{SO}_4)_3 \cdot 4\text{Na}_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$       2.3.5 =  $2\text{Nd}_2(\text{SO}_4)_3 \cdot 3\text{Na}_2\text{SO}_4 \cdot 5\text{H}_2\text{O}$ 

Results for the solubility of  $\text{Nd}_2(\text{SO}_4)_3$  in 1.6N  $\text{Na}_2\text{SO}_4$  solution  
from 110° to 195° are given by Lock, 1957.

THE SYSTEM NEODYMIUM SULFATE - RUBIDIUM SULFATE - WATER AT 25°  
(Zambonini and Caglioti, 1927)

Gms. per 100 gms.  
sat. sol.Gms. per 100 gms.  
sat. sol.
 $\text{Nd}_2(\text{SO}_4)_3$        $\text{Rb}_2\text{SO}_4$ 

Solid Phase

 $\text{Nd}_2(\text{SO}_4)_3$        $\text{Rb}_2\text{SO}_4$ 

Solid Phase

4.90	1.05	$\text{Nd}_2(\text{SO}_4)_3 \cdot 8\text{H}_2\text{O} + 1.1.8$	-	5.16	1.1.8
4.73	1.20	1.1.8	-	7.93	"
2.29	1.43	"	-	24.92	"
0.74	1.80	"	-	33.63	"
0.21	2.99	"	-	45.54	" + $\text{Rb}_2\text{SO}_4$

1.1.8 =  $\text{Nd}_2(\text{SO}_4)_3 \cdot \text{Rb}_2\text{SO}_4 \cdot 8\text{H}_2\text{O}$



## Nd NEODYMIUM

100 gms. H<sub>2</sub>O sat. with NdRb(SeO<sub>4</sub>)<sub>2</sub>·4H<sub>2</sub>O contain 12.5 gms. of the compound at 0° and 13.6 gms. at 20°. (Meyer and Kittelman, 1931.)

### THE SYSTEM NEODYMIUM SULFATE - THALLIUM SULFATE - WATER AT 25° (Zambonini and Cagliotti, 1925)

	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	Tl <sub>2</sub> SO <sub>4</sub>		Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	Tl <sub>2</sub> SO <sub>4</sub>	
SO	4.89	0.25	Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·8H <sub>2</sub> O + 1·1·3	0.30	3.00	1·1·8
	4.50	0.25	"	0.27	3.51	" + 1·4 <sup>1</sup> / <sub>2</sub>
	3.84	0.26	1·1·3	0.26	3.81	"
	3.81	0.27	"	0.26	3.85	1·4 <sup>1</sup> / <sub>2</sub>
	3.80	0.27	"	0.24	4.10	"
	3.78	0.28	1·1·8	0.19	4.70	"
	3.15	0.30	"	0.16	4.85	" + Tl <sub>2</sub> SO <sub>4</sub>
	1.86	0.45	"	0.11	4.90	"
	0.76	1.11	"	0.09	5.02	"

$$1\cdot1\cdot3 = \text{Nd}_2(\text{SO}_4)_3 \cdot \text{Tl}_2\text{SO}_4 \cdot 3\text{H}_2\text{O} \quad 1\cdot1\cdot8 = \text{Nd}_2(\text{SO}_4)_3 \cdot \text{Tl}_2\text{SO}_4 \cdot 8\text{H}_2\text{O}$$

$$1\cdot4\frac{1}{2} = \text{Nd}_2(\text{SO}_4)_3 \cdot 4\frac{1}{2}\text{Tl}_2\text{SO}_4$$

## NEODYMIUM SELENATE Nd<sub>2</sub>(SeO<sub>4</sub>)<sub>3</sub>

### SOLUBILITY OF NEODYMIUM SELENATE IN WATER (Friend, 1931)

The authors results were plotted and the following values taken from the average curve. Also see table following.

t°	Gms. Nd <sub>2</sub> (SeO <sub>4</sub> ) <sub>3</sub> per 100 gms.		Solid Phase	t°	Gms. Nd <sub>2</sub> (SeO <sub>4</sub> ) <sub>3</sub> per 100 gms.		Solid Phase
	sat.	sol.			sat.	sol.	
0	31.0		Nd <sub>2</sub> (SeO <sub>4</sub> ) <sub>3</sub> ·Aq.	50	29.2		Nd <sub>2</sub> (SeO <sub>4</sub> ) <sub>3</sub> ·Aq.
10.6	30.9		"	60	30.5		" + Nd <sub>2</sub> (SeO <sub>4</sub> ) <sub>3</sub> ·6H <sub>2</sub> O
20.0	29.5		"	62.5	22.0		Nd <sub>2</sub> (SeO <sub>4</sub> ) <sub>3</sub> ·6H <sub>2</sub> O
25.0	29.0		"	65	16.0		"
30	28.5		"	70	12.0		"
40	28.5		"	80	6.5		"
				90	3.2		"

The following results, differing very greatly from the above, are given by Meyer and Kittelmann, 1931.

Gms. Nd<sub>2</sub>(SeO<sub>4</sub>)<sub>3</sub> per 100 gms. H<sub>2</sub>O in contact with:

t°	Nd <sub>2</sub> (SeO <sub>4</sub> ) <sub>3</sub> ·5H <sub>2</sub> O    Nd <sub>2</sub> (SeO <sub>4</sub> ) <sub>3</sub> ·8H <sub>2</sub> O	
0	4	30
20	12	40

## NEODYMIUM Nd

SOLUBILITY OF NEODYMIUM SELENATE IN AQUEOUS SOLUTIONS OF SELENIC ACID  
(Friend, 1931)

t°	Gms. per 100 gms. sat. sol.		t°	Gms. per 100 gms. sat. sol.	
	H <sub>2</sub> SeO <sub>4</sub>	Nd <sub>2</sub> (SeO <sub>4</sub> ) <sub>3</sub>		H <sub>2</sub> SeO <sub>4</sub>	Nd <sub>2</sub> (SeO <sub>4</sub> ) <sub>3</sub>
0	3.84	29.54	40	60.0	7.9
8.6	5.87	26.29	45.6	1.34	28.27
13.0	5.93	34.92	45.6	5.49	27.35
17.6	8.6	25.23	45.6	6.39	27.18
17.0	12.4	23.72	55.4	1.66	27.29
24.0	4.14	26.35	84.4	44.0	7.55
30.0	4.52	25.32			

NEODYMIUM TUNGSTATE Nd<sub>2</sub>(WO<sub>4</sub>)<sub>3</sub>

WO

## SOLUBILITY IN WATER

(Results of Vickery, 1949)

	Unignited	Ignited
20°	0.021 gms./100 ml.	0.003 gms./100 ml.
100°	.027 "	.003 "

(Results of Hitchcock, 1895)

One liter H<sub>2</sub>O dissolves 0.0190 gm. Nd<sub>2</sub>(WO<sub>4</sub>)<sub>3</sub> at 22°, 0.0168 gm. at 65° and 0.0152 gm. at 98°. The mixtures were not constantly agitated and only two hours were allowed for saturation.

## NEON Ne

Ne

## SOLUBILITY IN WATER

The results of Lannung, 1930 and of Morrison and Johnstone, 1954 agree well. Earlier values of von Antropoff, 1919 and Valentiney, 1922 seem less reliable. Results in terms of β, cc. Ne (at 0°, 1 atm.) per gm. H<sub>2</sub>O at 1 atm. of Ne.

Lannung, 1930

5°	β
15	0.0108
18	0.0105
20	0.0104
25	0.0101
30	0.0099
37	0.0096

## SOLUBILITY IN WATER---Cont.

Morrison and Johnstone, 1954      Average Curve

t°	$\beta$	t°	$\beta$
9.1	0.00117	10	0.00115
11.5	0.00113	15	0.00108
15.0	0.00109	20	0.00104
19.8	0.00106	25	0.00102
24.4	0.00102	30	0.000994
28.8	0.00101	35	0.000973
31.3	0.000993	40	0.000955
32.1	0.000993	45	0.000944
42.1	0.000948	50	0.000940
49.5	0.000940	55	0.000941
58.8	0.000946	60	0.000945
61.0	0.000944	65	0.000954
64.4	0.000955	70	0.000970
65.4	0.000953	75	0.000991
66.6	0.000957		
72.5	0.000984		
74.1	0.000984		

SOLUBILITY OF NEON IN SALT SOLUTIONS AT 25°  
(Morrison and Johnstone, 1955)

"Salting out" coefficients  $k = \log \frac{S_0}{S} / C$ , where  $S_0$  = solubility in  $H_2O$  and salt concentrations are in moles per 1000 gms.  $H_2O$ .

Salt	k
NaCl	0.097
LiCl	0.059
KI	0.080

## SOLUBILITY OF NEON IN VARIOUS SOLVENTS

## Results of Lannung, 1930

$\beta$  = Bunsen coefficient = ml. Ne (0°, 1 atm.) dissolved in ml. solvent, at 1 atm. pressure of Ne

$\ell$  = Ostwald coefficient = ml. Ne (measured at t° of expt.) dissolved in 1 ml. of solvent, at 1 atm. pressure of Ne

Solvent	Solubility of Neon at					
	15°	18°	20°	25°	30°	37°
Water	$\beta$ 0.0108	0.0105	0.0104	0.0101	0.0099	0.0096
	$\ell$ 0.0114	0.0112	0.0112	0.0110	0.0110	0.0111
Methyl Alcohol	$\beta$ 0.0413	0.0423	0.0430	0.0444	0.0459	0.0480
	$\ell$ 0.0436	0.0451	0.0462	0.0485	0.0509	0.0545
Ethyl Alcohol	$\beta$ 0.0381	0.0394	0.0402	0.0417	0.0433	0.0442
	$\ell$ 0.0402	0.0420	0.0431	0.0455	0.0481	0.0502

(Cont.)

## SOLUBILITY OF NEON IN VARIOUS SOLVENTS--Cont.

$\beta$  = Bunsen coefficient = ml. Ne ( $0^\circ$ , 1 atm.) dissolved in ml. solvent, at 1 atm. pressure of Ne

$\ell$  = Ostwald coefficient = ml. Ne (measured at  $t^\circ$  of expt.) dissolved in 1 ml. of solvent, at 1 atm. pressure of Ne

Solvent	Solubility of Neon at						
		15°	18°	20°	25°	30°	37°
Acetone	{ $\beta$	0.043	0.045	0.046	0.048	--	--
	{ $\ell$	0.045	0.048	0.049	0.052	--	--
Benzene	{ $\beta$	0.0254	0.0264	0.0271	0.0288	0.0306	0.0330
	{ $\ell$	0.0268	0.0287	0.0291	0.0314	0.0340	0.0375
Cyclohexane	{ $\beta$	0.0333	0.0345	0.0353	0.0373	0.0392	0.0419
	{ $\ell$	0.0351	0.0368	0.0379	0.0407	0.0435	0.0476
Cyclohexanol	{ $\beta$	--	--	--	0.0152 <sup>a</sup>	0.0161	0.0173
	{ $\ell$	--	--	--	0.0166	0.0179	0.0196

<sup>a</sup>at  $26^\circ$  Cauquil, 1927 found  $\beta$  = 0.0155

Results of Clever, Battino, Saylor and Gross, 1957

$\ell$  = Ostwald coefficient

Solvent	$t^\circ$	$\ell$	Solvent	$t^\circ$	$\ell$
Benzene	14	0.0253	2,4 Dimethyl hexane	14.2	0.0534
	25	0.0293		25	0.0592
	39	0.0403		39	0.0673
Cyclohexane	14	0.0364	2,2,4 Trimethyl pentane	16.15	0.0625
	25	0.0392		25	0.0682
	39	0.0469		39	0.0754
n-Hexane	14	0.0607	n-Nonane	14	0.0408
	25	0.0707		25	0.0477
	38.7	0.0771		39	0.0535
n-Heptane	14	0.0535	n-Decane	15.9	0.0389
	25	0.0577		25	0.0444
	38.8	0.0676		39	0.0502
n-Octane	14.1	0.0480	n-Dodecane	15.9	0.0293
	25.2	0.0536		25	0.0347
	39	0.0638		39	0.0387
3-Methylheptane	14	0.0510	n-Tetradecane	15.9	0.0282
	25	0.0551		25	0.0316
	39	0.0647		40.1	0.0362
2,3 Dimethyl hexane	14	0.0485			
	25	0.0556			
	39	0.0625			

Results of Clever, Saylor and Gross, 1958

Methylcyclohexane	16	0.0395	Perfluoro- methylcyclo- hexane	16	0.0132
	30	0.0454		30	0.0146
	43.1	0.0562		43.1	0.0157

The solubility of Ne in nitroethane at  $24.85^\circ$  is  $\beta$  = 0.0245 (Friedman, 1954).

## Ne NEON

Data for the solubility of Ne and He in liquid argon at 83.9 to 87.5°K are given by Karasz and Halsey, Jr. (1958).

Results for the solubility of Ne, Ar, He and Xe in NaF - ZrF<sub>4</sub> melts at 600-800° are given by Grimes, Smith and Watson, 1958.

Data for the solubility of Ne in polyvinyl acetate from 8° to 40° are reported by Meares, 1958.

## NICKEL Ni

Qualitative data showing that just as iron, nickel is considerably attacked by water containing carbon dioxide, with formation of nickel carbonate, are given by Robl, 1924. A few quantitative results for special conditions are given.

Data for the distribution of nickel between zinc and lead are given by Tammann and Schaftmeister, 1924.

### SOLUBILITY OF NICKEL IN MILK (Quam, 1929)

Highly polished 4 x 7.5 cm. strips of nickel were each immersed in 50 cc. portions of raw milk and rocked 46 times per minute for one-half hour. The loss in weight of the Ni strips was determined and expressed as milligrams Ni dissolved per square decimeter of surface exposed. The dissolved nickel was also determined in the ash of the 50 cc. of milk by a modification of the  $\alpha$  benzil dioxane method. "

t°	Mgs. Ni dissolved per sq. decimeter of metal	t°	Mgs. Ni dissolved per sq. decimeter of metal
20	0.86	75	6.54
30	1.22	80	6.54
45	3.442	85	5.17
55	4.31	90	3.442
62.8	5.85	95	1.22

### SOLUBILITY OF NICKEL IN MERCURY (Irvin and Bussell, 1932)

An amalgam prepared from 0.2 gm. Ni in about 200 gms. Hg by electrolysis was filtered after two days through its own paste on a ground glass filter and the dissolved nickel in this filtrate found to be less than 0.00002 gm. per 100 gms. Hg. A determination by Tammann, Kollmann and Hinnuber, 1927, by potential difference measurements gave the result 0.0057 gm. mol. Ni per 1.0 gm. mol. Hg at 15°.

## AsO NICKEL ARSENITE

Data for the solubility of nickel arsenite at 20° in HNO<sub>3</sub>, H<sub>2</sub>SO<sub>4</sub> and HCl solutions at pH2-3 are given by Chukhlantsev, 1957.

## NICKEL ARSENATE

AsO

The Ksp of  $\text{Ni}_3(\text{AsO}_4)_2$  at  $20^\circ$  is  $3.1 (\pm 2.4) \times 10^{-26}$  at  $20^\circ$ , as determined in dilute  $\text{HCl}$ ,  $\text{H}_2\text{SO}_4$  and  $\text{HNO}_3$  solutions. (Chukhlantsev, 1956)

NICKEL BORATE  $\text{NiB}_6\text{O}_{10} \cdot 10\text{H}_2\text{O}$ 

BO

The solubility in 3% aqueous  $\text{H}_3\text{BO}_3$  at  $0^\circ$  is 45 gm. per liter. (Krymova, 1955.)

NICKEL BROMIDE  $\text{NiBr}_2 \cdot 6\text{H}_2\text{O}$ 

Br

SOLUBILITY IN WATER  
(Etard, 1894)

t°	Gms. $\text{NiBr}_2$ per 100 Gms. Solution	t°	Gms. $\text{NiBr}_2$ per 100 Gms. Solution	t°	Gms. $\text{NiBr}_2$ per 100 Gms. Solution
- 20	47.7	25	57.3	80	60.6
- 10	50.5	30	58	100	60.8
0	53	40	59.1	120	60.9
+ 10	55	50	60	140	60.9
20	56.7	60	60.4		

SOLUBILITY OF NICKEL BROMIDE IN PURE METHYL ALCOHOL  
(Lloyd, Brown, Glynwyn, Bonnel and Jones, 1928)

t°	Gms. $\text{NiBr}_2$ per 100 gms. $\text{CH}_3\text{OH}$	Solid Phase	t°	Gms. $\text{NiBr}_2$ per 100 gms. $\text{CH}_3\text{OH}$	Solid Phase
10	33.0	$\text{NiBr}_2 \cdot 6\text{CH}_3\text{OH}$	50	49.1	$\text{NiBr}_2$
20	35.1	"	60	53.7	"
30	38.1	"	70	59.6	"
40	43.3	"			

SOLUBILITY OF NICKEL BROMIDE IN ABSOLUTE ACETONE  
(Bell, Rowlands, Bamford, Thomas and Jones, 1930)

t°	Gms. $\text{NiBr}_2$ per 100 gms. $\text{CH}_3\text{COCH}_3$	Solid Phase	t°	Gms. $\text{NiBr}_2$ per 100 gms. $\text{CH}_3\text{COCH}_3$	Solid Phase
0	1.06	$\text{NiBr}_2$	30	0.55	$\text{NiBr}_2$
10	1.16	"	40	0.36	"
20	0.81	"	50	0.27	"

## NI NICKEL

### BrO NICKEL BROMATE $\text{Ni}(\text{BrO}_3)_2 \cdot 6\text{H}_2\text{O}$

100 gms. cold water dissolve 27.6 gms. nickel bromate.

### CH NICKEL ACETATE $\text{Ni}(\text{CH}_3\text{COO})_2$

The mean of four determinations of the solubility of nickel acetate in pure acetic acid, by Davidson and Chappell, 1933, was 12.37 mol. percent  $\text{Ni}(\text{CH}_3\text{COO})_2$  at  $30^\circ$ . The solid phase consisted of a finely divided greenish white substance without crystalline structure and containing from 54 to 66 mol. percent  $\text{Ni}(\text{CH}_3\text{COO})_2$ , thus indicating a solvated product of variable composition. Freezing-point determinations of  $\text{Ni}(\text{CH}_3\text{COO})_2 + \text{CH}_3\text{COOH}$  mixtures are also given.

### NICKEL $\beta$ METHYLADIPATE

100 cc. of sat. solution of neutral nickel racemic  $\beta$  methyladipate in water, contain 7.3 gms. of the salt at  $20^\circ$ . (Meurisse.)

### NICKEL CITRATE $\text{Ni}_3[(\text{COOCH}_2)_2\text{C}(\text{OH})\text{COO}]_2 \cdot 2\text{H}_2\text{O}$

100 cc. sat. solution in water contain 0.28 gm. Ni = 0.94 gm. anhydrous salt at  $10^\circ$ . (Pickering, 1915.)

### NICKEL POTASSIUM CITRATE $\text{K}_4\text{Ni}[(\text{COOCH}_2)_2\text{CONHCOO}]_2$

100 cc. sat. sol. in water contain 3.9 gms. Ni = 41 gms. salt at  $10^\circ$ . (Pickering, 1915.)

### NICKEL MALATE $\text{Ni}[\text{CH}_2\text{CHOH}(\text{COO})]_2 \cdot 3\text{H}_2\text{O}$

100 cc. sat. solution in water contain 0.02 gm. Ni = 0.06 gm. salt at  $10^\circ$ . (Pickering, 1915.)

### NICKEL FUMARATE $\text{Ni} \cdot \text{C}_4\text{H}_2\text{O}_4 \cdot 5\text{H}_2\text{O}$

100 gms.  $\text{H}_2\text{O}$  dissolve 0.36 gm.  $\text{NiC}_4\text{H}_2\text{O}_4$  at  $30^\circ$ . (Weiss and Downs, 1923.)

**NICKEL XANTHATE**  
(XANTHOGENATE)  $(C_2H_5OCSS)_2Ni$

The solubility in water is  $6.3 \times 10^{-5}$  gms./100 ml. solution.  
(Sheka and Kriss, 1957.)

The Ksp is  $3.5 \times 10^{-18}$ . (Oyama, et al., 1957.)

**NICKEL RUBEANATE**  $Ni(HMSSCSNH) ?$

The Ksp in water as determined in dilute electrolytes is  $1.1 \times 10^{-15}$ . (Malyuga, 1955.)

**NICKEL AMINO ACID SALTS**

CH

**SOLUBILITY IN WATER AND METHANOL AT 24.5°**  
(Lang, 1939)

Amino Acid	Salt Formula	Gms. Salt per 100 gms. Sat. Sol.	
		In Water	In Methanol
Glycine	$Ni(C_2H_4O_2N)_2 \cdot 2H_2O$	2.74	0.009
d, l Alanine	$Ni(C_3H_5O_2N)_2 \cdot 2H_2O$	0.91	.020
d, l Amino Butyric	$Ni(C_4H_7O_2N)_2 \cdot 2H_2O$	2.23	.027
l (+) - Valine	$Ni(C_5H_{10}O_2N)_2$	0.39	7.90
d, l - Leucine	$Ni(C_6H_{12}O_2N)_2 \cdot 2H_2O$	0.030	0.043
d, l - Isoleucine	$Ni(C_6H_{12}O_2N)_2 \cdot 2H_2O$	0.095	3.36
l (-) - Proline	$Ni(C_5H_8O_2N)_2 \cdot 2H_2O$	19.07	15.02
d, l - Glutamic		-	0.011
d, l - Serine		-	.014
d, l - Asparagine		-	.225

**NICKEL DIMETHYLGLYOXIME**  $Ni(CH_3C(NOH)C(NO)CH_3)_2$

**SOLUBILITY OF NICKEL DIMETHYLGLYOXIME IN AQUEOUS SALT SOLUTIONS AT 25°**  
(Christopher and Sandell, 1954)

Solution	pH	Micrograms Ni per liter
0.05 M Ammonium acetate	6.7	56
0.05 M Sodium bicarbonate	8.9	57
2.0 M Sodium chloride	6.8	29
H <sub>2</sub> O saturated with CHCl <sub>3</sub>	-	69



## NI NICKEL

The following data show the effect of pH on the solubility of nickel dimethylglyoxime in HCl - KCl solutions of 0.05 M ionic strength:

pH	Total Ni conc'n. moles per liter	pH	Total Ni conc'n. moles per liter
2.155	0.01034	2.77	0.00065
2.295	0.00595	3.185	0.000084
2.46	0.00272	3.64	0.000011
2.495	0.00245	4.29	0.0000017
2.98	0.00125		

From the above data  $K_{sp} = 4.2 - 5.1 \times 10^{-24}$ . Babko and Mikhel'son, 1951 found  $2 \times 10^{-25}$  in buffer mixtures at pH 3 and 3.5.

### SOLUBILITY OF NICKEL DIMETHYLGLYOXIME IN AQUEOUS ETHANOL AT 20-22° (Babko and Mikhel'son, 1955)

Wt. % C <sub>2</sub> H <sub>5</sub> OH	Ni(HD) <sub>2</sub> moles per liter	Wt. % C <sub>2</sub> H <sub>5</sub> OH	Ni(HD) <sub>2</sub> moles per liter
9.6	0.003	57.6	0.018
19.2	0.004	67.2	0.019
28.3	0.006	76.8	0.019
38.4	0.010	86.4	0.020
48.0	0.015	96	0.021

The solubility of nickel dimethyl glyoxime in chloroform at 25° is 0.141 gms. per liter. (Christopher and Sandell, 1954.)

Data for the solubility of nickel cyclohexanedione dioxime and nickel cycloheptanedione dioxime in water are given by Saggese, 1954.

### NICKEL GLUCONATE $Ni(C_6H_{11}O_7)_2 \cdot 3H_2O$

100 cc. sat. solution of nickel gluconate in water contain 9.65 gms.  $Ni(C_6H_{11}O_7)_2$  at 25°. (May, Weisberg and Herrick, 1929.)

### NICKEL BENZOATE $Ni(C_6H_5COO)_2 \cdot 3H_2O$

### NICKEL CHLOR, OXY AND NITRO BENZOATES

#### SOLUBILITY OF EACH SEPARATELY IN WATER AT 20° (Ephraim and Pfister, 1925)

Compound	Formula	Gms. anhydrous compd. per 100 cc. sat. sol.
Nickel Benzoate	$Ni(C_6H_5 \cdot COO)_2 \cdot 3H_2O$	1.291
Nickel-4-Chlor Benzoate	$Ni(C_6H_4 \cdot Cl \cdot COO)_2 \cdot 4H_2O$	0.660
Nickel-4-Oxy Benzoate	$Ni(C_6H_4 \cdot OH \cdot COO)_2 \cdot 7H_2O$	0.871
Nickel-4-Nitro Benzoate	$Ni(C_6H_4 \cdot NO_2 \cdot COO)_2 \cdot 8H_2O$	0.777

100 gms. methyl alcohol ( $\text{CH}_3\text{OH}$ ) dissolve 0.29 gm.  $\text{Ni}(\text{C}_6\text{H}_5\text{COO})_2$  at  $15^\circ$  and 0.30 gm. at  $66^\circ$  (b.pt.). (Henstock, 1934.)

### NICKEL NITROSO $\beta$ PHENYL HYDROXYLAMINE $\text{Ni}[\text{C}_6\text{H}_5\cdot\text{N}(\text{NO})\cdot\text{O}]_2$

The compound is prepared by precipitating cupferron (the ammonium salt of nitroso phenyl hydroxylamine) with a nickel salt.

One liter sat. solution of the compound in water contains 0.00089 gm. at. (= 0.052 gm.)  $\text{Ni}[\text{C}_6\text{H}_5\cdot\text{N}(\text{NO})\cdot\text{O}]_2$  at  $18^\circ$ . (Pinkus and Martin, 1927.)

### NICKEL CINNAMATE $\text{Ni}\cdot\text{C}_{18}\text{H}_{14}\text{O}_4\cdot 2\text{H}_2\text{O}$

100 cc. sat. sol. of nickel cinnamate in water contain 0.293 gm.  $\text{NiC}_{18}\text{H}_{14}\text{O}_4$  at  $20^\circ$ . (Ephraim and Pfister, 1925.)

### NICKEL HELIANTHATE $\text{Ni}(\text{C}_{14}\text{H}_{14}\text{N}_3\text{SO}_3)_2\cdot 4\text{H}_2\text{O}$

CH

1000 cc.  $\text{H}_2\text{O}$  dissolve 0.072 gms. of the salt at  $20\text{--}25^\circ$ . (Stark and Dohn, 1918.)

### NICKEL ANTHRACENE, BENZENE AND NAPHTHALENE SULFONATES

#### SOLUBILITY OF EACH SEPARATELY IN WATER

(Ephraim and Pfister, 1925, 1925a; Ephraim and Seger, 1925)

Compound and Formula	t°	Gms. anhydrous empd. per 100 cc. sat. sol.
Nickel Anthracene-1-sulfonate $\text{Ni}(\text{C}_{14}\text{H}_9\text{SO}_3)_2\cdot 6\text{H}_2\text{O}$	20	0.0253
Nickel Anthracene-2-sulfonate $\text{Ni}(\text{C}_{14}\text{H}_9\text{SO}_3)_2\cdot 6\text{H}_2\text{O}$	20	0.00463
Nickel Benzene sulfonate $\text{Ni}(\text{C}_6\text{H}_5\text{SO}_3)_2\cdot 6\text{H}_2\text{O}$	18	12.561
Nickel Benzene sulfonate $\text{Ni}(\text{C}_6\text{H}_5\text{SO}_3)_2\cdot 6\text{H}_2\text{O}$	34	16.518
Nickel Benzene sulfonate $\text{Ni}(\text{C}_6\text{H}_5\text{SO}_3)_2\cdot 6\text{H}_2\text{O}$	49.5	20.972
Nickel Benzene sulfonate $\text{Ni}(\text{C}_6\text{H}_5\text{SO}_3)_2\cdot 6\text{H}_2\text{O}$	64.5	26.685

(Cont.)

# Ni NICKEL

	Compound and Formula	t°	Gms. anhydrous compd. per 100 cc. sat. sol.
CH	Nickel Benzene sulfonate $\text{Ni}(\text{C}_6\text{H}_5\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	80.5	33.295
	Nickel Benzene sulfonate $\text{Ni}(\text{C}_6\text{H}_5\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	82.0	34.044
	Nickel Naphthalene-1-sulfonate $\text{Ni}(\text{C}_{10}\text{H}_7\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	17	4.978
	Nickel Naphthalene-2-sulfonate $\text{Ni}(\text{C}_{10}\text{H}_7\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	16.5	0.2833
	Nickel Naphthalene-2-sulfonate $\text{Ni}(\text{C}_{10}\text{H}_7\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	34.5	0.5289
	Nickel Naphthalene-2-sulfonate $\text{Ni}(\text{C}_{10}\text{H}_7\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	45.5	0.7434
	Nickel Naphthalene-2-sulfonate $\text{Ni}(\text{C}_{10}\text{H}_7\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	58.5	1.1658
	Nickel Naphthalene-2-sulfonate $\text{Ni}(\text{C}_{10}\text{H}_7\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	70.5	1.5972
	Nickel Naphthalene-2-sulfonate $\text{Ni}(\text{C}_{10}\text{H}_7\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	77.0	1.9973
	Nickel Naphthalene-2-sulfonate $\text{Ni}(\text{C}_{10}\text{H}_7\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	81.5	2.4136
	Nickel Naphthalene-2-sulfonate $\text{Ni}(\text{C}_{10}\text{H}_7\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	83.0	2.6886
	Nickel Naphthalene-5-Chlor-1-sulfonate $\text{Ni}(\text{C}_{10}\text{H}_6\text{SO}_2 \cdot \text{Cl})_2 \cdot 4\text{H}_2\text{O}$	20.0	0.618
	Nickel Naphthalene-6-Oxy-2-sulfonate $\text{Ni}(\text{C}_{10}\text{H}_6\text{SO}_3)_2 \cdot 8\text{H}_2\text{O}$	20.0	0.529

## NICKEL p-PHENOL SULFONATE p-Ni[C<sub>6</sub>H<sub>4</sub>(OH)SO<sub>3</sub>]<sub>2</sub>·8H<sub>2</sub>O

### SOLUBILITY IN WATER (Guerreschi, 1949)

t°	Gms. Ni[C <sub>6</sub> H <sub>4</sub> (OH)SO <sub>3</sub> ] <sub>2</sub> per 100 gms. sat. sol.	t°	Gms. Ni[C <sub>6</sub> H <sub>4</sub> (OH)SO <sub>3</sub> ] <sub>2</sub> per 100 gms. sat. sol.
15.0	20.99	34.7	29.07
18.7	22.36	39.8	31.33
20.0	22.79	46.2	34.21
23.0	24.00	50.2	35.89
24.8	24.80	54.8	37.84
25.6	25.21	60.6	40.31
30.0	27.04	65.7	42.41

NICKEL NAPHTHYLAMINE DISULFONATES  $\text{Ni} \cdot \text{C}_{10}\text{H}_5(\text{NH}_2)(\text{SO}_3)_2$ , 2.6.8 and 2.5.7

100 gms. sat. solution of nickel naphthylamine disulfonate 2.6.8 in water contain 33.2 gms. of the anhydrous compound at 15°. An aqueous solution of the 2.5.7 compound contains 35.5 gms. per 100 gms. sat. solution at 15°. (Braunschweig, 1922, 1926.)

## NICKEL XYLOL SELENATES and SULFONATE

CH

SOLUBILITY OF EACH IN WATER  
(Anschütz, Kallen and Riepenkröger, 1919)

- Compound and Formula	t°	Gms. anhydrous compd. per 100 gms. H <sub>2</sub> O
Nickel o Xylol Selenate $\text{Ni}[(\text{CH}_3)_2(1,2)\text{C}_6\text{H}_3 \cdot \text{SeO}_3(4)]_2 \cdot 5\text{H}_2\text{O}$	20	3.95
Nickel p Xylol Selenate $\text{Ni}[(\text{CH}_3)_2(1,4)\text{C}_6\text{H}_3 \cdot \text{SeO}_3]_2 \cdot 7\text{H}_2\text{O}$	15	2.31
Nickel o Xylol Sulfonate $\text{Ni}[(\text{CH}_3)_2(1,2)\text{C}_6\text{H}_3\text{SO}_3(4)]_2 \cdot 6\text{H}_2\text{O}$	16	3.63

## NICKEL 8-HYDROXYQUINOLATES

The Ksp of nickel 8-hydroxyquinolate at room temperature is  $5.6 \times 10^{-23}$ . The Ksp of nickel 8-hydroxy-2-methyl quinolate at room temperature is  $6.3 \times 10^{-21}$ . (Borrel and Paris, 1952.)

Data for the extraction of nickel by 8-hydroxyquinoline in chloroform are given by Moeller, 1943 and by Gentry and Sherrington, 1950. In the later case tartrate ions were present in the water.

The solubility product of nickel 8-hydroxyquinolin-5-sulfonic acid was determined by Nasanen and Uusitalo, 1954.

NICKEL SALICYLOENIMINE  $\text{Ni}(\text{HN}=\text{CNC}_6\text{H}_4)_2$ SOLUBILITY IN VARIOUS SOLVENTS  
(Alimarin and Koreneva, 1955)

This complex is prepared from salicylaldehyde and ammonia +  $\text{Ni}^{++}$ .

Solvent	Mg. Ni per ml.	Solvent	Mg. Ni per ml.
Benzyl alcohol	0.505	diethyl ether	0.015
i-Amyl alcohol	0.030	dibenzyl	0.065

(Cont.)

## NI NICKEL

Solvent	Mg. Ni per ml.	Solvent	Mg. Ni per ml.
Amyl acetate	0.032	Ethylene dichloride	0.041
Cyclohexanone	0.2	Butyl bromide	0.011
Acetophenone	0.15	Carbon tetrachloride	0.004
Acetone	0.05	Benzene	0.016
Chloroform	0.034		

## NICKEL ANTRAQUINONE 1,5 DISULFINIC ACID $\text{Ni}(\text{C}_{14}\text{H}_6\text{O}_2(\text{SO}_2)_2)$

### SOLUBILITY IN WATER (Kozlov and Smolin, 1949)

t°	Solubility	Solid Phase
20	one part in 340 of $\text{H}_2\text{O}$	$\text{Ni}(\text{C}_{14}\text{H}_6\text{O}_2(\text{SO}_2)_2) \cdot 5\text{H}_2\text{O}$
100	one part in 165 of $\text{H}_2\text{O}$	"

## CN NICKEL CYANIDE $\text{Ni}(\text{CN})_2$

### SOLUBILITY IN WATER

18°	0.000535 mole $\text{Ni}(\text{CN})_2$ per liter	(Masaki, 1931)
25°	0.000082 mole $\text{Ni}(\text{CN})_2$ per liter	(Hume and Kolthoff, 1950)

The latter authors show that the formula of the salt is actually  $\text{Ni}[\text{Ni}(\text{CN})_4]$ .

## NICKEL FERROCYANIDE $\text{Ni}_2\text{Fe}(\text{CN})_6$

A saturated solution in water contains  $2.0 \times 10^{-5}$  gm. ions  $\text{Ni}^{++}$  per liter. (Tananaev, Glushkova and Seifer, 1956.)

## NICKEL NITROPRUSSIATE $\text{NiFe}(\text{CN})_5\text{NO}$

One liter sat. solution of nickel nitro prussiate in water contain 0.00006 gm. mol.  $\text{NiFe}(\text{CN})_5\text{NO}$  at 20°. (Tomicek and Kubik, 1937.) A previous determination by Zuccari, 1914, 1915, gave 0.1 gm.  $\text{NiFe}(\text{CN})_5\text{NO}$  per liter of water which is about six times the present value.

## SCN NICKEL THIOCYANATE $\text{Ni}(\text{SCN})_2$

100 gms. sat. solution in water contain 35.48 gms.  $\text{Ni}(\text{SCN})_2$  at 25°. (de Sweemer, 1932.) The author also gives results for the systems  $\text{Ni}(\text{SCN})_2 + \text{KSCN} + \text{H}_2\text{O}$  and  $\text{Ni}(\text{SCN})_2 + \text{Co}(\text{SCN})_2 + \text{H}_2\text{O}$  at 25°.

NICKEL CARBONATE  $\text{NiCO}_3$ 

CO

SOLUBILITY OF NICKEL CARBONATE IN WATER  
(Smurov, 1938)The total pressure of  $\text{CO}_2 + \text{H}_2\text{O}$  was one atmosphere.

Partial Pressure $\text{CO}_2$ in atm.	Gms. Ni per 100 gms. Sat. Sol.				
	5°	15°	40°	50°	80°
0.0005	0.0168	0.0136	0.0061	0.0037	0.0007
.005	.0394	.0319	.0142	.0087	.0016
.05	.0924	.0784	.0333	.0204	.0037
.10	.1194	.0963	.0431	.0264	.0048

NICKEL OXALATE  $\text{NiC}_2\text{O}_4$ 

CO

## SOLUBILITY IN WATER

The solid phase is  $\text{NiC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ .

t°	Gms. $\text{NiC}_2\text{O}_4$ per liter sat. sol.	Reference
18	0.003	Scholder, Gadenne and Niemann, 1927
20	0.041	LeDrut and Hauss, 1937
25	0.0118	Berney, Argersinger and Reynolds, 1951

SOLUBILITY OF NICKEL OXALATE IN AQUEOUS SOLUTIONS OF FORMIC ACID AT 20°  
(LeDrut and Hauss, 1937)

The saturated solutions were analyzed by warming on the steam bath with excess of  $\text{H}_2\text{SO}_4$  to eliminate the  $\text{HCOOH}$  and titrating with 0.001n  $\text{KMnO}_4$ .

Gms. $\text{HCOOH}$ per 100 gms. solvent	Gms. $\text{NiC}_2\text{O}_4$ per liter sat. sol.	Solid Phase
0.0 ( = $\text{H}_2\text{O}$ )	0.041	$\text{NiC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$
25.0	0.022	"
50.0	0.028	"
95.0	0.100 (1)	"
100.0	0.075	"

(1) per 1000 gms. sat. solution. (Aschan, 1913.)

SOLUBILITY IN AQUEOUS  $\text{K}_2\text{C}_2\text{O}_4$  SOLUTIONS

When  $\text{K}_2\text{C}_2\text{O}_4$  is added to aqueous  $\text{NiC}_2\text{O}_4$  solutions, a minimum in solubility occurs: (Data of Berney, Argersinger and Reynolds, 1951 at 25°)

Moles per liter $\text{K}_2\text{C}_2\text{O}_4$ :	0	$5.4 \times 10^{-4}$	$4 \times 10^{-3}$
Moles per liter $\text{NiC}_2\text{O}_4$ :	$7.15 \times 10^{-5}$	$1.68 \times 10^{-5}$ (minimum)	$3.8 \times 10^{-5}$

# Ni NICKEL

## Cl NICKEL CHLORIDE $\text{NiCl}_2$

### SOLUBILITY OF NICKEL CHLORIDE IN WATER (Boye, 1934)

t°	Gms. $\text{NiCl}_2$ per 100 gms. sat. sol.		Solid Phase	t°	Gms. $\text{NiCl}_2$ per 100 gms. sat. sol.		Solid Phase
- 0.5	2.17		Ice	+17.5	37.1 (1)		$\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$
- 3.6	7.88		"	20	38.29 (3)		"
-11.3	15.6		"	25	39.6 (1)		"
-19.0	20.6		"	27.9	41.3		"
-26.7	24.2		"	28.8	41.6		" + $\text{NiCl}_2 \cdot 4\text{H}_2\text{O}$
-35.3	26.9		"	35.0	42.0		$\text{NiCl}_2 \cdot 4\text{H}_2\text{O}$
-41.0	29.0		"	50.0	43.2 (1)		"
-45.3	29.9		" + $\text{NiCl}_2 \cdot 7\text{H}_2\text{O}$	60.0	44.8 (1)		"
-40.8	30.0		$\text{NiCl}_2 \cdot 7\text{H}_2\text{O}$	64.3	46.1		" + $\text{NiCl}_2 \cdot 2\text{H}_2\text{O}$
-36.1	30.3		"	67.6	46.1		$\text{NiCl}_2 \cdot 2\text{H}_2\text{O}$
-34.2	31.3		"	75.0	46.3 (1)		"
-33.3	33.8		" + $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$	80	45.96 (3)		"
-29.1	33.8		$\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$	100.2	46.7		"
-20.2	33.9		"	110.4	46.8		"
-14.9	34.0		"	117.9 <sup>b</sup>	46.9		"
- 9.8	34.1		"				
0	34.8		"				
	35.27 (2)		"				

<sup>b</sup>boiling point

(1) Benrath, 1932

(2) Foote, 1923

(3) Babaev and Archako, 1935

### SOLUBILITY OF NICKEL CHLORIDE IN AQUEOUS HYDROCHLORIC ACID SOLUTIONS

#### Results at 20° (Foote, 1923)

Saturation was secured by constant rotation. The composition of the solid phases was determined by Schreinemakers graphic method.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{NiCl}_2$	HCl		$\text{NiCl}_2$	HCl	
35.27	0.0	$\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$	4.45	26.23	$\text{NiCl}_2 \cdot 4\text{H}_2\text{O}$
26.71	6.53	"	2.92	28.82	"
15.67	14.09	"	1.37	34.57	"
9.68	18.62	"	1.40	35.03	" + $\text{NiCl}_2 \cdot 2\text{H}_2\text{O}$
6.15	21.70	"	2.29	33.96	" (unstable)
5.30	23.03	"	1.57	34.7	" "
3.65	25.74	"	1.06	36.0	$\text{NiCl}_2 \cdot 2\text{H}_2\text{O}$
4.02	26.16	"	0.82	37.22	"
4.56	26.00	" + $\text{NiCl}_2 \cdot 4\text{H}_2\text{O}$	0.43	40.61	"

1000 cc. sat. HCl solution dissolve 4 gms.  $\text{NiCl}_2$  at 12°. (Ditte, 1881.)

(Cont.)

SOLUBILITY OF NICKEL CHLORIDE IN AQUEOUS HYDROCHLORIC ACID  
SOLUTIONS--Cont.

Results at 20° (Babaev and Archako, 1935)			Results at 80° (Babaev and Archako, 1935)		
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
NiCl <sub>2</sub>	HCl		NiCl <sub>2</sub>	HCl	
38.29	0.0	NiCl <sub>2</sub> ·6H <sub>2</sub> O	45.96	0.0	NiCl <sub>2</sub> ·4H <sub>2</sub> O
32.15	4.20	"	44.00	1.0	"
22.87	11.25	"	39.29	3.82	"
16.24	16.22	"	34.86	6.64	"
12.04	20.51	"	28.09	11.54	"
11.60	21.20	" + NiCl <sub>2</sub> ·4H <sub>2</sub> O	22.79	15.04	"
9.58	22.07	NiCl <sub>2</sub> ·4H <sub>2</sub> O	16.40	19.54	"
7.38	24.01	"	11.12	23.20	"
2.73	30.74	"	8.63	26.20	"

Cl

Data for the system NiCl<sub>2</sub> - NH<sub>4</sub>Cl - H<sub>2</sub>O are given by Kurnakov, Lushnar, and Kuznetsov, 1937.

100 gms. 95% formic acid dissolve 5.9 gms. NiCl<sub>2</sub> at 20.5°.  
(Aschan, 1913.)

DISTRIBUTION OF NICKEL CHLORIDE BETWEEN CAPRYL ALCOHOL AND WATER AT 25°  
(Garwin and Hixson, 1949)

Aqueous phase Wt. % NiCl <sub>2</sub> :	38.3	36.1	34.4	32.9	29.2
Alcohol phase Wt. % NiCl <sub>2</sub> :	0.0716	0.0446	0.0302	0.0244	0.0098

Results are also given for mixtures of NiCl<sub>2</sub> + CoCl<sub>2</sub>.

DISTRIBUTION OF NICKEL CHLORIDE BETWEEN CAPRYL ALCOHOL AND WATER  
AT 25° IN THE PRESENCE OF HYDROCHLORIC ACID  
(Garwin and Hixson, 1949a)

In each experiment the aqueous phase contained 13 - 16% by wt. NiCl<sub>2</sub>. Results are also given for the distributions in the presence of CaCl<sub>2</sub> and CoCl<sub>2</sub>.

Wt. % Total Cl in Aqueous Phase	K <sub>Ni</sub> (alc./aq.)	K <sub>HCl</sub> (alc./aq.)	Wt. % Total Cl in Aqueous Phase	K <sub>Ni</sub> (alc./aq.)	K <sub>HCl</sub> (alc./aq.)
11.8	0.71 x 10 <sup>-3</sup>	0.220	20.7	3.24 x 10 <sup>-3</sup>	0.512
13.4	1.02 "	.309	22.3	3.51 "	.508
16.0	1.60 "	.374	24.3	6.46 "	.511
17.9	2.03 "	.470	25.8	6.84 "	.543
19.2	2.70 "	.482	26.6	7.95 "	.538

When 1 gm. of nickel, as chloride, is dissolved in 100 cc. of 10% aq. HCl and shaken with 100 cc. of ether, 0.01 per cent of the nickel enters the ethereal layer. (Mylius, 1911.)



## NI NICKEL

The extraction of  $\text{NiCl}_2$  by ether from aqueous solutions with acid without HSCN was studied by Bock, 1951.

100 cc. of a mixture of equal volumes of diethyl ether and water, saturated with HCl at  $0^\circ$  will dissolve 0.0029 gms.  $\text{NiCl}_2$ . (Fischer and Seidel, 1941.)

Distribution data for  $\text{NiCl}_2$  between  $\text{H}_2\text{O}$  and tributyl phosphate at  $25^\circ$  and  $50^\circ$  are reported by Chatelet and Nicaud, 1956.

### SOLUBILITY OF NICKEL CHLORIDE IN ORGANIC SOLVENTS AT $25^\circ$ (Garwin and Hixson, 1949)

Solvent	Gms. $\text{NiCl}_2$ per 100 gms. Sat. Sol.	Solvent	Gms. $\text{NiCl}_2$ per 100 gms. Sat. Sol.
n-Butanol	6.1	Ethyl acetate	0.02
n-Amyl alcohol	7.25	Iso propyl acetate	.03
n-Hexanol	6.4	$\beta$ -methyl butyric acid	.42
2-Ethyl-1-butanol	1.49	Benzaldehyde	.13
2-Ethyl-1-hexanol	0.74	Furfural	.13
Capryl-2-octanol:		n-Heptane	.07
a) Commercial	.16	Benzene	.03
b) Ketone free	.26	Nitromethane	.00
Methyl ethyl ketone	.01	Nitrobenzene	.02
Methyl n-propyl ketone	.01	Ethylene dichloride	.04
Methyl isobutyl ketone	.01	Chlorobenzene	.03
Acetophenone	.05	Isopropyl ether	.00

#### Results in Additional organic Solvents

Solvent	t°	Solubility
Methanol	5	376 gms. $\text{NiCl}_2$ per 1000 ml. sat. sol.; solid phase $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ (Barber and Ali, 1950)
Ethanol	3	1.4 gms. $\text{NiCl}_2 \cdot 7\text{H}_2\text{O}$ per 100 gms. solvent (deBruyn, 1892)
	17	2.16 gms. $\text{NiCl}_2 \cdot 7\text{H}_2\text{O}$ per 100 gms. solvent (deBruyn, 1892)
	room	53.71 gms. $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ per 100 gms. solvent (Bodtker, 1897)
	room	10.05 gms. $\text{NiCl}_2$ per 100 gms. solvent (Bodtker, 1897)
Acetone	35	1 part in 16,000 parts acetone (Tillu, 1943)
Ethylene glycol	room	16.2 gms. $\text{NiCl}_2$ per 100 gms. sat. sol. (deConnick, 1905)

#### Results in Inorganic Liquids

Hydrazine	room	8 gms. $\text{NiCl}_2$ per 100 cc. solvent (Welsh and Broderson, 1915)
Selenium oxy-chloride $\text{SeOCl}_2$	25	0.15 gms. $\text{NiCl}_2$ per 100 gms. sat. sol. (Wise, 1923)

Melting points in the system  $\text{NiCl}_2 - \text{CoCl}_2$  are given by Moskalenko, 1957.

NICKEL NICKLORATE  $\text{Ni}(\text{ClO}_3)_2$ 

ClO

SOLUBILITY IN WATER  
(Meusser, 1902)

t°	Gms. $\text{Ni}(\text{ClO}_3)_2$ per 100 Gms. Solution	Mols. $\text{Ni}(\text{ClO}_3)_2$ per 100 Mols. $\text{H}_2\text{O}$	Solid Phase
- 9	26.62	2.90	Ice
-13.5	31.85	3.73	"
-18	49.55 <sup>b</sup>	7.84	$\text{Ni}(\text{ClO}_3)_2 \cdot 6\text{H}_2\text{O}$
- 8	51.52	8.49	"
0	52.66	8.88	"
16	(64.1) <sup>a</sup>	-	"
+18	56.74	10.47	$\text{Ni}(\text{ClO}_3)_2 \cdot 4\text{H}_2\text{O}$
40	64.47	15.35	"
48	67.60	16.65	"
55	68.78	17.59	"
65	69.05	18.01	"
79.5	75.50	24.68	"

NICKEL PERNICKLORATE  $\text{Ni}(\text{ClO}_4)_2 \cdot 9\text{H}_2\text{O}$ 

ClO

SOLUBILITY IN WATER  
(Goldblum and Terlikowski, 1912)

t°	d of Sat. Sol.	Gms. $\text{Ni}(\text{ClO}_4)_2$ per 100 Gms. $\text{H}_2\text{O}$	Solid Phase
0	-	0	Ice
-10.9	-	33.19	"
-21.3	-	46.68	"
-30.7	-	70	"
-49	-	-	Ice + $\text{Ni}(\text{ClO}_4)_3 \cdot 9\text{H}_2\text{O}$
-30.7	-	90	$\text{Ni}(\text{ClO}_4)_3 \cdot 9\text{H}_2\text{O}$
-21.3	-	92.5	"
0	1.573	104.6	$\text{Ni}(\text{ClO}_4)_3 \cdot 5\text{H}_2\text{O}$
7.5	1.576	106.8	$\text{Ni}(\text{ClO}_4)_3 \cdot 5\text{H}_2\text{O}$
18	1.576	110.1	"
26	1.584	112.2	"
45	1.594	118.6	"

## NI NICKEL

### SOLUBILITY OF NICKEL PERCHLORATE IN FURFURAL AND IN CELLOSOLVE AT ABOUT 20° (Cheney and Mann, 1931)

Solvent	Gms. $\text{Ni}(\text{ClO}_4)_2 \cdot 7\text{H}_2\text{O}$ per 100 cc. solvent	Solid Phase
Furfural	60	$\text{Ni}(\text{ClO}_4)_2 \cdot 6\text{H}_2\text{O}$
"	20	$\text{Ni}(\text{ClO}_4)_2 \cdot 2\text{H}_2\text{O}$
Cellosolve (1)	100+	$\text{Ni}(\text{ClO}_4)_2 \cdot 6\text{H}_2\text{O}$
"	35	$\text{Ni}(\text{ClO}_4)_2 \cdot 2\text{H}_2\text{O}$

(1) Monoethyl ether of ethylene glycol

### NICKEL HEXA ANTIPYRINE PERCHLORATE $[\text{Ni}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6](\text{ClO}_4)_2$

100 cc. sat. sol. of the salt in water contain 17.75 gms.  
 $[\text{Ni}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6](\text{ClO}_4)_2$  at 20°. (Wilke-Dörfurt and Schliephake, 1929.)

## F NICKEL FLUORIDE $\text{NiF}_2$

### SOLUBILITY OF NICKEL FLUORIDE IN WATER (Kurtenacker, Finger and Hey, 1933)

t°	Gms. $\text{NiF}_2$ per 100 gms. sat. sol.	Solid Phase
10	2.49	$\text{NiF}_2 \cdot 4\text{H}_2\text{O}$
20	2.50	"
50	2.50	"
90	2.52	"

100 cc. sat. solution of anhydrous (?) nickelous fluoride in water  
contain 4.03 gms.  $\text{NiF}_2$  at 25°. (Carter, 1928.)

### SOLUBILITY OF NICKEL FLUORIDE IN AQUEOUS SOLUTIONS OF HYDROFLUORIC ACID AT 20°

(Kurtenacker, Finger and Hey, 1933)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{NiF}_2$	$\text{HF}$		$\text{NiF}_2$	$\text{HF}$	
2.50	0	$\text{NiF}_2 \cdot 4\text{H}_2\text{O}$	11.45	17.46	$\text{NiF}_2 \cdot 4\text{H}_2\text{O}$
7.73	9.25	"	13.72	28.51	"
10.02	12.39	"	13.30	30.10	"

THE SYSTEM NICKEL FLUORIDE - POTASSIUM FLUORIDE - WATER  
(Kurtenacker, Finger and Hey, 1933)

Results at 20°			Results at 50°		
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
NiF <sub>2</sub>	KF		NiF <sub>2</sub>	KF	
1.98	1.21	Mixed Crystals	2.01	1.18	Mixed Crystals
1.20	3.52	"	1.12	4.30	"
0.80	6.32	"	0.26	9.25	"
0.52	9.64	"	0.03	15.4	"
0.40	12.9	"	0.01	19.2	"
0.01	16.8	"	0.0	27.7	"
0.0	37.5	"	0.0	41.3	"

THE SYSTEM NICKEL FLUORIDE - AMMONIUM FLUORIDE - WATER  
(Kurtenacker, Finger and Hey, 1933)

Results at 20°			Results at 50°		
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
NiF <sub>2</sub>	NH <sub>4</sub> F		NiF <sub>2</sub>	NH <sub>4</sub> F	
1.07	3.4	NiF <sub>2</sub> ·4H <sub>2</sub> O	1.60	5.0	NiF <sub>2</sub> ·4H <sub>2</sub> O
0.91	6.4	"	1.04	8.1	"
0.72	9.4	"	0.36	13.1	NiF <sub>2</sub> ·2NH <sub>4</sub> F·2H <sub>2</sub> O
0.51	10.4	NiF <sub>2</sub> ·2NH <sub>4</sub> F·2H <sub>2</sub> O	0.15	17.7	"
0.17	17.1	"	0.10	20.5	"
0.07	23.0	"	0.04	26.2	"
0.02	28.5	"	0.02	32.4	"
0.01	37.4	"	0.01	37.3	"
0.00	41.2	"	0.0	41.5	"

Data for the partition of NiF between aqueous HF solutions (1-20N) and ethyl ether at 20° are given by Bock and Hermann, 1956.

Less than 0.002 gm. Ni are present in 100 gms. of sat. sol. of NiF<sub>2</sub> in BrF<sub>3</sub> at 25°; less than 0.001 gm. Ni at 70°. (Sheft, Hyman and Katz, 1953.)

NICKEL HEXA ANTIPYRINE FLUOROBORATE [Ni(COC<sub>10</sub>H<sub>12</sub>N<sub>2</sub>)<sub>6</sub>](BF<sub>4</sub>)<sub>2</sub>

100 cc. sat. solution of the salt in water contain 4.8 gm. [Ni(COC<sub>10</sub>H<sub>12</sub>N<sub>2</sub>)<sub>6</sub>](BF<sub>4</sub>)<sub>2</sub> at 20°. (Wilke-Dörfurt and Mureck, 1929.)

# NI NICKEL

## NICKEL FLUOPHOSPHATE $[\text{Ni}(\text{NH}_3)_6][\text{PF}_3]_2$

At 21° the solubility in water is 0.0018 moles per liter. (Lange and Mueller, 1930.)

Solubility results for a long series of organic nickel fluo-phosphates in water are given by Lange and Mueller, 1930.

## I NICKEL IODIDE $\text{NiI}_2$

### SOLUBILITY IN WATER (Etard, 1894)

t°	Gms. $\text{NiI}_2$ per 100 Gms. Solution	t°	Gms. $\text{NiI}_2$ per 100 Gms. Solution	t°	Gms. $\text{NiI}_2$ per 100 Gms. Solution
-20	52.0	25	60.7	60	64.8
0	55.4	30	61.7	70	65.0
10	57.5	40	63.5	80	65.2
20	59.7	50	64.7	90	65.3

By interpolation the transition point for  $\text{NiI}_2 \cdot 6\text{H}_2\text{O} + \text{NiI}_2 \cdot 4\text{H}_2\text{O}$  is at 43°.

### SOLUBILITY OF NICKEL AMMONIUM IODIDE AT 20° IN:

Nitrobenzene		Acetonitrile	
moles iodine per mole nitrobenzene	moles iodine per mole of ammine in sat. sol.	moles iodine per mole acetonitrile	moles iodine per mole of ammine in sat. sol.

#### Solid phase $\text{Ni}(\text{NH}_3)_6\text{I}_2$

0.0082	3.20	0.0039	2.37
0.0142	3.00	0.0059	2.36
0.0189	2.92	0.0154	2.14

## IO NICKEL IODATE $\text{Ni}(\text{IO}_3)_2$

### SOLUBILITY IN WATER (Meusser, 1901)

t°	Gms. $\text{Ni}(\text{IO}_3)_2$ per 100 Gms. Solution	Mols. $\text{Ni}(\text{IO}_3)_2$ per 100 Mols.. $\text{H}_2\text{O}$	Solid Phase
0	0.73	0.033	$\text{Ni}(\text{IO}_3)_2 \cdot 4\text{H}_2\text{O}$
18	1.01	0.045	"
30	1.41	0.063	"

(Cont.)

## SOLUBILITY IN WATER--Cont.

t°	Gms. Ni(IO <sub>3</sub> ) <sub>2</sub> per 100 Gms. Solution	Mols. Ni(IO <sub>3</sub> ) <sub>2</sub> per 100 Mols. H <sub>2</sub> O	Solid Phase
0	0.53	0.023	Ni(IO <sub>3</sub> ) <sub>2</sub> ·2H <sub>2</sub> O (1)
18	0.68	0.030	"
30	0.86	0.039	"
50	1.78	0.080	"
8	0.52	0.023	Ni(IO <sub>3</sub> ) <sub>2</sub> ·2H <sub>2</sub> O (2)
18	0.55	0.0245	"
50	0.81	0.035	"
75	1.03	0.045	"
80	1.12	0.049	"
30	1.135	0.050	Ni(IO <sub>3</sub> ) <sub>2</sub>
50	1.07	0.046	"
75	1.02	0.045	"
90	0.988	0.044	"

(1) α Dihydrate (2) β Dihydrate

10

NICKEL AMMINES of the type [Ni(NH<sub>3</sub>)<sub>6</sub>]<sub>x</sub>X<sub>2</sub>

SOLUBILITY OF SEVERAL NICKEL AMMINES IN A MIXTURE OF EQUAL VOLUMES OF  
AQUEOUS AMMONIA ( $d_{22} = 0.95$ ) AND 96 PER CENT ETHYL ALCOHOL AT 18°  
(Ephraim and Mosimann, 1922)

Compound and Formula	Gms. compd. per liter sat. sol.	Gm. mols. compd. per liter sat. sol.
Nickel Hexammine Chlorate [Ni(NH <sub>3</sub> ) <sub>6</sub> ](ClO <sub>3</sub> ) <sub>2</sub>	74.75	0.228
Nickel Hexammine Nitrate [Ni(NH <sub>3</sub> ) <sub>6</sub> ](NO <sub>3</sub> ) <sub>2</sub>	44.55	0.156
Nickel Hexammine Chloride [Ni(NH <sub>3</sub> ) <sub>6</sub> ]Cl <sub>2</sub>	15.39	0.066
Nickel Hexamine Sulfate [Ni(NH <sub>3</sub> ) <sub>6</sub> ]SO <sub>4</sub>	14.22	0.055
Nickel Hexammine Thiosulfate [Ni(NH <sub>3</sub> ) <sub>6</sub> ]S <sub>2</sub> O <sub>3</sub>	12.87	0.047
Nickel Hexammine Tetrathionate [Ni(NH <sub>3</sub> ) <sub>6</sub> ]S <sub>4</sub> O <sub>6</sub>	11.96	0.031
Nickel Hexammine Bromide [Ni(NH <sub>3</sub> ) <sub>6</sub> ]Br <sub>2</sub>	7.384	0.023
Nickel Hexammine Perchlorate [Ni(NH <sub>3</sub> ) <sub>6</sub> ](ClO <sub>4</sub> ) <sub>2</sub>	2.503	0.0069
Nickel Hexammine Iodide [Ni(NH <sub>3</sub> ) <sub>6</sub> ]I <sub>2</sub>	1.906	0.0046

NICKEL HEXAMMINE PERRHENATE [Ni(NH<sub>3</sub>)<sub>6</sub>](ReO<sub>4</sub>)<sub>2</sub>

One liter of aqueous ammonia of d. = 0.930 dissolves 33.4 gms.  
[Ni(NH<sub>3</sub>)<sub>6</sub>](ReO<sub>4</sub>)<sub>2</sub> at 26°. (Wilke-Dörfurt and Gunzert, 1933.)

# Ni NICKEL

## NO NICKEL NITRATE $\text{Ni}(\text{NO}_3)_2$

### SOLUBILITY OF NICKEL NITRATE IN WATER (Sieverts and Schreiner, 1934)

See also Funk, 1900.

t°	Gms. $\text{NiNO}_3$ per 100 gms. sat. sol.		Solid Phase	t°	Gms. $\text{NiNO}_3$ per 100 gms. sat. sol.		Solid Phase
- 1.6	8.7		Ice	0	44.2		$\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$
- 6.0	16.2		"	+20.0	48.5		"
-10.3	22.3		"	25	50.0		"
-15.0	27.4		"	30	51.3		"
-22.1	33.4		"	40	54.3		"
-27.8	36.0		" + $\text{Ni}(\text{NO}_3)_2 \cdot 9\text{H}_2\text{O}$	50	58.2		"
-25.4	36.7		$\text{Ni}(\text{NO}_3)_2 \cdot 9\text{H}_2\text{O}$	54	60.0		" + $\text{Ni}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$
-23.7	37.2		"	60	61.2		$\text{Ni}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$
-20.0	38.3		"	75.4	64.3		"
-13.8	40.2		"	80.6	65.6		"
-11.1	41.2		"	85.4	67.2		" + $\text{Ni}(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O}$
-34.1	38.7		Ice + $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$	90.4	68.2		$\text{Ni}(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O}$
-25.9	40.0		$\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$	95	68.2		"
-20.6	40.5		"	99.5	69.2		"
-13.1	42.6		"	110.5	69.7		"
- 2.9	43.6		"	119.8	70.8		"

### THE SYSTEM NICKEL NITRATE - NITRIC ACID - WATER AT 25° (Sieverts and Schreiner, 1934)

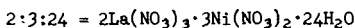
Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
$\text{Ni}(\text{NO}_3)_2$	$\text{HNO}_3$			$\text{Ni}(\text{NO}_3)_2$	$\text{HNO}_3$		
43.5	7.6		$\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$	5.3	73.9		$\text{Ni}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$
38.9	13.2		"	5.2	78.6		"
34.3	19.1		"	5.0	80.5		"
30.2	24.1		"	4.1	81.6		$\text{Ni}(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O}$
24.7	32.1		"	2.7	84.3		"
20.1	40.0		"	1.3	89.8		"
16.0	52.0		" + $\text{Ni}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$	0.3	95.3		"
9.9	60.2		$\text{Ni}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$	0.05	99.5		"
7.4	65.2		" (-25°) →	31.5	5.7		$\text{Ni}(\text{NO}_3)_2 \cdot 9\text{H}_2\text{O}$
5.9	70.5		" (+50°) →	0.4	99.3		$\text{Ni}(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O}$

For data in the system  $\text{Ni}(\text{NO}_3)_2$  -  $\text{Ni}(\text{OH})_2$  -  $\text{H}_2\text{O}$  and basic nickel nitrates see Tananaev and Bokmel'der, 1957; Aksel'rud and Fialkov, 1950.

THE SYSTEM NICKEL NITRATE - LANTHANUM NITRATE - WATER AT 25°  
(Urazov and Shevtsova, 1957)

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
La(NO <sub>3</sub> ) <sub>3</sub>	Ni(NO <sub>3</sub> ) <sub>2</sub>		La(NO <sub>3</sub> ) <sub>3</sub>	Ni(NO <sub>3</sub> ) <sub>2</sub>	
60.28	0.00	La(NO <sub>3</sub> ) <sub>3</sub> ·6H <sub>2</sub> O	6.13	32.00	2:3:24
55.26	3.86	2:3:24	10.37	36.98	"
52.34	5.90	"	6.12	41.50	"
42.53	12.12	"	2.35	43.54	"
35.60	16.50	"	0.00	48.08	Solid Solution
29.20	20.60	"	0.00	50.28	" "
24.23	23.45	"	0.00	51.70	NiNO <sub>3</sub> ·6H <sub>2</sub> O
21.00	27.38	"			

NO



THE SYSTEM NICKEL NITRATE-n-HEXYL ALCOHOL - WATER AT 25°  
(Templeton and Daly, 1952)

Water was determined by Karl Fischer reagent; nickel with dimethylglyoxime.

Water-rich phase, Wt. %			Alcohol-rich phase, Wt. %		
Ni(NO <sub>3</sub> ) <sub>2</sub>	H <sub>2</sub> O	n-C <sub>6</sub> H <sub>13</sub> OH	Ni(NO <sub>3</sub> ) <sub>2</sub>	H <sub>2</sub> O	n-C <sub>6</sub> H <sub>13</sub> OH
47.7 <sup>a</sup>	46.9	5.4	10.31 <sup>a</sup>	7.35	82.34
-	-	-	9.35	7.01	83.64
46.5	49.5	4.0	8.21	6.91	84.89
43.9	50.2	5.9	6.92	6.37	86.71
42.5	56.8	0.7	4.80	5.75	89.45
-	-	-	2.45	4.89	92.66
40.1	60.1	(-0.2)	1.93	4.75	93.32
37.8	61.3	0.9	1.23	4.61	94.16
36.8	64.1	(-0.9)	1.20	4.60	94.20
36.2	62.7	1.1	1.19	4.68	94.13
35.7	65.8	(-1.5)	0.96	4.58	94.46
29.5	67.5	3.0	0.55	4.70	94.75
28.6	70.8	0.6	0.37	4.83	94.80
26.55	70.9	2.6	0.344	4.80	94.86
26.4	69.6	4.0	0.346	4.80	94.90
23.8	-	-	0.247	4.73	95.02
18.2	77.3	4.5	0.177	5.50	94.33
17.8	82.1	0.1	0.0926	5.78	94.13
15.8	82.3	1.9	0.0464	5.76	94.19
10.3	88.5	1.2	0.0203	6.18	93.80
10.18	85.0	4.8	0.0104	5.99	93.91

<sup>a</sup>saturated system

The organic layer of a solution of Ni(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O in tri-n-butyl phosphate at 25-27° contains 10.5 gms. Ni(NO<sub>3</sub>)<sub>2</sub> per 100 gms. sat. sol. (Wendlandt and Bryant, 1955.)



## NI NICKEL

100 gms. sat. solution in glycol contain 7.5 gms.  $\text{Ni}(\text{NO}_3)_2$  at room temperature. (de Coninck.)

100 cc. anhydrous hydrazine dissolve 3 gms.  $\text{Ni}(\text{NO}_3)_2$  at room temperature. (Welsh and Broderson, 1915.)

## O NICKEL OXIDE $\text{NiO}$

At  $500^\circ\text{C}$ , 1000 atm. 0.002%  $\text{NiO}$  dissolve in steam. At  $600^\circ$ , 1000 atm. 0.0034% dissolve. (Morey, listed by Ellis and Fyfe, 1957.)

## OH NICKEL HYDROXIDE $\text{Ni}(\text{OH})_2$

The solubility product is given as  $2.1 \times 10^{-17}$  by Britton (1935),  $1.6 \times 10^{-14}$  by Wijs (1925),  $6.5 \times 10^{-16}$  by Gayer and Garrett (1949), and  $6.2 \times 10^{-16}$  (Thermodynamic) by Nasanen (1943),  $1.36 \times 10^{-15}$  by Aksel'rud and Fialkov, 1950,  $1.0\text{--}1.8 \times 10^{-16}$  by Jena and Prasad, 1956. The solubility in moles per liter is  $1 \times 10^{-4}$  (Almkvist, 1918 at  $20^\circ$ ) also (Gayer and Garrett, 1949 at  $25^\circ$ );  $9.3 \times 10^{-6}$  (Oka, 1940).

### SOLUBILITY OF NICKEL HYDROXIDE IN SOLUTIONS OF $\text{HCl}$ AND $\text{NaOH}$ AT $25^\circ$ (Gayer and Garrett, 1949)

Moles per 1000 gms. $\text{H}_2\text{O}$		Moles per 1000 gms. $\text{H}_2\text{O}$			
$\text{NaOH}$	$\text{Ni}(\text{OH})_2$	$\text{HCl}$	$\text{Ni}(\text{OH})_2$	$\text{HCl}$	$\text{Ni}(\text{OH})_2$
$1.60 \times 10^{-3}$	$1 \times 10^{-7}$	0.0000	0.00010	0.0308	0.0160
$1.00 \times 10^{-2}$	$4 \times 10^{-7}$	.0025	.0013	.0447	.0230
$1.00 \times 10^{-1}$	$2 \times 10^{-6}$	.0056	.0029	.0523	.0271
1.00	$6 \times 10^{-6}$	.0100	.0053	.0811	.0413
8.00	$7 \times 10^{-6}$	.0160	.0083	.1001	.0511
10.00	$4 \times 10^{-6}$	.0236	.0120		
15.00	$5 \times 10^{-6}$				

### SOLUBILITY OF $\text{Ni}(\text{OH})_2$ IN AQUEOUS $\text{NH}_3$ SOLUTIONS

#### Results of Paris, 1951 at $16^\circ$

Equiv. per liter:

$\text{NH}_3$	0.62	1.12	1.85	2.53	3.06	4.88	6.32	10.20
Ni	0.004	0.009	0.035	0.056	0.067	0.127	0.185	0.330

Other results in aqueous ammonia solutions are reported by Arkipov, Pakshver and Podbornova (1950) (also in aqueous  $\text{NaOH}$ ), Shaw and Ghosh (1950, 1951). For earlier work see Bonsdorff, 1904.

NICKEL PYROPHOSPHATE  $\text{Ni}_2\text{P}_2\text{O}_7$ 

PO

For Ksp and complex formation data see Yatsimirskii and Vasil'ev, 1956.

## NICKEL SULFIDE NiS

S

Attention is called by Kolthoff, 1931, to the incorrectness of the results of Weigel, 1906, for the solubility of nickel sulfide in water. It is considered that the values for the solubilities of most sulfides in water are of small or no practical importance. It is recommended that the relations between the solubility and the hydrogen ion and hydrogen sulfide concentrations be expressed by the reaction constant.

Danges (1947) determined the amount of NiS which dissolved under varying conditions of time, reagents added ( $\text{H}_2\text{S}$ ,  $\text{Na}_2\text{S}$ ,  $(\text{NH}_4)_2\text{S}$ ) and the concentration of added reagent.

The best value for Ksp is  $2 \times 10^{-21}$  (Goates, Gordon and Faux, 1952.)

1000 cc. of sat. solution of nickel sulfide in aqueous 2.0 normal sulfuric acid contain 0.0094 gm. NiS at 20°. (Moser and Behr, 1924.)

Melting points are given for:

$\text{Ni}_2\text{S}_3 + \text{Ni}$	(Chizhikov, Gulyanitskaya and Bogovarova, 1955)
$\text{Ni}_2\text{S}_3 + \text{FeS}$	(Kushima and Asano, 1953)
$\text{NiS} + \text{FeS}$	(Schenck and von der Forst, 1942)
$\text{NiS} + \text{FeS} + \text{CoS}$	(Anisheva and Kusakin, 1958)

NICKEL SULFATE  $\text{NiSO}_4$ 

SO

## SOLUBILITY IN WATER

The various data for this system are in only fair agreement. All authors agree on the nature of the phases and on the transition temperatures, but the reported solubilities differ by 1-3%. From the eutectic to 31° the stable phase is the green 7-hydrate; between 31° and 52° it is the blue 6-hydrate and above 52°, the green 6-hydrate. In addition, Rohmer found 5-, 4-, 3-, 2-, and 1-hydrates at high temperatures, mostly metastable.

The table below gives the most probable value for the solubility of the stable phases, based principally on the values of Tantzov (1924, 1925), Vilbrant and Bender (1923), and Rohmer (1939). The original values are tabulated in the table following.

t°	Gms. $\text{NiSO}_4$ per 100 Gms. $\text{H}_2\text{O}$	Solid Phase	t°	Gms. $\text{NiSO}_4$ per 100 Gms. $\text{H}_2\text{O}$	Solid Phase
0	27.6	$\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$	40	47.9	$\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$
5	30.1	"	45	50.2	"
10	32.7	"	50	52.4	"
15	35.4	"	53.3	53.5	" + $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$
20	38.0	"	55	54.5	$\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$
25	40.8	"	60	56.4	"
30	43.7	"	70	60.6	"
31.2	44.0	" + $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$	80	66	"
35	45.8	$\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$	90	72	"
			100	78	"

# Ni NICKEL

## SOLUBILITY OF $\text{NiSO}_4$ IN WATER--Cont.

### Original Solubility Results:

- (1) =  $\text{NiSO}_4 \cdot \text{H}_2\text{O}$       (4) =  $\text{NiSO}_4 \cdot 4\text{H}_2\text{O}$       ( $6\beta$ ) =  $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$  (green)  
(2) =  $\text{NiSO}_4 \cdot 2\text{H}_2\text{O}$       (5) =  $\text{NiSO}_4 \cdot 5\text{H}_2\text{O}$       (7) =  $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$   
(3) =  $\text{NiSO}_4 \cdot 3\text{H}_2\text{O}$       ( $6\alpha$ ) =  $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$  (blue)      \* = metastable  
t = transfer point      (T) Tantzov, 1924, 1925

Vilbrandt and Bender, 1923			Rohrer, 1939			Steele and Johnson, 1904		
SO	Gms. $\text{NiSO}_4$ per 100 gms. $\text{H}_2\text{O}$		Gms. $\text{NiSO}_4$ per 100 gms. $\text{H}_2\text{O}$		Solid Phase	Gms. $\text{NiSO}_4$ per 100 gms. $\text{H}_2\text{O}$		Solid Phase
	t°		t°			t°		
- 4.25	27.335	(7)	- 0.9	10.0	Ice	-5	25.74	(7)
- 2.0	23.366	(7)	- 1.6	14.6	Ice	0	27.22	(7)
0.0	26.189	(7)	- 3.4	26.6	Ice+(7)	9	31.55	(7)
3.19	28.884	(7)	0	28.1	(7)	22.6	37.90	(7)
6.0	30.282	(7)	10	33.0	(7)	30	42.46	(7)
15.65	35.491	(7)	20	38.4	(7)	32.3	44.02	(7)
20.0	37.70(T)	(7)	25	41.2	(7)	33	45.74	(7)
25	40.594	(7)	30	44.1	(7)	34	45.5	(7)
25	40.40(T)	(7)	32.6	45.6*	(7)	32.3	43.57	( $6\alpha$ )
30	43.568	(7)	27	43.1*	( $6\alpha$ )	33.0	43.35	( $6\alpha$ )
30	43.28(T)	(7)	30.7	44.3	(7+ $6\alpha$ )	34.0	43.83	( $6\alpha$ )
35	47.03(T)	(7)	35.0	46.0	( $6\alpha$ )	33.0	43.35	( $6\alpha$ )
40	50.42(T)	(7)	40.0	48.2	( $6\alpha$ )	35.6	43.79	( $6\alpha$ )
31.55 <sup>t</sup>	- (T)	(7+ $6\alpha$ )	50.0	52.8	( $6\alpha$ )	44.7	48.05	( $6\alpha$ )
36.7 <sup>t</sup>	.. (T)	(7+ $6\beta$ )	58.2	56.5*	( $6\alpha$ )	50.0	50.15	( $6\alpha$ )
20	40.09(T)	( $6\alpha$ )	50.0	53.2	( $6\beta$ )	53.0	52.34	( $6\alpha$ )
25	41.56(T)	( $6\alpha$ )	53.8	54.6	( $6\beta$ + $6\alpha$ )	54.5	52.50	( $6\beta$ )
30	43.56(T)	( $6\alpha$ )	55	55.0	( $6\beta$ )	57.0	53.40	( $6\beta$ )
31.71	45.299	( $6\alpha$ )	50	56.9	( $6\beta$ )	60	54.80	( $6\beta$ )
35.0	45.58(T)	( $6\alpha$ )	70	61.0	( $6\beta$ )	70	59.44	( $6\beta$ )
40	47.533	( $6\alpha$ )	80.5	67.0	( $6\beta$ )	80	63.17	( $6\beta$ )
40	47.6(T)	( $6\alpha$ )	90.7	73.6*	( $6\beta$ )	99	76.71	( $6\beta$ )
50	52.171	( $6\alpha$ )	100.8	82.0*	( $6\beta$ )			
53.25	54.041	( $6\alpha$ )	106.0	89.0*	( $6\beta$ )			(7 = $6\alpha$ at 31.5°)
20	44.37(T)	( $6\beta$ )	98	79.2*	( $6\beta$ +5)			( $6\alpha$ = $6\beta$ at 53.3°)
25	45.36(T)	( $6\beta$ )	100	80.0*	(5)			
30	46.56(T)	( $6\beta$ )	105	82.5*	(5)			
40	49.16(T)	( $6\beta$ )	97	78.5*	( $6\beta$ +4)			
58.21	55.389	( $6\beta$ )	100	78.6*	(4)			
60.11	55.557	( $6\beta$ )	106	80.1*	(4)			
79.75	64.476	( $6\beta$ )	96.4	78.0*	( $6\beta$ +3)			
94.22	72.597	( $6\beta$ )	100	77.3*	(3)			
			106	76.8	(3)			
			90.3	73.1*	( $6\beta$ +2)			
			104	73.0*	(2)			
			84.8	69.3*	( $6\beta$ +1)			
			104	69.3*	(1)			

Additional solubility determinations are given by Benrath and Theimann, 1934.

SOLUBILITY OF NICKEL SULFATE IN WATER ABOVE 100°  
(Benrath, 1941)

Solid Phase  $\text{NiSO}_4 \cdot \text{H}_2\text{O}$

t°	Gms. $\text{NiSO}_4$ per 100 gms. Sat. Sol.	t°	Gms. $\text{NiSO}_4$ per 100 gms. Sat. Sol.	t°	Gms. $\text{NiSO}_4$ per 100 gms. Sat. Sol.
150	55.2	195	40	203	25
170	50	203	35	205	10
195	44.2	205	30	205	1

THE SYSTEM NICKEL SULFATE - SULFURIC ACID - WATER

Results at 12.5° (Montemartini and Losana, 1928)

30

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{NiSO}_4$	$\text{H}_2\text{SO}_4$			$\text{NiSO}_4$	$\text{H}_2\text{SO}_4$	
1.3208	24.06	0.0	$\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$	1.4076	4.51	45.02	$\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$
1.2988	18.91	10.25	" "	1.4721	2.62	53.20	" + $\text{NiSO}_4 \cdot 2\text{H}_2\text{O}$
1.2958	13.62	18.16	$\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$	1.5450	0.87	63.32	$\text{NiSO}_4 \cdot 2\text{H}_2\text{O}$
1.3992	8.56	23.42	"	1.6466	0.22	72.61	" + $\text{NiSO}_4$
1.3236	6.84	32.10	"	1.7728	0.17	81.80	$\text{NiSO}_4$
1.3598	5.20	40.82	"	1.8430	0.11	98.91	"

Results at 20° (Babajewa and Daniluschkina, 1936)

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
$\text{NiSO}_4$	$\text{H}_2\text{SO}_4$			$\text{NiSO}_4$	$\text{H}_2\text{SO}_4$		
27.53	0.0		$\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$	17.63	13.33		$\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$ (blue)
24.13	4.28		"	13.72	19.86		"
22.64	5.92		"	8.56	30.46		"
21.14	8.80		"	6.71	40.67		"
20.60	10.20		" + $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$	9.56	52.45		"
18.60	11.85		$\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$ (blue)	0.77	68.01		$\text{NiSO}_4 \cdot 2\text{H}_2\text{O}$

The authors also give similar results for the temperatures 0°, 40°  
and 80°.

Results at 25° (Rohmer, 1939)

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
$\text{NiSO}_4$	$\text{H}_2\text{SO}_4$			$\text{NiSO}_4$	$\text{H}_2\text{SO}_4$		
29.2	0.0		$\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$	22.0	9.4		$\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$
24.9	5.1		"	19.8	12.6		"
23.4	7.4		" + $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$	14.2	21.1		"

(Cont.)

# Ni NICKEL

## SOLUBILITY OF NICKEL SULFATE IN WATER ABOVE 100°--Cont.

### Results at 25° (Rohmer, 1939)--Cont.

	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	NiSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>		NiSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	
SO	8.1	35.3	NiSO <sub>4</sub> ·6H <sub>2</sub> O	7.0	45.3	NiSO <sub>4</sub> ·H <sub>2</sub> O
	9.0	40.6	"	4.0	50.4	"
	9.0	42.0	" + NiSO <sub>4</sub> ·H <sub>2</sub> O	2.1	54.6	"
	10.8	43.5*	"	1.0	59.1	"
	12.5	43.7*	"	0.3	61.0	"
	16.9	42.7*	"	0.0	66.0	"
	20.1	41.1*	"	0.0	89.0	"
	10.5	43.2*	" + NiSO <sub>4</sub> ·4H <sub>2</sub> O	0.0	91.0	" + NiSO <sub>4</sub>
	9.2	46.7*	NiSO <sub>4</sub> ·4H <sub>2</sub> O	0.0	91.2	NiSO <sub>4</sub>
	8.6	50.0*	"	0.0	94.8	"

This author also gives similar results for the temperatures 0°, 50° and 90° showing both stable and metastable equilibrium at each temperature.

### THE SYSTEM NICKEL SULFATE, POTASSIUM SULFATE AND WATER AT 25° (Caven and Johnston, 1926)

Additional results for this system at other temperatures, by Benrath, 1932, will be found recorded in connection with potassium sulfate.

	Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
	NiSO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>		NiSO <sub>4</sub>	K <sub>2</sub> SO <sub>4</sub>	
	27.94	0.00	NiSO <sub>4</sub> ·7H <sub>2</sub> O	15.66	4.75	NiSO <sub>4</sub> ·K <sub>2</sub> SO <sub>4</sub> ·6H <sub>2</sub> O
	27.87	3.82	"	10.15	4.11	"
	27.92	6.30	"	3.90	4.15	"
	27.90	8.26	" + NiSO <sub>4</sub> ·K <sub>2</sub> SO <sub>4</sub> ·6H <sub>2</sub> O	1.35	4.93	"
	23.09	6.82	NiSO <sub>4</sub> ·K <sub>2</sub> SO <sub>4</sub> ·6H <sub>2</sub> O	0.33	11.16	" + K <sub>2</sub> SO <sub>4</sub>
	19.33	5.62	"	0.0	10.59	K <sub>2</sub> SO <sub>4</sub>

NICKEL POTASSIUM SULFATE  $\text{NiK}_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ 

SO

EQUILIBRIUM IN THE SYSTEM NICKEL POTASSIUM SULFATE - ZINC POTASSIUM  
SULFATE - WATER AT 25°  
(Hill, Durham, and Ricci, 1940)

Sat. Sol. Wt. %		Solid Phase Wt. %		Solid Phase
$\text{ZnK}_2(\text{SO}_4)_2$	$\text{NiK}_2(\text{SO}_4)_2$	$\text{ZnK}_2(\text{SO}_4)_2$	$\text{NiK}_2(\text{SO}_4)_2$	
11.72 <sup>a</sup>	0.0	-	-	$\text{ZnK}_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$
10.64	0.456	63.83	11.71	Hexahydrated Solid Solution
9.36	1.030	50.22	25.32	"
7.91	1.695	37.8	37.65	"
6.01	2.660	24.49	50.97	"
3.99	3.78	13.63	61.68	"
0.0	6.33 <sup>b</sup>	-	-	$\text{NiK}_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$

<sup>a</sup>density = 1.109<sup>b</sup>density = 1.056NICKEL AMMONIUM SULFATE  $\text{Ni}(\text{NH}_4)_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ 

SO

7.09 gms. of the anhydrous salt are dissolved in 100 gms. of saturated aqueous solution at 25° (0.2614 molar) density = 1.057. (Hill, Durham, and Ricci, 1940.)

8.45 gms. of the hydrated salt are dissolved in 100 gms. of aqueous saturated solution at 20°. (Gorshtein and Silanteva, 1954.)

THE SYSTEM NICKEL SULFATE - RUBIDIUM SULFATE - WATER  
(Benrath, 1932)

t°	Gms. per 100 gms. sat. sol.		Solid Phase	t°	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{Rb}_2\text{SO}_4$	$\text{NiSO}_4$			$\text{Rb}_2\text{SO}_4$	$\text{NiSO}_4$	
0	1.84	22.59	$\text{NiSO}_4 \cdot 7\text{H}_2\text{O} + 1.1.6$	44.5	11.04	6.38	1.1.6
0	3.25	7.89	1.1.6	54	3.94	35.75	" + $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}\alpha$
25	33.7	0.08	$\text{Rb}_2\text{SO}_4 + 1.1.6$	60	14.6	8.45	1.1.6
25	6.81	3.96	1.1.6	69	16.8	9.73	"
25	2.17	30.9	$\text{NiSO}_4 \cdot 7\text{H}_2\text{O} + 1.1.6$	88	22.35	12.96	"
29	2.32	34.6	" + "	100	46.99	0.91	" + $\text{Rb}_2\text{SO}_4$
			+ $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}\alpha$	100	25.57	14.88	1.1.6
				100	7.98	42.8	" + $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}\beta$

1.1.6 =  $\text{NiSO}_4 \cdot \text{Rb}_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$

# NI NICKEL

## THE SYSTEM NICKEL SULFATE - THALLIUM SULFATE - WATER (Benrath, 1932)

t°	Gms. per 100 gms. sat. sol.		Solid Phase	t°	Gms. per 100 gms. sat. sol.		Solid Phase
	Tl <sub>2</sub> SO <sub>4</sub>	NiSO <sub>4</sub>			Tl <sub>2</sub> SO <sub>4</sub>	NiSO <sub>4</sub>	
0	2.69	0.16	Tl <sub>2</sub> SO <sub>4</sub> + 1.1.6	46	5.77	1.77	1.1.6
0	1.68	0.51	1.1.6	46	1.55	32.62	" + NiSO <sub>4</sub> ·6H <sub>2</sub> Oα
0	0.63	21.30	" + NiSO <sub>4</sub> ·7H <sub>2</sub> O	55	7.30	2.25	1.1.6
25	5.15	0.33	" + Tl <sub>2</sub> SO <sub>4</sub>	55	2.28	33.85	" + NiSO <sub>4</sub> ·6H <sub>2</sub> Oβ
25	3.20	1.01	1.1.6	80	14.65	3.15	" + Tl <sub>2</sub> SO <sub>4</sub>
25	0.89	27.92	" + NiSO <sub>4</sub> ·7H <sub>2</sub> O	80	13.42	4.13	"
30	2.28	33.85	" + " + NiSO <sub>4</sub> ·6H <sub>2</sub> Oα	80	4.32	37.99	" + NiSO <sub>4</sub> ·6H <sub>2</sub> Oβ
46	8.29	0.85	1.1.6 + Tl <sub>2</sub> SO <sub>4</sub>	100	20.08	7.34	" + Tl <sub>2</sub> SO <sub>4</sub>
				100	7.03	41.45	" + NiSO <sub>4</sub> ·6H <sub>2</sub> Oβ

## SOLUBILITY OF NICKEL SULFATE IN AQUEOUS SOLUTIONS OF METHYL ALCOHOL AT 14° (de Bruyn, 1903)

Small test tubes of 4-6 cc. capacity were used. They were almost completely filled with the salt and solvent and placed in the bath in an inclined position with salt occupying the upper part of the tube. This caused a "spontaneous circulation of the solvent." The solutions were analyzed by precipitating NiO with KOH at the boiling point, in porcelain vessels.

Wt. % CH <sub>3</sub> OH in Solvent	Gms. NiSO <sub>4</sub> per 100 Gms. Sat. Sol. in Contact with:			
	NiSO <sub>4</sub> ·7H <sub>2</sub> O as Solid Phase	NiSO <sub>4</sub> ·6H <sub>2</sub> Oα as Solid Phase	NiSO <sub>4</sub> ·6H <sub>2</sub> Oβ as Solid Phase	NiSO <sub>4</sub> ·4H <sub>2</sub> O as Solid Phase
0 (H <sub>2</sub> O)	26.4	26 (low)	27.2	25.1
10	19.7	22 (?)	20.4	-
20	13.1	14.7	14	14.8
30	6.8	6.6	7.5	-
40	2.8	2.4	3.1	-
50	1.3	1	1.4	1.4
60	0.8	0.4	0.6	-
70	0.6	0.2	0.4	-
80	0.65	0.2	0.4	0.66
85	1.5	0.3	0.7	-
90	5.7	1.2	2.5	-
95	11	6	9(?)	-
100	16.8	12.4 (low)	15.7 (low)	7.38

NiSO<sub>4</sub>·6H<sub>2</sub>Oα is greenish blue. NiSO<sub>4</sub>·6H<sub>2</sub>Oβ is more greenish than the α salt.

SOLUBILITY OF  $\text{NiSO}_4 \cdot 3\text{CH}_3\text{OH} \cdot 3\text{H}_2\text{O}$  IN AQUEOUS  $\text{CH}_3\text{OH}$  AT  $14^\circ$   
(de Bruyn, 1903)

Approximately two hours were allowed for attainment of equilibrium.

In solutions containing more than 15%  $\text{H}_2\text{O}$  the salt is gradually transformed to  $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$ .

Wt. Per cent $\text{CH}_3\text{OH}$	Gms. $\text{NiSO}_4$ per 100 Gms. Sat. Sol.	Wt. Per cent $\text{CH}_3\text{OH}$	Gms. $\text{NiSO}_4$ per 100 Gms. Sat. Sol.
85	1.93	90	0.70
86	1.73	92.5	0.50
87	1.48	95	0.455
88	1.25	97.5	0.77
89	1.01	100	3.72

S0

Data for the distribution of  $\text{NiSO}_4$  between butyl alcohol and aqueous  $\text{H}_2\text{SO}_4$ ,  $\text{Na}_2\text{SO}_4$ , and  $(\text{NH}_4)_2\text{SO}_4$  at  $25^\circ$  and  $70^\circ$  are reported by Schlea, 1955.

SOLUBILITY OF NICKEL SULFATE IN ABSOLUTE METHYL AND ETHYL ALCOHOLS  
(Gibson, Driscoll and Jones, 1929)

Results for Methyl Alcohol			Results for Ethyl Alcohol		
t°	Gms. $\text{NiSO}_4$ per 100 gms. $\text{CH}_3\text{OH}$	Solid Phase	t°	Gms. $\text{NiSO}_4$ per 100 gms. $\text{C}_2\text{H}_5\text{OH}$	Solid Phase
15	0.061	$\text{NiSO}_4$	15	0.017	$\text{NiSO}_4$
25	0.081	"	35	0.020	"
35	0.110	"	45	0.022	"
45	0.157	"	55	0.025	"
55	0.222	"			

100 gms. methanol dissolve 115 gms.  $\text{NiSO}_4$  at  $5^\circ$  when the saturating phase is  $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$ . (Barber and Ali, 1950.)

100 gms. absolute ethyl alcohol dissolve 1.4 gm.  $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$  at  $4^\circ$  and 2.2 gms. at  $17^\circ$ . (de Bruyn, 1892.)

100 gms. sat. solution in glycol contain 9.7 gms.  $\text{NiSO}_4$  at room temperature. (de Coninck, 1905.)

NICKEL (TRI)ETHYLENEDIAMINE THIOSULFATE  $\text{Ni}[\text{C}_2\text{H}_4(\text{NH}_2)_2]_3\text{S}_2\text{O}_3$

SOLUBILITY IN WATER AND AQUEOUS ETHANOL  
(Gast and Aldrich, 1951)

Read in part from the authors' curves.

	t°	mg. salt per ml. soln.		Wt. % $\text{C}_2\text{H}_5\text{OH}$	mg. salt per ml. soln.
In Water	20	1.35	In Aqueous Ethanol at $20^\circ$	0	1.35
	30	1.75		20	0.53
	50	2.7		30	0.36
	100	7.1		40	0.20



# Ni NICKEL

## SeO NICKEL SELENITE $\text{NiSeO}_3$

The  $K_{sp}$  is  $1.0 \times 10^{-5}$  at  $20^\circ$ . (Chukhlantsev and Tomashevskii, 1957.)

## SeO NICKEL SELENATE $\text{NiSeO}_4$

### SOLUBILITY OF NICKEL SELENATE IN WATER (Klein, 1940)

$t^\circ$	Density	Gms. $\text{NiSeO}_4$ per 100 gms.		Solid Phase
		Sat. Sol.	$\text{H}_2\text{O}$	
- 1.2	1.300	-	-	Ice
- 2.1	-	16.09	19.17	Ice + $\text{NiSeO}_4 \cdot 6\text{H}_2\text{O}$
- 3.0	-	21.01	26.60	$\text{NiSeO}_4 \cdot 6\text{H}_2\text{O}$
0	1.2675	21.65	27.63	"
15	1.3134	25.06	33.44	"
21.6	1.3351	26.58	36.20	"
30	1.3651	26.58	36.20	"
40	1.4045	31.09	45.11	"
50	1.4473	33.77	50.98	"
60	1.4971	36.81	58.25	"
70	1.5505	39.64	65.67	"
80	1.6154	42.70	74.79	"
90	1.6863	46.54	87.05	"
85.2	1.6332	43.88	78.18	$\text{NiSeO}_4 \cdot 4\text{H}_2\text{O}$
90	1.6434	44.34	79.66	"
95	1.6448	44.85	81.32	"
100	1.6641	45.65	83.99	"
103.6	-	Boiling Point at 745 mm.		

### THE SYSTEM NICKEL SELENATE - SELENIC ACID - WATER AT $30^\circ$ (Rohrer and Fronig, 1950)

Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
$\text{NiSeO}_4$	$\text{H}_2\text{SeO}_4$	den- sity		$\text{NiSeO}_4$	$\text{H}_2\text{SeO}_4$	den- sity	
28.87	0.11	1.365	$\text{NiSeO}_4 \cdot 6\text{H}_2\text{O}$	8.91	58.84	1.893	$\text{NiSeO}_4 \cdot 4\text{H}_2\text{O}^m$
22.62	9.34	1.372	"	8.03	47.22	1.646	$\text{NiSeO}_4 \cdot \text{H}_2\text{O}$
16.12	20.26	1.415	"	4.81	53.08	1.679	"
10.67	32.99	1.479	"	4.19	55.16	1.694	"
8.81	38.99	1.537	"	3.28	57.58	1.720	"
8.39	41.02	1.552	"	0.96	64.71	1.814	"
8.68	49.64	1.723	" (m)	0.45	68.44	1.888	"
9.36	51.18	1.756	" (m)	0.27	70.98	1.923	"
9.37	51.16	1.761	$\text{NiSeO}_4 \cdot 4\text{H}_2\text{O}^m$	0.23	74.70	2.038	"
8.89	52.94	1.794	" (m)	0.15	76.46	2.071	"
8.87	53.38	1.816	" (m)	0.04	83.85	2.262	"
8.65	55.87	1.831	" (m)	0.03	86.22	2.294	"

m = metastable

## NICKEL SILICATES

SiO

A discussion of hydrothermal studies in the system  $\text{NiO} - \text{SiO}_2 - \text{H}_2\text{O}$  is given by Franzen and Van Eyk Van Voorthuijsen, 1950.

## NEPTUNIUM Hp

NEPTUNIUM NITRATES  $\text{Np}(\text{NO}_3)_4$ ,  $\text{NpO}_2(\text{NO}_3)_2$ 

NO

Data for the distribution of  $\text{Np}(\text{NO}_3)_4$  and  $\text{NpO}_2(\text{NO}_3)_2$  concentrations between aqueous  $\text{HNO}_3$  and tributyl phosphate are given by Alcock, Best Hesford and McKay, 1958 and by Healy and McKay, 1956.

Distribution of  $\text{Np}^{\text{IV}}$ ,  $\text{Np}^{\text{V}}$ , and  $\text{Np}^{\text{VI}}$  between 1 - 9 N aqueous  $\text{HNO}_3$  and dibutyl carbitol, ether, and methyl-i-butyl-ketone are reported by Kooi, 1956.

## NEPTUNIUM OXIDE

O

## HYDROXIDES

OH

Results of LaChapelle, Magnusson and Hindman, 1949

$\text{NpO}_2$  (peroxide) ppts. from 0.8 M  $\text{HNO}_3$  + 3 M  $\text{H}_2\text{O}_2$ . Solubility is 0.10 g. Np per liter

$\text{Np}(\text{OH})_4$  soly. in 0.5 M  $(\text{NH}_4)_2\text{SO}_4$  sat'd. with  $\text{NH}_3$  is 0.0029 g. Np per liter

$\text{Np}(\text{OH})_5$  soly. in 0.5 M  $(\text{NH}_4)_2\text{SO}_4$  sat'd. with  $\text{NH}_3$  is 0.78 g. Np per liter

$\text{Np}(\text{OH})_6$  soly. in 0.5 M  $(\text{NH}_4)_2\text{SO}_4$  sat'd. with  $\text{NH}_3$  is 0.27 g. Np per liter

NEPTUNIUM PHOSPHATE  $\text{Np}_3(\text{PO}_4)_4$ 

PO

The solubility in 0.9 M  $\text{HNO}_3$  + 0.1 M  $\text{H}_3\text{PO}_4$  is 0.1 g. Np per liter. (LaChapelle, Magnusson and Hindman, 1949.)

## 0 OXYGEN

### OXYGEN O<sub>2</sub>

#### SOLUBILITY OF OXYGEN IN WATER

Some early determinations give slightly high values at lower temperatures (see Bohr and Bock, below). Recent determinations indicate that the lower values are probably correct (Morrison and Billet, also table following)

$\beta$  = ml O<sub>2</sub> (at S.T.P.) absorbed by 1 ml H<sub>2</sub>O at a pressure of O<sub>2</sub> of 1 atm.

t°	$\beta$			t°	$\beta$		
	Winkler 1891	Morrison and Billet 1952	Bohr & Bock 1891		Winkler 1891	Morrison and Billet 1952	Bohr & Bock 1891
0	0.0489	-	0.0496	40	0.0231	0.0232	0.0233
5	0.0429	-	0.439	50	0.0209	0.0208	0.207
10	0.0380	-	0.390	60	0.0195	0.0196	0.189
15	0.0342	0.0341	0.350	70	0.0183	0.0186	0.178
20	0.0310	0.0308	0.317	80	0.0176	0.0177	0.172
25	0.0283	0.0284	0.290	90	0.0172	-	0.169
30	0.0261	0.0265	0.268	100	0.0170	-	0.168

#### SOLUBILITY OF OXYGEN IN WATER IN CONTACT WITH AIR

These results, of considerable commercial and biological importance have been measured directly and calculated from data on pure oxygen. Morgan and Richardson, 1930 found that the values obtained in these two ways are the same. Extensive data upon the rate of solution of atmospheric oxygen and nitrogen in water are given in a series of papers by Adeney and Becker 1916-1920, 1919, 1920 and 1921.

Recent data again tend toward lower solubility values (see also table above). The following table was compiled by Truesdale, Downing and Lowden, 1955 for comparison of the various results these authors found the solubility at one atmosphere pressure (air and water vapor) to be:  $C = 14.161 - 0.3943t + 0.007714t^2 - 0.0000646t^3$  where C is the concentration of oxygen in water in parts per million, and t is °C.

t°								Truesdale, Downing and Lowden 1954, 1955
	Fox 1909	Winkler 1889 <sup>a</sup>	Winkler 1891 <sup>b</sup>	Roscoe & Lunt 1889	Jacobson 1905 <sup>c</sup>	Bohr & Bock, 1891	Royal Comm. 1908 <sup>d</sup>	
0	14.65	14.56	14.55	-	14.30	14.79	-	14.16
5	12.80	12.72	12.73	12.41	12.48	13.02	-	12.37
10	11.33	11.27	11.24	11.11	11.01	11.58	11.11	10.92
15	10.15	10.09	10.06	9.98	9.85	10.32	9.98	9.76
20	9.17	9.10	9.10	8.96	8.91	9.30	8.99	8.84
25	8.38	8.29	8.24	8.25	8.16	8.46	8.18	8.11
30	7.63	7.53	7.52	-	-	7.71	-	7.52
35	7.10	-	-	-	-	7.08	-	7.02

<sup>a</sup>Titrimetric analysis <sup>b</sup>gasometric <sup>c</sup>Gas quoted by Fox, 1909

<sup>d</sup>Royal Commission on Sewage Disposal, 5th Report, 1908, Appendix 6, Part XIII

SOLUBILITY OF OXYGEN IN WATER AT HIGH PRESSURES  
(Pray, Schweickert and Minnich, 1952; Frolich et al., 1931)

Values read from smoothed curves drawn by the latter authors.

°F.	CC. O <sub>2</sub> (S.T.P.) per gm. H <sub>2</sub> O				
	100 p.s.i.a.	200 p.s.i.a.	300 p.s.i.a.	400 p.s.i.a.	500 p.s.i.a.
100	0.16	0.33	0.53	0.72	0.89
200	0.10	0.23	0.43	0.59	0.74
300	0.10	0.26	0.44	0.61	0.76
400	0.20	0.45	0.62	0.84	1.01
500	0.41	0.82	1.11	1.40	2.00
600	0.78	1.48	2.27	3.03	3.81

Results for the solubility of O<sub>2</sub> in water at 1000, 1500, and 2000 p.s.i. from 32° to 625° F. are reported by Zoss, Suciu and Sibbitt. In agreement with the data above, minimum solubility occurs at about 233°F.

SOLUBILITY OF OXYGEN IN AQUEOUS SOLUTIONS OF ACIDS AND BASES

Results in terms of the Ostwald Coefficient  $\ell$  which shows the ratio of the volume (v) of gas absorbed at any pressure and temperature, to the volume (V) of the absorbing liquid.  $\beta$  is the Bunsen absorption coefficient in which the volume of gas is corrected to S.T.P.

A = Geffcken, 1904    B = Bohr, 1910    C = Christoff, 1906

	Concentration per Liter		Solubility of Oxygen			
	Gram Equiv.	Grams	$\ell_{15^\circ}$	$\ell_{20^\circ}$	$\beta_{21^\circ}$	$\ell_{25^\circ}$
Water alone	-	-	0.0363	-	-	0.0308
Hydrochloric Acid	0.5	18.22	0.0344	-	-	0.0296
"	1.0	36.45	0.0327	-	-	0.0287
"	2.0	72.90	0.0299	-	-	0.0267
Nitric Acid	0.5	36.52	0.0348	-	-	0.0302
"	1.0	63.05	0.0336	-	-	0.0295
"	2.0	126.10	0.0315	-	-	0.0284
Sulphuric Acid	0.5	24.52	0.0338	-	-	0.0288
"	1.0	49.04	0.0319	-	-	0.0275
"	2.0	98.08	0.0335	-	-	0.0251
"	3.0	147.12	0.0256	-	-	0.0229
"	4.0	196.16	0.0233	-	-	0.0209
"	5.0	245.20	0.0213	-	-	0.0194
"	0	-	-	-	0.0310	-
"	4.9	-	-	-	0.0195	-
"	8.9	-	-	-	0.0155	-
"	10.7	-	-	-	0.0143	-
"	20.3	-	-	-	0.0119	-
"	24.8	-	-	-	0.0103	-
"	29.6	-	-	-	0.0117	-
"	34.3	-	-	-	0.0201	-
"	35.8 (=96%)	-	-	-	0.0275	-

(Cont.)

# 0 OXYGEN

## SOLUBILITY OF OXYGEN IN AQUEOUS SOLUTIONS OF ACIDS AND BASES--Cont.

A = Geffcken, 1904    B = Bohr, 1910    C = Christoff, 1906

	Concentration per Liter		Solubility of Oxygen			
	Gram Equiv.	Grams	15°	20°	21°	25°
Sulphuric Acid	0	Wt. %	-	0.03756	-	-
"	35.82	"	-	0.01815	-	-
"	61.62	"	-	0.01407	-	-
"	95.60	"	-	0.03303	-	-
Potassium Hydroxide	0.5	28.08	0.0291	-	-	0.0252
"	1.0	56.16	0.0234	-	-	0.0206
Sodium Hydroxide	0.5	20.03	0.0288	-	-	0.0250
"	1.0	40.06	0.0231	-	-	0.0204
"	2.0	80.12	0.0152	-	-	0.0133

## SOLUBILITY OF OXYGEN IN SEA WATER (Fox, 1909a)

Before using the sample of sea water for the solubility determinations, it was found necessary to add acid, otherwise the CO<sub>2</sub> could not be boiled out or the precipitation of neutral carbonates prevented. The very small amount of acid was titrated back, using phenolphthaleine as indicator.

Results in terms of cc. of oxygen absorbed by 1000 cc. of sea water from a free dry atmosphere at 760 mm. pressure.

The calculated formula expressing the solubility is:  $1000 a = 10.291 - 0.2809 t + 0.006009 t^2 - 0.0000632 t^3 - C1 (0.1161 - 0.003922 t + 0.0000631 t^2)$ .

Parts Chlorine per 1000	0°	4°	8°	12°	16°	20°	24°	28°
0	10.29	9.26	8.40	7.68	7.08	6.57	6.14	5.75
4	9.83	8.85	8.04	7.36	6.80	6.33	5.91	5.53
8	9.36	8.45	7.68	7.04	6.52	6.07	5.67	5.31
12	8.90	8.04	7.33	6.74	6.24	5.82	5.44	5.08
16	8.43	7.64	6.97	6.43	5.96	5.56	5.20	4.86
20	7.97	7.23	6.62	6.11	5.69	5.31	4.95	4.62

A recalculation of Fox's determinations to parts per million, with correction for vapor pressure, is published by Whipple and Whipple (1911).

More recent determinations of the solubility in saline water are reported by Truesdale, Downing and Lowden, 1955 between 0 and 40°. Extensive tables are given, and the results are somewhat lower than the older data of Fox, above.

SOLUBILITY OF OXYGEN IN AQUEOUS SALT SOLUTIONS AT 25°  
(MacArthur, 1916)

Aq. Salt Solution	d <sub>25</sub> Aq. Solution	cc. oxygen per Liter	Aq. Salt Solution	d <sub>25</sub> Aq. Solution	cc. oxygen per Liter
Dist. H <sub>2</sub> O	1	5.78	0.50 n KI	1.056	5.20
0.125n NH <sub>4</sub> Cl	1.0015	2.31	1 n KI	1.116	4.75
0.25 n NH <sub>4</sub> Cl	1.0025	1.16	2 n KI	1.23	3.77
1 n NH <sub>4</sub> Cl	1.014	0.07	5 n KI	1.46	1.81
0.125n BaCl <sub>2</sub>	1.019	5.40	0.25 n KNO <sub>3</sub>	1.015	5.49
0.25 n BaCl <sub>2</sub>	1.042	5.04	0.50 n KNO <sub>3</sub>	1.029	5.11
0.50 n BaCl <sub>2</sub>	1.082	4.27	1 n KNO <sub>3</sub>	1.059	4.61
1 n BaCl <sub>2</sub>	1.177	3.10	2 n KNO <sub>3</sub>	1.110	3.65
0.25 n CaCl <sub>2</sub>	1.022	5.08	0.125n K <sub>2</sub> SO <sub>4</sub>	1.016	5.11
1 n CaCl <sub>2</sub>	1.084	3.71	0.25 n K <sub>2</sub> SO <sub>4</sub>	1.032	4.66
5 n CaCl <sub>2</sub>	1.34	2.14	0.5 n K <sub>2</sub> SO <sub>4</sub>	1.060	3.89
0.125n CsCl	1.014	5.67	0.125n RbCl	1.0094	5.65
0.125n LiCl	1.0004	5.63	0.125n NaBr	1.007	5.65
0.50 n LiCl	1.0091	5.17	0.25 n NaBr	1.017	5.52
1 n LiCl	1.021	4.59	0.50 n NaBr	1.036	5.15
2 n LiCl	1.044	3.63	1 n NaBr	1.075	4.47
3 n LiCl	1.113	1.97	2 n NaBr	1.150	3.37
4 n LiCl	1.220	1.12	3 n NaBr	1.219	2.57
0.125n MgCl <sub>2</sub>	1.011	5.35	4 n NaBr	1.305	2.02
0.50 n MgCl <sub>2</sub>	1.044	4.37	6 n NaBr	1.455	1.28
1 n MgCl <sub>2</sub>	1.085	3.18	0.125n NaCl	1.0022	5.52
2 n MgCl <sub>2</sub>	1.160	2.22	0.25 n NaCl	1.0067	5.30
4 n MgCl <sub>2</sub>	1.284	0.78	0.50 n NaCl	1.017	4.92
5 n MgCl <sub>2</sub>	1.343	0.54	1 n NaCl	1.038	4.20
0.25 n KBr	1.019	5.29	2 n NaCl	1.075	3.05
2 n KBr	1.079	3.27	3 n NaCl	1.112	2.24
4 n KBr	1.162	1.84	4 n NaCl	1.149	1.62
0.125n KCl	1.003	5.52	0.125n Na <sub>2</sub> SO <sub>4</sub>	1.014	5.04
0.25 n KCl	1.0086	5.30	0.25 n Na <sub>2</sub> SO <sub>4</sub>	1.032	4.60
0.50 n KCl	1.020	4.98	0.50 n Na <sub>2</sub> SO <sub>4</sub>	1.063	3.97
1 n KCl	1.042	4.26	1 n Na <sub>2</sub> SO <sub>4</sub>	1.130	3.00
2 n KCl	1.086	3.21	0.125n Sucrose	1.015	5.40
3 n KCl	1.134	2.36	0.25 n Sucrose	1.033	4.82
4 n KCl	1.170	1.86	0.50 n Sucrose	1.068	4.39
0.125n KI	1.013	5.65	1 n Sucrose	1.147	3.20
0.25 n KI	1.027	5.49	2 n Sucrose	1.330	1.84

Results of Geffcken, 1904

	Salt. conc'n		t15°	t25°
	N	g./liter		
Potassium Sulphate	0.5	43.59	0.0294	0.0253
Potassium Sulphate	1.0	87.18	0.0237	0.0207
Sodium Chloride	0.5	29.25	0.0308	0.0262
Sodium Chloride	1.0	58.5	0.0260	0.0223
Sodium Chloride	2.0	119.0	0.0182	0.0158

# 0 OXYGEN

## Results of Eucken and Hertzberg, 1950

### in NaCl solutions

Salt	t°	moles salt per 1000 gms. H <sub>2</sub> O	Ostwald coeff. $\ell$	Salt	t°	moles salt per 1000 gms. H <sub>2</sub> O	Ostwald coeff. $\ell$
NaCl	0	0	0.0490	KCl	20	0.47	0.0285
		0.48	0.0409			0.97	0.0243
		1.23	0.0306			1.59	0.0196
		2.49	0.0193	LiCl	0	0.58	0.0397
	15	0	0.0365			1.64	0.0334
		0.69	0.0289			2.34	0.0211
		1.74	0.0203			0.37	0.0295
	20	0	0.0332		20	0.88	0.0251
		0.81	0.0254			1.94	0.0182
		1.77	0.0187			0.49	0.0358
	25	0	0.0307	MgCl <sub>2</sub>	0	1.13	0.0234
		0.64	0.0250			1.70	0.0163
		1.53	0.0187			0.65	0.0225
KCl	0	0.62	0.0387		20	1.24	0.0158
		1.18	0.0309			1.93	0.0107
		2.76	0.0172				

The "salting-out" coefficient  $k = \log \frac{S_0}{S} / C$  for oxygen in tetraethyl ammonium bromide solutions at 25° is -0.046, where C is in moles salt per 1000 gms. H<sub>2</sub>O and S<sub>0</sub> is the solubility of oxygen in pure water.

(Morrison and Johnstone, 1955.)

## SOLUBILITY OF OXYGEN IN AQUEOUS SOLUTIONS OF ORGANIC COMPOUNDS

### In Aqueous Alcohol at 20° and 760 MM

(Lubarsch, 1889)

Wt. % Alcohol	Vol. % Absorbed O	Wt. % Alcohol	Vol. % Absorbed O	Wt. % Alcohol	Vol. % Absorbed O
0	2.98	23.08	2.52	50	3.50
9.09	2.78	28.57	2.49	66.67	4.95
16.67	2.63	33.33	2.67	80	5.66

### In Aqueous 95 Vol. % Ethanol

(Kretschmer, Nowakowska and Wiebe, 1946)

	-25°	0°	25°	50°
Ostwald coefficient $\ell$	0.1825	0.1868	0.1917	0.2019

(Cont.)

In Aqueous Chloral Hydrate at 20°

(Mueller, 1912-13)

Gms. $\text{CCl}_3\cdot\text{CH}(\text{OH})_3$ per 100 Gms. Aq. Sol.	$d_{20}$ of Aq. Sol.	Abs. Coef. $\beta$ (Bunsen) at 20°
16.9	1.0798	0.02795
32	1.1630	0.02495
52.9	1.2935	0.02325
61.08	1.354	0.02410
65.5	1.382	0.02580
71.4	1.4404	0.02730
78	1.46	0.03280

In Aqueous Glycerol at 15°

(Mueller, 1912-13)

Gms. $(\text{CH}_2\text{OH})_2\text{CHOH}$ per 100 Gms. Aq. Sol.	$d$ of Aq. Sol.	Abs. Coef. $\beta$ (Bunsen) at 15°
20.5	$d_{12.5} = 1.0509$	0.02742
25	$d_{13} = 1.0621$	0.02521
37.3	$d_{14.5} = 1.0957$	0.02022
45	$d_{12.5} = 1.1161$	0.01744
52	$d_{12.5} = 1.1351$	0.01570
71.5	$d_{12.5} = 1.1908$	0.00950
88.5	$d_{13.5} = 1.236$	0.00886

In Aqueous Glucose at 20°

(Mueller, 1912-13)

In Aqueous Cane Sugar at 15°

(Mueller, 1912-13)

Gms. $\text{C}_6\text{H}_{12}\text{O}_6$ per 100 Gms. Aq. Sol.	$d_{20}$ of Aq. Sol.	Abs. Coef. $\beta$ (Bunsen) at 20°	Gms. $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ per 100 Gms. Aq. Sol.	$d_{20}$ of Aq. Sol.	Abs. Coef. $\beta$ (Bunsen) at 15°
10.84	1.0413	0.02690	12.1	1.0482	0.02969
20.7	1.0835	0.02250	24.38	1.1022	0.02396
33.8	1.1370	0.01815	28.44	1.1205	0.02181
51.9	1.2295	0.01390	42.96	1.1938	0.01600
58.84	1.2649	0.01250	50	1.2318	0.01359

SOLUBILITY OF OXYGEN IN BLOOD AT 38°

(Sendroy, Dillon and Van Slyke, 1934)

The authors point out that the earlier results reported by Bohr (1905) were not directly determined but estimated on the assumption that since his experiments showed hydrogen to be only 92 percent as soluble in blood as in water, oxygen would also have the same "relative solubility". The authors, have therefore, made direct determinations of the solubility of oxygen in blood and also determined the effect of its various constituents upon this solubility. The Van Slyke-Neil (1924) manometric gas apparatus was used (see preceding remarks in connection with results for the solubility of oxygen in water by Orcutt and SeEVERS). The results are given in terms of the Bunsen Abs. Coefficient defined on p. 1228



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## SOLUBILITY OF OXYGEN IN BLOOD AT 38°--Cont.

Solvent	Oxygen Abs. Coef. $\beta$
Water	0.02323
Aq. 0.155 normal NaCl	0.02211
Plasma	0.0209
Cells	0.0261
Whole Blood of normal hemoglobin content	0.0230 (0.034 at 20°)
Hemoglobin	0.0280*

\*This result shows the cc. O<sub>2</sub> taken up by 1 gm. of dissolved hemoglobin when the gas tension is 760 mm.

Data for the solubility of oxygen in hemoglobin are given by Jolin (1889).

Data for the solubility of oxygen in defibrinated ox-blood and ox-serum, at pressures varying from 760 to about 1400 mm. Hg, are given by Findlay and Creighton (1911).

## SOLUBILITY OF OXYGEN IN ORGANIC SOLVENTS

The data in the following two tables are in agreement and are generally somewhat higher than the values reported by earlier investigators.

### Results of Horiuti, 1931, 1932

t°	Solubility of O <sub>2</sub> in terms of the Ostwald Expression $\ell$ in:					
	CCl <sub>4</sub>	C <sub>6</sub> H <sub>5</sub> Cl	C <sub>6</sub> H <sub>6</sub>	(CH <sub>3</sub> ) <sub>2</sub> CO <sup>a</sup>	CH <sub>3</sub> CO <sub>2</sub> CH <sub>3</sub>	(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O
-78	--	--	--	0.2147	0.1901	0.4505
-60	--	--	--	0.2175	0.1987	0.4329
-40	--	--	--	0.2253 (-41.3°)	0.2126	0.4244
-20	--	--	--	0.2385	0.2288	0.4247
0	0.2865	0.1748	--	0.2550	0.2488	0.4325
+10	0.2926	0.1804	0.2091	0.2649	0.2583	--
20	0.2996	0.1863	0.2186	0.2736	0.2703 (21.85°)	0.4511
25	0.302	0.189	0.223	0.280	0.273	0.455
30	0.3056	0.1915	0.2281	0.2846	0.2789	--
40	0.3124	0.1974	0.2371	0.2954	0.2877	--
50	0.3196	0.2031	0.2483	--	--	--
60	0.3246	0.2094	0.2576	--	--	--
70	--	0.2163	--	--	--	--
80	--	0.2214	--	--	--	--

<sup>a</sup>See also table below

## SOLUBILITY OF OXYGEN IN BLOOD AT 38°--Cont.

Results of Kretschmer, Nowaskowska, and Wiebe, 1946

Solvent	Ostwald Coefficient $\ell$			
	-25°	0°	25°	50°
Absolute Ethanol	0.2387	0.2409	0.2417	0.2481
Methanol	.2427	.2446	.2476	.2550
Isopropanol	-	.2443	.2463	.2552
n-Butanol	-	.2085	.2100	.2171
Acetone <sup>a</sup>	.2390	.2570	.2794	-
Iso-Octane	.3874	.3701	.3725	.3864
50% Acetone by vol. in Ethanol	-	.2409	.2552	.2733
50% Iso-Octane by vol. in Ethanol	-	.3119	.3163	.3225

<sup>a</sup>See also table above

The following data of Fischer and Pfeleiderer, 1922 are lower and probably less accurate than those above, but may be useful in showing comparative solubilities.

Solvent	t° of saturation	Abs. coef. $\alpha$	Solubility $\ell$ (Ostwald)
Water	20	0.021	0.023
Aqueous 0.1n KOH	20	0.024	0.026
Petroleum Ether (b. pt. ~ 65°)	18.5	0.409	0.436
Benzine (b. pt. 65°-100°)	18	0.292	0.312
Com. Petroleum	18	0.159	0.170
Paraffine Oil	18	0.114	0.122
Chloroform	16	0.205	0.217
Carbon Tetrachloride	18	0.230	0.245
Acetylene Tetrachloride (C <sub>2</sub> H <sub>4</sub> Cl <sub>4</sub> )	18	0.100	0.107
Methyl Alcohol	18.5	0.175	0.187
Ethyl Alcohol (96%)	20	0.143	0.154
Amyl Alcohol (iso)	16	0.163	0.173
Acetone	19	0.207	0.222
Ethyl Ether	20.2	0.415	0.446
Ethyl Acetate	20	0.163	0.175
Benzene	19	0.163	0.174
Toluene	18	0.168	0.179
Xylene (Com.)	16	0.169	0.179
Nitrobenzene	18	0.070	0.075
Tetra hydro naphthalene (Tetralin)	17	0.094	0.100
Pyridine	18	0.099	0.105

## SOLUBILITY OF OXYGEN IN OILS AND OTHER SOLVENTS

Solvent	t°	Solubility	Reference
Mineral oil, $d_{27} = 0.868$ ; f.pt. = $-37^{\circ}$ ; $7100^{\circ}\text{F} = 285$ (Savbolt)	24	$\beta = 0.134$	Kubie, 1927
Heavy lube oil, surface tension = 29.4	21	$\ell = 0.129$	Szebehely, 1951
Light lube oil, surface tension = 25.4	21	$\ell = 0.171$	Szebehely, 1951
Aircraft engine fuel, surface tension = 23.4	21	$\ell = 0.263$	Szebehely, 1951
Aircraft engine fuel, surface tension = 17.8	21	$\ell = 0.359$	Szebehely, 1951
Petroleum oil, surface tension = 28.5 (Kerosene)	-18	$\ell = 0.218$	Derry, et al., 1952
Petroleum oil, surface tension = 25.8	+18	$\ell = 0.227$	Derry, et al., 1952
Petroleum oil, surface tension = 25.0	25	$\ell = 0.232$	Derry, et al., 1952
Petroleum oil, surface tension = 23.0	42	$\ell = 0.238$	Derry, et al., 1952
Petroleum oil, surface tension = 29.5	25	$\ell = 0.1705$	Rodman and Maude, 1925
Petroleum oil, surface tension = 24.0	80	$\ell = 0.1925$	Rodman and Maude, 1925
Technical Xylene, B.pt. 134-138°	23	$\ell = 0.177$ Reznikovskii, Tarasova and Dogadkin,	1950
Toluene	20	$\ell = 0.128$ Reznikovskii, Tarasova and Dogadkin,	1950
Ligroin, B.pt. 110-120°	20	$\ell = 0.156$ Reznikovskii, Tarasova and Dogadkin,	1950
White spirit, B.pt. 165-200°	19	$\ell = 0.170$ Reznikovskii, Tarasova and Dogadkin,	1950
Cracking gasoline, B.pt. 115-150°	19	$\ell = 0.178$ Reznikovskii, Tarasova and Dogadkin,	1950
Cyclohexanol	16	$\ell = 0.192$	Cauquil, 1927
Liquid paraffin $d = 0.835$	38	$\beta = 0.098$	Rodnight, 1954
Olive oil	38	$\beta = 0.102$	Rodnight, 1954
Silicone oil, $\eta = 5$ c.s.	38	$\beta = 0.25$	Rodnight, 1954
Silicone oil, $\eta = 1$ c.s.	38	$\beta = 0.30$	Rodnight, 1954
Butter oil	40	$\beta = 0.142$	Schaffer and Haller, 1943
Butter oil	60	$\beta = 0.127$	Schaffer and Haller, 1943
Cottonseed oil	22	$\beta = 0.11$	Vibrans, 1935
Cottonseed oil	40	$\beta = 0.127$	Schaffer and Haller, 1943
Lard	40	$\beta = 0.115$	Schaffer and Haller, 1943
Corn oil	22	$\beta = 0.11$	Vibrans, 1935
n-C <sub>7</sub> F <sub>16</sub>	25	$\beta = 0.548$	Gjaldbaek, 1952
CS <sub>2</sub>	25	$\beta = 0.162$	Gjaldbaek, 1952
Dimethyl formamide	25	$\beta = 0.1$	DuPont, 1955
Hexane	25	mole fraction = 0.00193	Wolfe, 1951
Paraffin oil $MW = 405$ , 30% naphthenic	20	mole fraction = 0.00278	Luther and Hiemenz, 1957
Mixed decyl + dodecyl alcohols	20	mole fraction = 0.00104	Luther and Hiemenz, 1957

SOLUBILITY OF OXYGEN IN VARIOUS SOLVENTS AT 25° AT HIGH PRESSURES  
(Frolich, Tauch, Hogan and Peer, 1931)

The determinations were made by shaking the solvent and oxygen together at various pressures in a 2 liter steel cylinder at 25° and after attainment of equilibrium withdrawing a sample of the saturated solution over mercury in one of three burets, so designed that the volumes could be measured with the same degree of accuracy at any ratio of gas to liquid. The results show that if the gas does not form a chemical compound with the solvent it follows Henry's Law over a wide pressure range within the limits of error allowed in engineering calculations. The solubility may for practical purposes be considered a linear function of the absolute pressure. In the case of the following results for oxygen,  $y$  is the volume of  $O_2$  at 25° and 1 atmosphere per unit volume of liquid, and  $x$  is the absolute pressure in atmospheres.

	Pressure Range in atmospheres	Solubility Equation
Water	0 - 70	$y = 0.028x$
Formic Acid	0 - 70	$y = 0.047x$
Carbon Tetrachloride	0 - 70	$y = 0.031x$
Pentane	0 - 100	$y = 0.576x$
Gas Oil (d. = 0.8319)	0 - 70	$y = 0.154x$

INFLUENCE OF ANESTHETICS UPON THE SOLUBILITY OF OXYGEN IN OLIVE OIL  
(Hamberger, 1911)

Name and Concentration of Narcotic added to the Oil		Solubility of Oxygen in:	
		Pure Solvent	Narcotic Solution
Suifonal	(0.8 per 100)	9.69	4.55
"		9.69	5.68
"		9.69	6.25
Trional	( saturated )	9.10	4.55
"		9.10	5.68
Tetronal	(2 per 100)	9.67	9.10
"		9.67	9.20
Camphor	(10 per 100)	8.53	7.96
Monochlorhydrine	(5 per 100)	9.10	7.50
"	(2.5 per 100)	9.10	7.50
"	(1.25 per 100)	9.10	7.90
Dichlorhydrine	(10 per 100)	9.10	7.96
"	(5 per 100)	9.10	8.00
Phenylurethan	(5 per 100)	8.53	6.25
"	(2.5 per 100)	8.53	7.50

## 0 OXYGEN

### SOLUBILITY OF OXYGEN IN RUBBER (Carpenter, 1947)

The rubber contained 100 parts of smoked sheet rubber by weight, 2.5 parts sulfur, 3.0 parts ZnO, 1.0 parts stearic acid, 0.5 parts each of mercaptobenzthiazole and agrite white. The adsorption was carried out in the dark on a cylindrical piece of the vulcanized product, and diffusion rates were also measured.

t°	Gms. N <sub>2</sub> per cc. Rubber per atm.	cc. N <sub>2</sub> (0°, 760 mm.) per 100 cc. Rubber per atm.
21	-	8.3 (7.3) <sup>a</sup>
25	-	8.5 (7.9) <sup>b</sup>
30	1.21 x 10 <sup>-4</sup>	-
35	1.25 x 10 <sup>-4</sup>	-
40	1.26 x 10 <sup>-4</sup>	-
45	1.29 x 10 <sup>-4</sup>	-

<sup>a</sup>Venable and Fuwa, 1922

<sup>b</sup>Barrer, 1941

### SOLUBILITY OF OXYGEN IN CHLORINE AT 25° (Krievé and Mason, 1956)

pp O <sub>2</sub> atm:	0.785	0.936	1.31	1.49	1.65
mole % O <sub>2</sub> :	5.22	6.67	9.13	10.53	11.99

### SOLUBILITY OF OXYGEN IN LIQUID SULFUR DIOXIDE (Dorné and Ferguson, 1939)

The determinations were made in an apparatus which permitted measurements under static and under circulating conditions. An equation for the variation of absorption with pressure was calculated and from this the following mean values were derived.

t°	cc O <sub>2</sub> (at 0° and 760 mm) dissolved by 1 gm. SO <sub>2</sub> at 1 atmosphere pressure	cc O <sub>2</sub> (at 0° and 760 mm) dissolved by 1 gm. SO <sub>2</sub> at 1 atmosphere pressure
-20	25	10
-10	50	20
0	98	30
		183
		331
		575

## SOLUBILITY OF OXYGEN IN NITRIC ACID MIXTURES

At 25°: Sprague, 1955; at higher temperatures: Robertson, Jr., Mason and Corcoran, 1955. Sprague's values are considerably lower than the others.

(Henry's Law Constants)

At 25°				At Higher Temperatures				
Wt. %			Moles O <sub>2</sub> per liter-atm.	Wt. %			t°	Moles O <sub>2</sub> per liter-atm.
HNO <sub>3</sub>	N <sub>2</sub> O <sub>4</sub>	H <sub>2</sub> O		HNO <sub>3</sub>	N <sub>2</sub> O <sub>4</sub>	H <sub>2</sub> O		
100	0	0	0.00294	100	0	0	37.7	0.00555
93.94	0	6.06	0.00204				54.4	0.00580
90.10	0	9.90	0.00133	85	15	0	37.7	0.00369
85.15	0	14.85	0.000828				54.4	0.00385
80.97	0	19.03	0.000703	94	0	6	37.7	0.00416
69.11	0	30.89	0.000886				54.4	0.00426
92.52	7.48	0	0.00294				71.1	0.00498
88.69	11.31	0	0.00267				87.8	0.00563
85.64	14.36	0	0.00190					
79.99	20.01	0	0.00171					

The solubility of oxygen and other gases in Metals has been extensively studied. A very complete bibliography of this work and of gas solubility is general is given in Landolt and Bornstein "Tabellen", 5th edition, 3rd supplement, first part, 1935.

For data on the solubility of oxygen in Nb see Braver, 1941; in liquid Bi see Griffith and Mallett, 1953; in Pt, Pd, Ni, Fe, Mn, and Si see Himmler, 1950; in Fe containing Al, Si or Mn see Hilty and Crafts, 1950; in  $\alpha$ -Fe, see Seybolt, 1954; in Pb see McMaster, 1952 and also Sano and Minowa, 1953; in Fe + FeO with SiO<sub>2</sub> present, see Derge, 1949.

Liquid - liquid and liquid - vapor equilibria in the system oxygen - ozone are reported by Schumacher, 1953, 1953a; Jenkins and Birdsall, 1954; Jenkins, DiPaolo and Birdsall, 1955; Brown, Berger and Hersh, 1955.

O<sub>3</sub> OZONE

## SOLUBILITY IN WATER

The solubility has been investigated many times, with only approximate agreement among the various results. Rawson (1953) reviews the data up to that time. It seems certain that some dissociation occurs, and that some of the discrepancies have been caused by reducing impurities. Rawson reports the rate of approach to saturation and took considerable care in the determinations; still, he reports finding occasional values that were different from the averages, far beyond the limits of experimental error. All observers agree that ozone obeys Henry's law.

## O<sub>3</sub> OZONE

### SOLUBILITY IN WATER--Cont.

Results are in terms of the Ostwald coefficient, which is the ratio of the concentration of gas in the vapor phase to that in the solvent. Also called the solubility ratio.

- (1) Luther, 1905      (2) Rothmund, 1912      (3) Meddows Taylor, 1947  
 (4) Briner and Perrottet, 1939      (5) Hoather, 1948      (6) Schone, 1873  
 (7) Fischer and Tropsch, 1917

(Rawson, 1955) (von Mailfert, 1894) (Japanese, 1932) (other refs.)

t°	l	t°	l	t°	l	t°	l
9.6	0.39	0	0.641	5	0.44	0	0.44 (1)
14.5	0.29	6	0.562	10	0.38		0.494 (2)
20.3	0.21	11.8	0.500	20	0.29	3	0.49 (3)
25.5	0.17	13	0.482	30	0.20	3.5	0.486 (4)
30.6	0.14	15	0.456	40	0.15	15	0.18? (5)
35.1	0.12	27	0.270	50	0.11	18	0.49 (7)
39.0	0.07	33	0.195	60	0.08	18.2	0.39 (6)
		40	0.112			19.8	0.347 (4)
		47	0.077			20	0.34 (3)
		55	0.031				0.23 (1)
		60	0				

### SOLUBILITY OF OZONE IN VARIOUS SOLVENTS

Solvent	t°	Bunsen Abs. Coef. β	Reference
0.1 N H <sub>2</sub> SO <sub>4</sub>	0	0.460	(Rothmund, 1912; see also Kachtanow and Obstchouk, 1937)
aq. NaCl (35 gm./l.)	3.5	0.24	(Briner and Perrottet, 1939)
	19.8	0.17	(Briner and Perrottet, 1939)
Acetic acid	18.2	2.57	(v. Wartenberg and Podjaski, 1925)
"	30.2	1.74	
"	38.3	1.54	
Acetic anhydride	0	2.08	
Dichloroacetic acid	0	1.65	
Propionic acid	17.3	3.73	(Fischer and Tropsch, 1917)
Propionic anhydride	18.2	2.82	
Carbon tetrachloride	0	3.04	
	15	3.0	

## O<sub>3</sub> OSMIUM TETROXIDE OsO<sub>4</sub>

### SOLUBILITY IN WATER

Average of Squire and Caines, 1905; v. Wartenborg, 1924; Tschugajew and Fritmann, 1928; Anderson and Yost, 1938.

t°	0°	5°	10°	15°	20°	25°
Gms. OsO <sub>4</sub> per 100 gms. sat. sol.:	5.00	5.20	5.44	5.70	6.04	6.56

DISTRIBUTION OF OsO<sub>4</sub> BETWEEN CCl<sub>4</sub> AND WATER AT 25°  
(Anderson and Yost, 1938)

Moles OsO <sub>4</sub> per mole of		$\frac{C}{W}$	Moles OsO <sub>4</sub> per mole of		$\frac{C}{W}$
H <sub>2</sub> O layer (W)	CCl <sub>4</sub> layer (C)		H <sub>2</sub> O layer (W)	CCl <sub>4</sub> layer (C)	
0.0001464	0.01204	82.2	0.00189	0.1563	82.7
0.00405	0.0320	79.0	0.00196	0.175	89.3
0.000582	0.0424	72.9	0.00234	0.22	94.0
0.000614	0.0424	81.2	0.002715	0.2564	94.5
0.000653	0.0530	81.2	0.00381	0.426	112.0
0.000715	0.0582	81.4	0.00423	0.520	123.0
0.00135	0.109	80.7	0.00459	0.6065	132.2
0.00137	0.117	85.4	0.00470	0.598	127.3
			0.00507	0.693	136.5

100 gms. CCl<sub>4</sub> dissolve  $375 \pm 17$  gms. OsO<sub>4</sub> at 25°. (Anderson and Yost, 1938.)

At 24.85°, the Ostwald coefficient of solubility  $\ell = 1100$  in nitromethane. (Friedman, 1954.)

PHOSPHORUS (WHITE) P<sub>4</sub>

P

SOLUBILITY IN VARIOUS ORGANIC SOLVENTS

(1) Groot and Hildebrand, 1948      (2) Christomanos, 1905

t°	Gms. P per 100 gms. Solvent	t°	Gms. P per 100 gms. Solvent	t°	Gms. P per 100 gms. Solvent
<u>Results in n-Heptane (1)</u>					
0	0.86*	33	1.94	71	3.72
25	1.49*	40.4	2.23	78	3.83
32.9	1.89*	42	2.26	84	4.50
40	2.16*	46	2.40	100	5.66
41	2.21*	50	2.62	131	7.58
42	2.23*	63	3.27		

Results in Carbon Tetrachloride (1)

0	0.64*	25	1.32	59	2.56
25	1.27*	42	1.89	72	3.16
32.9	1.58*	45	1.96	91	4.10
40	1.82*	48	2.09	94	4.23
41	1.94*	51	2.19	100	4.55
42	1.89*	52	2.28		

Results in Acetone (Approximate) (1)

0	0.05*	25	0.14*	40	0.22*
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\*In equilibrium with solid phosphorus. All other data are for liquid phosphorus.

(Cont.)



# P PHOSPHORUS

## SOLUBILITY IN VARIOUS ORGANIC SOLVENTS--Cont.

t°	Gms. P per 100 gms. Solvent	t°	Gms. P per 100 gms. Solvent	t°	Gms. P per 100 gms. Solvent
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### Results in Benzene (Christomanos, 1905)

(Specific gravities in parentheses)

0	1.513		23	3.399 (0.8875)	50	10.03
5	1.99		25	3.70 (0.8861)	55	7.32
8	2.31 (0.8990)		30	4.60	60	7.90
10	2.4 (0.8985)		35	5.17	65	8.40
15	2.7 (0.894)		40	5.75	70	8.90
18	3.1 (0.892)		45	6.11	75	9.40
20	3.2 (0.890)				81	10.03

### Results in Ethyl Ether (Christomanos, 1905)

(Specific gravities in parentheses)

0	0.434		15	0.90 (0.723)	28	1.60
5	0.62		18	1.01 (0.719)	30	1.75
8	0.79 (0.732)		20	1.04 (0.718)	33	1.80
10	0.85 (0.729)		23	1.12 (0.722)	35	2.00
			25	1.39 (0.728)		

### Results of Hildebrand and Büchner, 1920

p Dibrom Benzene		Ethylene Bromide		Naphthalene		Phenanthrene	
t°	Mol. % P <sub>4</sub>	t°	Mol. % P <sub>4</sub>	t°	Mol. % P <sub>4</sub>	t°	Mol. % P <sub>4</sub>
154.3	41	169.6	41	132.8	26	199.2	55
159.4	49	165.0	44	201.4	49	199.5	57
162.0	54	163.0	47	195.5	56	199.1	73
163.0	61	165.5	56	202.7	60	198.0	80
159.0	70	162.2	63	201.6	74	200*	
163*		151.7	81	200.2	75		
		165*		190.4	80		
*Critical temperature				202*			

The critical temperatures of solutions given above were obtained by plotting the preceding results and reading from the curve. Single determinations in decane and chlorobenzene gave as critical temperatures, >390° and 264° respectively.

## SOLUBILITY OF PHOSPHORUS IN CARBON DISULFIDE

### Results of Hildebrand and Buchner, 1920

t°	Mol. % P <sub>4</sub>
-7.8	6
-6.7	34
-5.9	43
-6.4	50
-6.4	59
-6.6	74
-6.5 critical temperature	(Cont.)

## SOLUBILITY OF PHOSPHORUS IN CARBON DISULFIDE--Cont.

Results of Cohn and Inouye, 1910

t°	Gms. P per 100 Gms. Sat. Sol.
-10	31.40
- 7.5	35.85
- 5	41.95
- 3.5	66.14
- 3.2	71.72
- 2.5	75.0
0	81.27
+ 5	86.3
10	89.8

## SOLUBILITY OF YELLOW PHOSPHORUS IN SEVERAL SOLVENTS

Solvent	t°	Gms. P per 100 Gms. Solution	
Almond Oil	15	1.25	} Stich, 1903
Oleic Acid	15	1.06	
Paraffin	15	1.45	
Water	15	0.0003	
Acetic Acid (96%)	15	0.105	
Ethanol (d. = 0.799)	cold	0.312	} Buchner
	hot	0.416	
Glycerol (d <sub>15</sub> = 1.256)	15-16	0.25	Ossendowski, 1907

Data for the solubility of phosphorus in several slightly polar solvents is given by Negisi, 1940.

RED PHOSPHORUS is completely insoluble in turpentine even up to 270° provided the determination is made without access of air (sealed tube). If air is not excluded a portion of the red phosphorus may be converted to yellow phosphorus which would dissolve. (Colson, 1907.)

RECIPROCAL SOLUBILITY OF PHOSPHORUS AND SULFUR, DETERMINED BY THE  
SYNTHETIC (SEALED TUBE) METHOD  
(Giran, 1906)

(Mixtures of P and S were sealed in small tubes and first heated to about 200° to cause combination. They were then cooled to the solidification point and gradually heated to the temperature at which the last crystal disappeared. The following results, which were read from the diagram, show the eutectics and maxima of the curves.)

Eutectics			Maxima of Curves		
t°	Mole. % S in Mixture	Solid Phase	t°	Mole. % S in Mixture	Solid Phase
-40	33.5	P <sub>4</sub> S <sub>3</sub> + P <sub>2</sub>	+167	43.6	P <sub>4</sub> S <sub>2</sub>
+46	50	P <sub>4</sub> S <sub>2</sub> + P <sub>2</sub> S <sub>3</sub>	296	60.8	P <sub>2</sub> S <sub>3</sub>
230	67.5	P <sub>2</sub> S <sub>3</sub> + P <sub>2</sub> S <sub>6</sub>	272	72.1	P <sub>2</sub> S <sub>5</sub>
243	75	P <sub>2</sub> S <sub>5</sub> + PS <sub>6</sub>	314	86.1	PS <sub>6</sub>

## P PHOSPHORUS

Additional data for the system P + S are given by Boulouch (1902 and 1906) and by Helff, 1893.

Fusion-point data for mixtures of phosphorus and selenium are given by Robinson and Scott, 1933. Results for mixtures of phosphorus and thallium are given by Mansuri, 1927. For phosphorus and antimony by Vogel and Horstman, 1952.

### Br PHOSPHORUS TRIBROMIDE $PBr_3$

Melting points are given for:

P + Br	(Pushin and Makuc, 1950)
$PBr_3 + S_2Br_2$	(Pusin and Makuc, 1938)
$PBr_3 + SnBr_4$	(Pusin and Makuc, 1938)
$PBr_3 + SbBr_3$	(Pusin and Makuc, 1938)
$PBr_3 + PSBr_3$	(Van Arkel and Lebbink, 1937)
$PBr_3 + \text{trinitrotoluene}$	(Pushin, et al., 1947)

### Cl PHOSPHORUS TRICHLORIDE $PCl_3$ PENTACHLORIDE $PCl_5$ OXYCHLORIDE $POCl_3$

Melting points are given for:

$PCl_3 + SnCl_4$	(Pusin and Makuc, 1938)
$PCl_3 + \text{benzaldehyde}$	(Faizullin and Trifonov, 1954)
$PCl_3 + POCl_3$	(Groeneveld, van Spronsen and Kouwenhoven, 1953)
$POCl_3 + TiCl_4$	(Groeneveld, van Spronsen and Kouwenhoven, 1953)
$POCl_3 + SO_2Cl_2$	(Lutschinsky Litchatschewa, 1935)
$POCl_3 + AlCl_3$	(Groeneveld and Zhur, 1957)
$POCl_3 + GaCl_3$	(Greenwood and Wade, 1957)
$POCl_3 + \text{pyridine}$	(Zeffert, Coulter and Macy, 1953)
$POCl_3 + HfCl_4 \text{ in nitrobenzene}$	(Sheka and Voitovich, 1957)
$POCl_3 + ZrCl_4 \text{ in nitrobenzene}$	(Sheka and Voitovich, 1957)
$PCl_5 + \text{acrylonitrile}$	(Fialkov, Kuzmenko and Kostromina, 1955)
$PCl_5 + \text{acrylonitrile} + \text{tetramethyl ammonium chloride}$	(Fialkov, Kuzmenko and Kostromina, 1955)

### H PHOSPHINE $PH_3$

#### SOLUBILITY IN AQUEOUS SOLUTIONS (Weston, Jr., 1954)

Solvent	t°	$\beta$	Solvent	t°	$\beta$
$H_2O$	24.3	0.201	0.275 M NaCl	24.3	0.192
	26.8	0.195	0.550 M NaCl	24.3	0.176
	33.0	0.173	0.825 M NaCl	24.3	0.169
	40.1	0.154	1.100 M NaCl	24.3	0.151
	50.0	0.137	0.2 M $H_2SO_4$	24.3	0.202
1M NaOH	24.3	0.115	2.0 M $H_2SO_4$	24.3	0.183

$\beta = \text{ml } PH_3 (0^\circ, 760 \text{ mm}) \text{ dissolved in } 1 \text{ ml of solvent}$

PHOSPHORUS TRIIODIDE  $PI_3$ 

I

Fusion-point data are given for:



(Jaeger and Doornbosch, 1912)

PHOSPHORUS TRIOXIDE  $P_2O_3$ 

O

SOLUBILITY OF PHOSPHORUS TRIOXIDE IN ORGANIC SOLVENTS  
(Semenchenko and Shakparonov, 1948)

t°	Solvent	Moles $P_2O_3$ per 100 moles Sat. Sol.	t°	Solvent	Moles $P_2O_3$ per 100 moles Sat. Sol.
15	$C_6H_6$	0.067	15	$C_2H_5OH$	0.005
10	$CS_2$	.956	15	Glycerin	.007
15	$(C_2H_5)_2O$	.022			

PHOSPHORIC ACID  $H_3PO_4$ 

THE SYSTEM PHOSPHORIC ACID - ETHER - WATER AT 23°  
(Bachelet, Cheylan, and Le Bris, 1947)

Gms. per 100 gms. Sat. Sol.		Gms. per 100 gms. Sat. Sol.		Gms. per 100 gms. Sat. Sol.	
$H_3PO_4$	$(C_2H_5)_2O$	$H_3PO_4$	$(C_2H_5)_2O$	$H_3PO_4$	$(C_2H_5)_2O$
0.0	98.76	40.10	40	48.30	12.10
16.14	80.72	42.70	34.70	46.75	7.88
26.98	67.40	43.80	29.10	31.30	7.80
30.70	61.40	44	27.50	15.85	7.70
33.68	56	45.60	22.80	3.04	7.50
37.10	46.30	47.70	15.90	0.0	6.53

DISTRIBUTION OF PHOSPHORIC ACID BETWEEN ETHER AND WATER AT 23°  
(Bachelet, Cheylan, and Le Bris, 1947)

Gms. $H_3PO_4$ per 100 gms.		Gms. $H_3PO_4$ per 100 gms.		Gms. $H_3PO_4$ per 100 gms.	
$H_2O$	$(C_2H_5)_2O$	$H_2O$	$(C_2H_5)_2O$	$H_2O$	$(C_2H_5)_2O$
34.8	0.01	88.3	0.50	136.5	1.78
55.5	.076	105	.95	130.8	1.41
82	.26	116	1.17		

100 gms. phosphorus trioxide ( $P_2O_3$ ) dissolve 1.7 gm. P at 25°.  
(Miller, 1928.)

## P PHOSPHORUS

### PHOSPHOMOLYBDIC ACID $\text{H}_3\text{PO}_4 \cdot 12\text{MoO}_3 \cdot n\text{H}_2\text{O}$

Souchay, 1945 studied the systems phosphomolybdic acid - ether - water and phosphomolybdic acid - sulfuric acid - ether - water at 23.8° and found  $\text{H}_3\text{PO}_4 \cdot 12\text{MoO}_3 \cdot 30\text{H}_2\text{O}$  to be the stable phase in water solution at this temperature. The saturated solution contains 52 wt. %  $\text{H}_3\text{PO}_4 \cdot 12\text{MoO}_3$ . In solutions containing 24 - 33 wt. %  $(\text{C}_2\text{H}_5)_2\text{O}$ ,  $\text{H}_3\text{PO}_4 \cdot 12\text{MoO}_3 \cdot 14\text{H}_2\text{O}$  is the stable phase.

Data for the formula  $\text{P}_2\text{O}_5 \cdot 20\text{MoO}_3 \cdot 5\text{H}_2\text{O}$ :

Solubility in Ether (Parmentier, 1887)

t°	0°	8.1°	19.3°	27.4°	32.9°
Gms. Acid per 100 gms. Ether	80.6	84.7	96.7	103.9	107.9

## S PHOSPHORUS SULFIDES $\text{P}_4\text{S}_3$ , $\text{P}_4\text{S}_7$ , $\text{P}_4\text{S}_{10}$

SOLUBILITY IN CARBON DISULFIDE, BENZENE, AND IN TOLUENE  
(Stock, 1910)

t°	Gms. $\text{P}_4\text{S}_3$ per 100 Gms.			Gms. $\text{P}_4\text{S}_7$ per 100 Gms. $\text{CS}_2$	Gms. $\text{P}_4\text{S}_{10}$ per 100 Gms. $\text{CS}_2$
	$\text{CS}_2$	$\text{C}_6\text{H}_6$	$\text{C}_6\text{H}_5\text{CH}_3$		
- 20	11.1	--	--	--	0.083
0	27	--	--	0.005	0.182
+ 17	100	2.5	3.125	0.0286	0.223
80	--	11.1	--	--	--
110	--	--	15.4	--	--

Melting points for the system P + S are given by Illarionov and Sokolova, 1952.

### PHOSPHORUS SELENIDE $\text{P}_4\text{Se}_3$

100 cc. carbon disulfide dissolve 7.1 gm.  $\text{P}_4\text{Se}_3$  at about 20°. (Mai, 1928.)

## PROTOACTINIUM HALIDES and NITRATE

The extraction of Pa from HBr and HCl solutions by diisobutyl ketone and diisopropyl ketone and of the nitrate by americium acetate was studied by Goble, Golden and Maddock, 1956.

## PROTOACTINIUM HYDROXIDE

The solubility of the hydroxide in aqueous  $\text{HNO}_3$ ,  $\text{HCl}$ ,  $\text{H}_2\text{SO}_4$ ,  $\text{HClO}_4$  and  $\text{HF}$  is reported by Thompson, 1952.

## LEAD

Pb

## SOLUBILITY IN WATER AND AQUEOUS SOLUTIONS

Pariaud and Archinard, 1952 used electrolytically pure metals which had been degassed and freed of fines. The water was distilled 3 times, neutral and degassed. They report an equilibrium solubility of 310  $\gamma$  per liter at  $24^\circ$ .

An extensive investigation of the solubility of lead in the water passing through lead pipes is described by Paul, Ohlmuller, Heise and Auerbach, 1906. The solubility is increased by oxygen,  $\text{CO}_2$ , sulfates and perhaps other salts; it is decreased by hydrocarbonates.

Other experiments upon this subject are described by Zink, 1933. Lead of 98.24 percent purity was subjected to the action water free from and containing  $\text{CO}_2$  and various salts for periods of 24 hours. The bearing of these results upon the use of lead pipes as conductors for water supplies is discussed. Since the constituents of water passing through lead pipes form compounds which coat the interior of the pipes, the author gives the following values for the solubility of some of these products.

Compound		Mgs. Pb dissolved per liter	
Lead Oxide	$\text{PbO}$	63.8	
Lead Hydroxide	$3\text{PbO} \cdot \text{H}_2\text{O}$	93.3	
Lead Carbonate	(observed)	1.75	
Lead Carbonate	(calculated)	0.04	
$\frac{1}{2}$ basic "	(observed)	1.3	
$\text{PbO} \cdot 2\text{PbCO}_3 \cdot \text{H}_2\text{O}$	(calculated)	less than	0.04
Lead Sulfate	$\text{PbSO}_4$	26.0	
$\frac{1}{2}$ basic "	$\text{PbO} \cdot \text{PbSO}_4$	10.6	
$\frac{1}{4}$ " "	$3\text{PbO} \cdot \text{PbSO}_4 \cdot \text{H}_2\text{O}$	22.0	
Lead Chloride	$\text{PbCl}_2$	696.0	
$\frac{1}{2}$ basic "	$\text{PbO} \cdot \text{PbCl}_2 \cdot \text{H}_2\text{O}$	79.0	
$\frac{1}{4}$ " "	$3\text{PbO} \cdot \text{PbCl}_2 \cdot \text{H}_2\text{O}$	21.0	
Lead Nitrate	$\text{Pb}(\text{NO}_3)_2$	516.0	

The solubilities of various porcelain glazes containing lead in vinegar and citric acid solutions with varying conditions of exposure was determined by Geller and Creamer, 1939.

Studies on the corrosion of lead by sulfuric and nitrosylsulfuric acids were made by Adaduroff and Bauman, 1935.

# Pb LEAD

## SOLUBILITY OF LEAD IN MERCURY (Thompson, 1935)

A special apparatus and technique was necessary to avoid the oxidation which rapidly occurs in lead amalgams.

t°	Gm. Atom % Pb in sat. sol.	t°	Gm. Atom % Pb in sat. sol.
20	1.476	50	2.742
30	1.780	60	3.419
40	2.199	70	4.330

## SOLUBILITY OF LEAD IN LIQUID AMMONIA - SODIUM SOLUTIONS AT -33° (F. H. Smith, 1917)

Gm. Atoms Na per Liter of Liquid Ammonia	Gm. Atoms Pb Dissolved per Gm. Atom Na	Gm. Atoms Na per Liter of Liquid Ammonia	Gm. Atoms Pb Dissolved per Gm. Atom Na
0.078	1.95	0.13	2.17
0.093	2.20	0.14	2.12
0.094	2.03	0.33	1.83
0.110	2.24	0.34	1.73
0.12	1.78		

Results are given for the following systems:

Pb + PbCl <sub>2</sub>	(Urazov and Karnaukhov, 1954)(Karpachev, Stromberg and Jordan, 1942; 700°)(Corbett and Von Winbush, 1955; 600-800°)
Pb + PbS	(Esin and Sryvalin, 1951)
Pb + PbO	(Gebhardt and Obrowski, 1954)
Pb + SnCl <sub>2</sub> = Sn + PbCl <sub>2</sub> at 600°	(Körber and Oelson, 1932)
at 550°	(Jander and Striebich, 1937)
at 500°, 600°	(Lorenz and Schulz, 1928b)
Pb + SnBr <sub>2</sub> = Sn + PbBr <sub>2</sub> at 400°	(Lorenz and Schulz, 1928a)
Pb + 2TlCl = 2Tl + PbCl <sub>2</sub> at 500°	(Lorenz and Schmitt, 1930)
Pb + ZnCl <sub>2</sub> = Zn + PbCl <sub>2</sub> at 580°	(Jellinek and Siewers, 1932)
	(Urazov and Sokolova, 1944)
2Pb + Ag <sub>4</sub> P <sub>2</sub> O <sub>7</sub> = Ag + Pb <sub>2</sub> P <sub>2</sub> O <sub>7</sub> at 1200°	(Jellinek and Siewers, 1932)
Pb + SnS = Sn + PbS at 910°	(Anderson and Ridge, 1932)(Vogel and Zastera, 1950)
Pb + 2AgCl = PbCl <sub>2</sub> + 2Ag	(Urazov and Karnaukhov, 1956)

## LEAD ARSENITE Pb<sub>3</sub>(AsO<sub>3</sub>)<sub>2</sub>

AsO

## THE SYSTEM PbO - As<sub>2</sub>O<sub>3</sub> - H<sub>2</sub>O AT 25° (Story and Anderson, 1924)

Data are given for the composition (As<sub>2</sub>O<sub>3</sub> : PbO mole ratio) of the solid phase in equilibrium with various concentrations of As<sub>2</sub>O<sub>3</sub> in solution, but the PbO concentration in the liquid is not reported.

Gms. As <sub>2</sub> O <sub>3</sub> per 100 ml. solution:	< 0.05	Solid Phase:	Pb(OH) <sub>2</sub>
	0.05 - 2.20		Pb(AsO <sub>2</sub> ) <sub>2</sub>
	> 2.20		As <sub>2</sub> O <sub>3</sub>

The solubility of lead arsenite in dilute  $\text{HNO}_3$ ,  $\text{H}_2\text{SO}_4$  and  $\text{HCl}$  solutions (pH 2 - 3) at  $20^\circ$  is reported by Chukhlantsev, 1957.

LEAD ARSENATE  $\text{PbHAsO}_4$ 

AsO

THE SYSTEM LEAD OXIDE - ARSENIC PENTOXIDE - WATER AT  $25^\circ$ 

(Acid Region)

(Tartar, Rice and Sweo, 1931)

The results show that the lead arsenates are very insoluble. Qualitative tests of the liquid phase for the precipitation of lead as sulfate, chromate and sulfide gave negative results. It is suggested that precipitation as dilead arsenate can be used as a quantitative method for the determination of lead.

d. of sat. sol.	Gms. $\text{As}_2\text{O}_5$ per 100 gms. sat. sol.	Solid Phase	d. of sat. sol.	Gms. $\text{As}_2\text{O}_5$ per 100 gms. sat. sol.	Solid Phase
1.031	2.10	$\text{PbHAsO}_4$	1.732	54.56	$\text{PbHAsO}_4$
1.113	13.40	"	1.894	61.35	" + $\text{Pb}(\text{H}_2\text{AsO}_4)_2$
1.219	23.50	"	2.032	65.90	$\text{Pb}(\text{H}_2\text{AsO}_4)_2$
1.476	42.61	"	2.201	70.70	"
1.232	54.56	"	-	71.4	" + $\text{H}_3\text{AsO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$

Two gm. portions of amorphous dilead arsenate were agitated at  $32^\circ$  with 90 to 180 cc. portions of 0.0338 normal aqueous ammonia for two days. The saturated solutions were found to contain only traces of lead but amounts of  $\text{As}_2\text{O}_5$  varying from 1.956 to 1.429 gms. per liter. (McDonnell and Smith, 1916.)

Chukhlantsev, 1956 gives the Ksp of lead arsenate, as determined in dilute  $\text{HNO}_3$ ,  $\text{H}_2\text{SO}_4$  and  $\text{HCl}$  at  $20^\circ$ , as  $4 \times 10^{-36}$ .

The solubility of  $\text{PbHAsO}_4$  in water was estimated to be 2.55 mg./l. by polarographic reduction of Pb at the cathode, and 1.3 mg./l. by reduction of As at the cathode. However, the sample used probably contained  $\text{PbH}_4(\text{AsO}_4)_2$ .

SOLUBILITY OF COMMERCIAL LEAD ARSENATE IN AQUEOUS SOLUTIONS OF SALTS  
(Stewart, 1922)

The sample of commercial lead arsenate was guaranteed to contain not less than 25 per cent of arsenic and not more than  $1\frac{1}{2}$  per cent water soluble arsenic. The aqueous solutions containing an excess of the lead arsenate were shaken two or more times daily for three weeks or more at room temperature. One liter of each sat. solution was treated with 10 cc. of  $\text{HNO}_3$  + 10 cc. of  $\text{H}_2\text{SO}_4$  and evaporated to appearance of white fumes. The arsenic in the residue was determined by the modified Williamson method. Two concentrations of salt solutions were used, namely 0.01447 normal and 0.0723 normal. The solubility of the lead arsenate in distilled water was found to be 3.0 parts arsenic per million. In tap-water containing 212 parts of solids per million (mostly Ca and Mg bicarbonates) it was 33.8 parts arsenic per million.



## Pb LEAD

Each result in the tables represents an average of 2 to 10 determinations. Data are also given for the solubility of lead arsenate in soil solutions.

### RESULTS FOR THE SOLUBILITY OF LEAD ARSENATE IN 0.01447 NORMAL SALT SOLUTIONS

Salt of	Parts Arsenic dissolved per million parts of aqueous solution of						Secondary Phosphate	Primary Phosphate
	Carbonate	Chloride	Nitrate	Bicarbonate	Sulfate	Bisulfate		
K	165.2	39.3	4.5	139.9	4.6	241.9	174.2	29.1
Na	184.8	31.7	5.3	136.4	5.9	260.9	168.9	11.8
NH <sub>4</sub>	175.6	37.0	3.4	136.4	3.5	271.5	177.6	18.7
Ca	73.4	54.7	2.0	-	5.6	296.3	73.9	36.6
Mg	4.1	36.6	3.5	37.4	4.5	268.5	93.5	21.0

### Results for the solubility in 0.0723 normal salt solutions

Salt of	Parts Arsenic dissolved per million parts of aqueous solution of						Secondary Phosphate	Primary Phosphate
	Carbonate	Chloride	Nitrate	Bicarbonate	Sulfate	Bisulfate		
K	115.9	156.0	8.1	99.8	5.8	647.2	292.9	78.0
Na	131.8	130.5	13.5	96.7	5.7	1016.9	357.0	84.6
NH <sub>4</sub>	119.2	-	5.4	162.5	-	838.3	392.1	63.0
Ca	36.5	105.4	4.3	13.5	4.2	615.2	57.7	67.5
Mg	20.1	101.2	3.5	85.4	2.6	572.3	46.1	38.0

The solubility of commercial lead hydrogen arsenate, containing 64.2% PbO and 32.54% As<sub>2</sub>O<sub>3</sub>, in aqueous solutions of acids and salts and their combinations was studied by Robinson, 1929, for the purpose of finding the best solvent for use in removing arsenical spray residues from fruit under commercial conditions. It was found that acids dissolve the maximum amount of arsenate in 5 minutes with no increase up to 30 minutes. Most of the dilute salt solutions dissolved only a trace of the arsenical. When 0.25 percent Na<sub>2</sub>SO<sub>4</sub> was combined with 0.1 percent HCl the solubility was increased to more than 5 times that for HCl alone. This combination was found to be the most effective.

The solubility of PbHAsO<sub>4</sub> in various body fluids was determined by Fairhall, 1939.

## 80 LEAD BORATE Pb(BO<sub>2</sub>)<sub>2</sub>·H<sub>2</sub>O

100 cc. anhydrous hydrazine dissolve about 2 gms. Pb(BO<sub>2</sub>)<sub>2</sub> at room temperature. (Welsh and Broderson, 1915.)

## 8r LEAD SUB BROMIDE PbBr

1000 cc. sat. solution of lead subbromide in water contain 0.4 milliequivalents PbBr at 25°, as determined by the conductivity method. (Denham, 1918.)

LEAD BROMIDE  $\text{PbBr}_2$ 

Br

## SOLUBILITY IN WATER

(Lichty, 1903)

t°	Density of Solutions, H <sub>2</sub> O at 0°	Gms. $\text{PbBr}_2$ per 100		Milligram Mols. $\text{PbBr}_2$ per 100	
		cc. Solution	Gms. H <sub>2</sub> O	cc. Solution	Gms. H <sub>2</sub> O
0	1.0043	0.4554	0.4554	1.242	1.242
15	1.0053	0.7285	0.7305	1.987	1.989
25	1.0061	0.9701	0.9744	2.646	2.655
35	1.0060	1.3124	1.3220	3.577	3.603
45	1.0059	1.7259	1.7457	4.705	4.760
55	1.0046	2.1024	2.1376	5.731	5.827
65	1.0028	2.516	2.574	6.859	7.016
80	1.0000	3.235	3.343	8.819	9.113
95	0.9995	4.1767	4.3613	11.386	11.890
100	--	4.550	4.751	12.40	12.94

SOLUBILITY OF LEAD BROMIDE IN WATER AT TEMPERATURES ABOVE 100°  
(Benrath, Gjedebo, Schiffers and Wunderlich, 1937)

t°	Gms. $\text{PbBr}_2$ per 100 gms. sat. sol.	t°	Gms. $\text{PbBr}_2$ per 100 gms. sat. sol.
143	7.3	285	33.5
181	12.0	302	46.7
217	17.1	302	57.5
245	22.4	302	71.0
26.7	28.2	307	86.6

Between 39 and 80 percent  $\text{PbBr}_2$  two liquid layers are formed at 302°.

SOLUBILITY OF LEAD BROMIDE IN AQUEOUS SOLUTIONS OF  
HYDROBROMIC ACID AT 25°  
(v. Hevey and Wagner, 1930)

d. of sat. sol.	Normality of aq. HBr solution	Gms. $\text{PbBr}_2$ per 100 cc sat. sol.
1.005	0.0	0.9711
1.0074	0.014	0.946
1.056	1.065	0.390
1.099	1.721	0.980
1.443	4.200	24.540

At 10°, 100 grams H<sub>2</sub>O containing 72.0 grams HBr dissolve 55.0 grams  $\text{PbBr}_2$  per 100 gms. solvent, and solution has Sp. Gr. 2.06.  
(Ditte, 1891.)

Pb LEAD

THE SYSTEM LEAD BROMIDE - POTASSIUM BROMIDE - WATER AT 25°  
(Burrage, 1926)

For additional data see tables following.

	Gms. per 1000 gms. sat. sol.		Solid Phase	Gms. per 1000 gms. sat. sol.		Solid Phase
	KBr	PbBr <sub>2</sub>		KBr	PbBr <sub>2</sub>	
Br	0.0	9.69	PbBr <sub>2</sub>	190.5	6.66	KBr·PbBr <sub>2</sub>
	0.56	9.46	"	206.4	7.53	"
	1.31	8.75	"	216.1	8.68	"
	4.23	7.82	"	256.9	14.94	"
	13.25	3.47	"	301.1	31.60	" + KBr·PbBr <sub>2</sub> · $\frac{1}{3}$ H <sub>2</sub> O
	22.92	2.56	"	319.7	36.22	KBr·PbBr <sub>2</sub> · $\frac{1}{3}$ H <sub>2</sub> O
	49.67	3.10	" + KBr·2PbBr <sub>2</sub>	338.0	42.48	"
	56.09	2.92	KBr·2PbBr <sub>2</sub>	356.8	50.38	"
	129.4	3.30	"	388.7	72.05	" + KBr
	131.8	3.45	"	393.2	49.29	KBr
	145.4	4.27	"	402.8	18.35	"
	182.7	5.60	"	405.2	0.0	"

SOLUBILITY OF LEAD BROMIDE IN AQUEOUS SOLUTIONS OF SALTS AT 25°  
(Herz and Hellebrandt, 1923)

Aq. salt solution	Gm. mol. PbBr <sub>2</sub> per liter sat. sol.	Aq. salt solution	Gm. mol. PbBr <sub>2</sub> per liter sat. sol.	Aq. salt solution	Gm. mol. PbBr <sub>2</sub> per liter sat. sol.
H <sub>2</sub> O alone	0.02625	0.73n NaBr	0.00860	2.95n $\frac{CaCl_2}{2}$	0.01357
0.48n KCl	0.00556	1.47 "	0.02247	3.93 "	0.02355
0.97 "	0.00582	2.20 "	0.07043	0.52n $\frac{CaBr_2}{2}$	0.00677
1.94 "	0.00620	2.93 "	0.1958	1.04 "	0.01205
2.91 "	0.01057	3.67 "	0.3936	2.08 "	0.04380
3.88 "	0.01505	4.40 "	0.7337	3.13 "	0.1175
0.79n KBr	0.00725	0.52n $\frac{BaCl_2}{2}$	0.00574	4.17 "	0.5187
1.58 "	0.00874	1.04 "	0.00765	0.66n $\frac{SrCl_2}{2}$	0.00564
2.16 "	0.02650	2.08 "	0.02388	1.23 "	0.00627
3.23 "	0.08542	0.45n $\frac{BaBr_2}{2}$	0.00607	2.66 "	0.01545
4.28 "	0.17900	0.91 "	0.01091	3.09 "	0.02000
0.47n NaCl	0.00456	1.82 "	0.04443	4.18 "	0.02718
0.95 "	0.00561	2.76 "	0.1604	0.52n $\frac{SrBr_2}{2}$	0.00673
1.89 "	0.00844	3.67 "	0.4140	1.04 "	0.01273
2.84 "	0.01466	0.49n $\frac{CaCl_2}{2}$	0.00462	2.08 "	0.04367
3.79 "	0.03053	0.98 "	0.00544	3.12 "	0.1559
4.74 "	0.06144	1.97 "	0.00693	4.16 "	0.5687

<sup>a</sup>also see tables above and below

SOLUBILITY OF LEAD BROMIDE IN AQUEOUS SALT SOLUTIONS AT 25°  
(Randall and Vietti, 1928)

In Aqueous Solutions of:

Lead Nitrate		Barium Nitrate		Cadmium Bromide		Potassium Nitrate	
Gm. Mols. per 1000 gms. H <sub>2</sub> O		Gm. Mols. per 1000 gms. H <sub>2</sub> O		Gm. Mols. per 1000 gms. H <sub>2</sub> O		Gm. Mols. per 1000 gms. H <sub>2</sub> O	
Pb(NO <sub>3</sub> ) <sub>2</sub>	PbBr <sub>2</sub>	Ba(NO <sub>3</sub> ) <sub>2</sub>	PbBr <sub>2</sub>	CdBr <sub>2</sub>	PbBr <sub>2</sub>	KBr	PbBr <sub>2</sub>
0.002	0.02664	0.000	0.02680	0.0010	0.02637	0.001	0.02645
0.005	0.02644	0.002	0.02735	0.0020	0.02591	0.002	0.02611
0.010	0.02622	0.005	0.02808	0.0050	0.02466	0.005	0.02500
0.050	0.02663	0.010	0.02883	0.0100	0.02307	0.010	0.02345
0.100	0.02954	0.020	0.03034	0.0500	0.01450	0.050	0.01380
0.200	0.03544	0.050	0.03370	0.1000	0.01117	0.100	0.00859
0.500	0.05342	0.100	0.03780	0.2000	0.00939	0.200	0.00694
0.952	0.07754	0.200	0.04385	0.5000	0.01072	0.389	0.00700**
1.655	0.1268	0.3513	0.05008	1.000	0.01597	0.804	0.00740**
1.964	0.1346*	0.4116	0.05337*	4.182	0.06508*	1.200	0.01137**

\*These solutions simultaneously saturated with both salts.

\*\*Solid phase 2PbBr<sub>2</sub>·KBr.

(For potassium nitrate, see also two preceding tables.)

Data for the solubility of mixed crystals of lead bromide and lead chloride in water are given by Meyer, 1922, 1926.

SOLUBILITY OF LEAD BROMIDE IN PYRIDINE  
(Heise, 1912)

t°	Gms. PbBr <sub>2</sub> per 100	Solid Phase	t°	Gms. PbBr <sub>2</sub> per 100	Solid Phase
	Gms. Pyridine			Gms. Pyridine	
-26	1.02	PbBr <sub>2</sub> ·3C <sub>5</sub> H <sub>5</sub> N	45	0.661	PbBr <sub>2</sub> ·2C <sub>5</sub> H <sub>5</sub> N
-10	0.89	"	64	0.800	"
- 5	0.84	"	77	0.969	"
0	0.80	"	95	1.33	"
+13	0.661	"	100	1.44	"
19*	-	" + PbBr <sub>2</sub> ·2C <sub>5</sub> H <sub>5</sub> N	105	1.56	"
26	0.583	PbBr <sub>2</sub> ·2C <sub>5</sub> H <sub>5</sub> N			

\*transfer point

100 gms. liquid sulfur dioxide (SO<sub>2</sub>) dissolve 0.012 gm. PbBr<sub>2</sub> at 0°. (Jander and Ruppolt, 1937.)

## Pb LEAD

Melting point data are given for the following systems:

$\text{PbBr}_2 + \text{PbI}_2$	(Delgery, 1946; Monkemeyer, 1906)
$\text{PbBr}_2 + \text{PbCl}_2$	(Delgery, 1946; Favorskii, 1940; Monkemeyer, 1906; Calingaert, Lamb, and Meyer, 1949)
$\text{PbBr}_2 + \text{AgBr}$	(Tubaudt and Eggert, 1920)
$\text{PbBr}_2 + \text{PbF}_2$	(Sandonnini, 1911)
$\text{PbBr}_2 + \text{PbO}$	(Sandonnini, 1914; Baroni, 1934; Knowles, 1950, 1951; Lamb and Niebylski, 1953)
$\text{PbBr}_2 + \text{CdCl}_2 \rightleftharpoons \text{PbCl}_2 + \text{CdBr}_2$	(Il'yasov, Rozhkovskaya and Bergman, 1957)

## Br BASIC LEAD BROMIDES

The  $K_{sp}$  of  $\text{PbBr}_2 \cdot \text{Pb}(\text{OH})_2$  is  $2 \times 10^{-15}$ , of  $\text{PbBr}_2 \cdot 3\text{Pb}(\text{OH})_2$  is about  $10^{-17}$  at room temperature. (Charreton, 1951.)

LEAD DICYCLOHEXYL DIBROMIDE  $(\text{C}_6\text{H}_{11})_2\text{PbBr}_2$

LEAD DICYCLOHEXYL DICHLORIDE  $(\text{C}_6\text{H}_{11})_2\text{PbCl}_2$

SOLUBILITY OF EACH IN SEVERAL SOLVENTS AT 22.5°  
(Grüttner, 1914)

Solvent	Grams per 100 Grams Solvent	
	$(\text{C}_6\text{H}_{11})_2\text{PbBr}_2$	$(\text{C}_6\text{H}_{11})_2\text{PbCl}_2$
Benzene	0.014	0.016
Carbon Tetrachloride	0.004	0.004
Chloroform	0.078	0.083
Alcohol + Pyridine (1:1)	2.560	2.904

Similar results are also given for lead tetracyclohexyl,  $\text{Pb}(\text{C}_6\text{H}_{11})_4$ , lead tetraphenyl,  $\text{Pb}(\text{C}_6\text{H}_5)_4$ , and lead diphenyldicyclohexyl,  $\text{Pb}(\text{C}_6\text{H}_5)_2(\text{C}_6\text{H}_{11})_2$ .

Solvent	Grams per 100 Grams Solvent		
	$\text{Pb}(\text{C}_6\text{H}_{11})_4$	$\text{Pb}(\text{C}_6\text{H}_5)_4$	$\text{Pb}(\text{C}_6\text{H}_5)_2(\text{C}_6\text{H}_{11})_2$
Alcohol	0.010	0.020	0.324
Benzene	1.068	1.145	2.298
Carbon Tetrachloride	0.244	0.303	0.845
Ethyl Acetate	0.030	0.123	0.231

LEAD BROMATE  $\text{Pb}(\text{BrO}_3)_2$ 

BrO

SOLUBILITY OF LEAD BROMATE IN AQUEOUS SALT SOLUTIONS AT 25°  
(MacDougall and Hoffman, 1936)

## Results for Aqueous Solutions of:

Potassium Nitrate			Sodium Nitrate		
d. of sat. sol.	Gm. Mols. per liter		d. of sat. sol.	Gm. Mols. per liter	
	sat.	sol.		sat.	sol.
	$\text{KNO}_3$	$\text{Pb}(\text{BrO}_3)_2$		$\text{NaNO}_3$	$\text{Pb}(\text{BrO}_3)_2$
1.0112	0.0	0.03437	1.0141	0.04833	0.03884
1.0156	0.04883	0.03924	1.0184	0.1013	0.04317
1.0181	0.09934	0.04378	1.0266	0.1991	0.04984
1.0286	0.1956	0.05104	1.0424	0.3938	0.06144
1.0456	0.3901	0.06396	1.0564	0.5874	0.07112
1.0608	0.5784	0.07577	1.0837	0.9655	0.08898
1.0906	0.9339	0.09818	1.1460	1.8655	0.1294
1.1327	1.4419	0.1293	1.2010	2.6860	0.1651
1.1833	2.0352	0.1685	1.3378	4.8546	0.2536
1.2220	2.6423	0.1732	1.4824	7.1770	0.3416

Lithium Nitrate			Strontium Nitrate		
d. of sat. sol.	Gm. Mols. per liter		d. of sat. sol.	Gm. Mols. per liter	
	sat.	sol.		sat.	sol.
	$\text{LiNO}_3$	$\text{Pb}(\text{BrO}_3)_2$		$\text{Sr}(\text{NO}_3)_2$	$\text{Pb}(\text{BrO}_3)_2$
1.0135	0.04925	0.03849	1.0117	0.00557	0.03581
1.0158	0.09873	0.04224	1.0129	0.01031	0.03702
1.0244	0.2049	0.04874	1.0144	0.01958	0.03893
1.0348	0.3633	0.04800	1.0226	0.05020	0.04455
1.0446	0.5815	0.06517	1.0332	0.09944	0.05180
1.0649	0.9644	0.07867	1.0548	0.1975	0.06339
1.0880	1.4258	0.09337	1.0933	0.3903	0.08177
1.1302	2.3032	0.1190	1.1301	0.5804	0.09739
1.1887	3.5192	0.1534	1.1971	0.9446	0.1249
1.2562	4.9703	0.1930	1.3438	1.7789	0.1765
			1.5261	2.8704	0.2228

Calcium Nitrate			Lead Nitrate		
d. of sat. sol.	Gm. Mols. per liter		d. of sat. sol.	Gm. Mols. per liter	
	sat.	sol.		sat.	sol.
	$\text{Ca}(\text{NO}_3)_2$	$\text{Pb}(\text{BrO}_3)_2$		$\text{Pb}(\text{NO}_3)_2$	$\text{Pb}(\text{BrO}_3)_2$
1.0099	0.00627	0.03565	1.0104	0.00495	0.03371
1.0117	0.01116	0.03640	1.0118	0.00992	0.03312
1.0135	0.02156	0.03921	1.0132	0.01990	0.03258
1.0195	0.1215	0.05387	1.0356	0.0994	0.03145
1.0425	0.1975	0.06202	1.0643	0.1978	0.03264
1.0869	0.4920	0.08769	1.1120	0.3882	0.03657
1.1283	0.7784	0.1105	1.1735	0.5804	0.04102
1.2090	1.3805	0.1435	1.2786	0.9470	0.05046
1.3074	2.1719	0.1813	1.3402	1.1663	0.05613
1.4215	3.1950	0.2118	1.4011	1.3807	0.06183

**Pb LEAD**

**CH LEAD FORMATE  $\text{Pb}(\text{HCOO})_2$**

SOLUBILITY OF LEAD FORMATE IN AQUEOUS SOLUTIONS OF BARIUM FORMATE AT 25°  
(Fock, 1897)

Mol. % in Solution		Grams per Liter		Sp. Gr. of Solutions	In Solid Phase Mol. % of	
$\text{Pb}(\text{HCO}_2)_2$	$\text{Ba}(\text{HCO}_2)_2$	$\text{Pb}(\text{HCO}_2)_2$	$\text{Ba}(\text{HCO}_2)_2$		$\text{Pb}(\text{HCO}_2)_2$	$\text{Ba}(\text{HCO}_2)_2$
0	100	-	28.54	1.2204	0	100
0.29	99.71	1.104	28.65	1.2213	1.72	98.28
0.74	99.26	2.803	28.90	1.2251	5.29	94.71
1.24	98.76	5.309	32.24	1.2529	11.94	88.06
2.91	97.09	11.42	29.29	1.2341	24.81	75.19
5.92	94.08	23.11	28.13	1.2355	56.54	43.46
100	0	28.35	-	1.0911	100	0

SOLUBILITY OF LEAD FORMATE IN FORMIC ACID  
(Kendall and Adler, 1921)

t°	Gm. Mol. $\text{Pb}(\text{HCOO})_2$ per 100 gm. mol. sat. sol.	Solid Phase
20	0.21	$\text{Pb}(\text{HCOO})_2$
73.1	0.30	"
109.4	0.42	"
124.5	0.51	"

**LEAD METHIONATE  $\text{PbCH}_2\text{O}_6\text{S}_2 \cdot 2\text{H}_2\text{O}$**

100 gms.  $\text{H}_2\text{O}$  dissolve 8.4 gm.  $\text{PbCH}_2\text{O}_6\text{S}_2$  at 25°. (Backer and Terpstra, 1929.)

**LEAD ACETATE (OUS)  $\text{Pb}(\text{CH}_3\text{COO})_2$**

SOLUBILITY OF LEAD ACETATE IN WATER  
(Dundon and Henderson, 1922)

The analysis of the saturated solutions was made by a method of "floating equilibrium". To a known weight of saturated solution of unknown concentration, water was added until the mixture attained the same density as a glass float calibrated at a definite arbitrary temperature. The saturated solutions were prepared by constant stirring in a thermostat and approaching equilibrium from 0.5° to 3.0° above the temperature desired. The solid was  $\text{Pb}(\text{CH}_3\text{COO})_2 \cdot 3\text{H}_2\text{O}$  in all cases.

## SOLUBILITY OF LEAD ACETATE IN WATER -Cont.

t°	d. of sat. sol.	Gms. Pb(CH <sub>3</sub> COO) <sub>2</sub> per 100 gms.		t°	d. of sat. sol.	Gms. Pb(CH <sub>3</sub> COO) <sub>2</sub> per 100 gms.	
		H <sub>2</sub> O	sat. sol.			H <sub>2</sub> O	sat. sol.
0	1.140	19.7	16.5	30	1.41	69.7	41.1
5	-	23.6	19.4	35	1.48	88.9	47.1
10	1.195	29.3	22.8	40	1.60	116.0	53.7
15	1.220	35.6	26.4	45	1.73	153.0	60.7
20	1.260	44.3	30.7	50	1.88	221.0	67.6
25	1.330	55.2	35.6				

THE SYSTEM LEAD OXIDE, ACETIC ACID, WATER AT 25°  
(Sakabe, 1914)

CH

Gms. per 100 Gms. Sat. Sol.			Gms. per 100 Gms. Sat. Sol.		
PbO	CH <sub>3</sub> COOH	Solid Phase	PbO	CH <sub>3</sub> COOH	Solid Phase
4.18	21.53	Pb(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> ·3H <sub>2</sub> O	7.15	7.26	(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> )(HO)Pb + (C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> Pb·2(HO) <sub>2</sub> Pb
3.80	16.78	"	5.20	5.61	(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub> Pb·2(HO) <sub>2</sub> Pb
3.16	13.07	"	3.78	4.17	"
2.64	5.49	"	2.89	2.51	"
3.34	5.36	"	1.45	1.03	"
4.38	7.30	"	1.05	0.54	PbO
5.18	7.92	" + (C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> )(HO)Pb	1.07	0.48	"
5.59	7.72	(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> )(HO)Pb	1.00	0.20	"
6.51	7.79	"			

Equilibrium was attained quickly in the acid solutions but 2-3 days were required in case of the basic salts. Both sat. solutions and solid phases were analyzed.

THE SYSTEM LEAD ACETATE - ACETIC ACID - WATER  
(Tarbuton and Vosburgh, 1932)

From 7 to 14 days were required for attainment of equilibrium depending upon the manner of preparing the solutions. The previous results of Sandved, 1927, are shown to be in error in certain respects.

## Results at 25°

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
CH <sub>3</sub> COOH	Pb(CH <sub>3</sub> COO) <sub>2</sub>	Solid Phase	CH <sub>3</sub> COOH	Pb(CH <sub>3</sub> COO) <sub>2</sub>	Solid Phase
0.00	35.50*	Pb(CH <sub>3</sub> COO) <sub>2</sub> · 3H <sub>2</sub> O	24.13	68.33	Pb(CH <sub>3</sub> COO) <sub>2</sub> · 1/2H <sub>2</sub> O
8.21	35.44	"	25.50	70.54	"
19.14	39.13	"	25.20	71.54	"
26.91	47.11	"			Pb(CH <sub>3</sub> COO) <sub>2</sub> · 1/2CH <sub>3</sub> COOH
26.55	57.38	"	30.94	66.00	"
22.27	67.90	" + Pb(CH <sub>3</sub> COO) <sub>2</sub> · 1/2H <sub>2</sub> O	31.71	65.66	"
		Pb(CH <sub>3</sub> COO) <sub>2</sub> · 1/2H <sub>2</sub> O	40.19	58.29	"
23.25	68.15		41.82	57.06	"
			44.56	54.95	"

\*Jackson, 1914

(Cont.)



## Pb LEAD

## THE SYSTEM LEAD ACETATE - ACETIC ACID - WATER--Cont.

## Results at 30°

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
CH <sub>3</sub> COOH	Pb(CH <sub>3</sub> COO) <sub>2</sub>	Solid Phase	CH <sub>3</sub> COOH	Pb(CH <sub>3</sub> COO) <sub>2</sub>	Solid Phase
9.64	41.61	Pb(CH <sub>3</sub> COO) <sub>2</sub> ·3H <sub>2</sub> O	25.40	69.45	Pb(CH <sub>3</sub> COO) <sub>2</sub> ·H <sub>2</sub> O
17.47	45.81	"	20.49	69.27	"
23.78	55.43	"	24.36	73.50	"
22.45	63.08	"	23.66	72.13	"
23.86	71.08	"	19.92	70.18	"
			23.39	70.45	"

CH

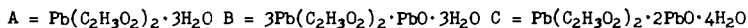
## Results of Osaka and Hara, 1917 at 25°-45°

The saturated solutions were prepared by constant agitation for two days. The lead in the saturated solutions was determined as sulfate.

Normality of Aq. CH <sub>3</sub> COOH	Gms. Pb(CH <sub>3</sub> COO) <sub>2</sub> per 100 gms. sat. sol. at		
	25°	35°	45°
0.025	35.11	46.65	60.61
0.05	34.96	46.56	60.55
0.10	34.72	46.35	69.42

THE SYSTEM LEAD ACETATE - LEAD OXIDE - WATER AT 25°  
(Jackson, 1914)

These results show the solubility of lead acetate in aqueous solutions containing increasing amounts of lead hydroxide. The mixtures were constantly agitated for periods varying from 2 to 7 days. Both the saturated solutions and the solid phases were analyzed. The basic lead in a given sample was determined by measuring the volume of standard acid neutralized by it. The neutral lead acetate was determined by precipitation of the lead as sulfate or as oxalate.

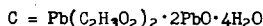


d <sub>25</sub> of 4 Sat. Sol.	Gms. per 100 Gms. Sat. Sol.		Solid Phase	d <sub>25</sub> of 4 Sat. Sol.	Gms. per 100 Gms. Sat. Sol.		Solid Phase
	PbO	Pb(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>			PbO	Pb(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>	
1.326	-0.27*	35.19	A	1.942	16.25	48.85	B
1.334	+0.10	35.60	A	1.956	16.65	49.04	B
1.367	1.01	37.14	A	2.024	18.83	48.71	B
1.422	3.38	38.93	A	2.161	22.23	48.52	B
1.531	6.01	41.95	A	2.193	22.94	48.96	B
1.658	9.47	44.71	A	-	23.28	49.14	B
-	14.22	47.88	A	2.220	23.53	49.01	B
1.852	14.44	47.92	A	2.280	24.74	49.21	B + C
-	15.89	48.95	A + B	2.048	23.59	43.17	C
1.930	15.90	48.42	B	1.951	22.78	40.78	C

\*In this case the acidity is expressed in terms of PbO

(Cont.)

## THE SYSTEM LEAD ACETATE - LEAD OXIDE - WATER AT 25°--Cont.



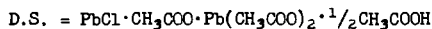
d <sub>25</sub> of 4 Sat. Sol.	Gms. per 100 Gms. Sat. Sol.		Solid Phase	d <sub>25</sub> of 4 Sat. Sol.	Gms. per 100 Gms. Sat. Sol.		Solid Phase
	PbO	Pb(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>			PbO	Pb(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>2</sub>	
1.657	19.63	31.40	C	1.117	7.79	5.25	C
1.599	18.73	29.63	C	-	7.17	4.17	Pb(OH) <sub>2</sub>
1.382	14.62	20.96	C	1.100	6.84	4.31	"
1.348	13.41	19.65	C	1.095	6.54	4.25	"
1.229	10.66	12.99	C	1.085	5.91	3.82	"
1.157	8.47	8.64	C	1.075	5.29	3.40	"
1.119	7.87	5.27	C	-	0.20	0.11	"

CH

Experiments on the formation of basic lead acetates in aqueous ammonium hydroxide and sodium hydroxide solutions are described by Dubrisay and Saint Maxen, 1936. The temperature or method of securing saturation is not stated. The results are given only in the form of a diagram which shows that in each case the amount of lead in solution increases from about 20 to 34 percent as the concentration of alkali increases from 0 to 0.04 gm. mol. percent (?) and then very rapidly decreases as the concentrations of alkali increases to about 0.1 gm. mol. percent.

THE SYSTEM LEAD ACETATE - LEAD CHLORIDE - WATER AT 25°  
(Sandved, 1929)

The mixtures were prepared at 35° and after cooling to 25°, equilibrium was attained in 5 hours. The concentration of free acid in the solutions varied from 1.4 to 1.6 percent. The system is therefore strictly speaking not ternary but "pseudo ternary".



Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
PbCl <sub>2</sub>	Pb(CH <sub>3</sub> COO) <sub>2</sub>		PbCl <sub>2</sub>	Pb(CH <sub>3</sub> COO) <sub>2</sub>	
0.0	35.53	Pb(CH <sub>3</sub> COO) <sub>2</sub> · 3H <sub>2</sub> O	3.32	25.95	D.S.
0.73	35.92	"	4.48	21.25	" + PbCl <sub>2</sub>
1.08	36.40	"	4.00	20.63	PbCl <sub>2</sub>
1.46	37.43	" + D.S.	3.01	13.47	"
2.03	36.44	D.S.	2.07	6.91	"
2.43	30.21	"	1.06	0.0	"

The author also gives similar results for the temperature 35° as well as complete results for the quarternary system Pb(CH<sub>3</sub>COO)<sub>2</sub> + PbCl<sub>2</sub> + CH<sub>3</sub>COOH + H<sub>2</sub>O at 25°.

# Pb LEAD

## SOLUBILITY OF LEAD ACETATE IN AQUEOUS SOLUTIONS OF POTASSIUM ACETATE AT 25° (Fox, 1909)

Gms. per 100 Gms. Sat. Sol.		Solid Phase
CH <sub>3</sub> COOK	(CH <sub>3</sub> COO) <sub>2</sub> Pb	
0	35.9	(CH <sub>3</sub> COO) <sub>2</sub> Pb·3H <sub>2</sub> O
13.87	38.05	"
15.40	36.90	"

## SOLUBILITY OF LEAD ACETATE IN AQUEOUS SOLUTIONS OF ETHYL ALCOHOL AT 25° (Seidell, 1910)

CH

Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. (C <sub>2</sub> H <sub>5</sub> O <sub>2</sub> ) <sub>2</sub> Pb per 100 Gms. Sat. Sol.	Solid Phase
0	1.343	36.5	(C <sub>2</sub> H <sub>5</sub> O <sub>2</sub> ) <sub>2</sub> Pb·3H <sub>2</sub> O
10	1.275	32.3	"
20	1.215	28.6	"
30	1.157	25	"
40	1.105	21.9	"
50	1.055	18.7	"
60	1.002	15.6	"
70	0.955	12.4	"
80	0.907	9.4	"
81	0.905	9	"
85	0.855	4	(C <sub>2</sub> H <sub>5</sub> O <sub>2</sub> ) <sub>2</sub> Pb
90	0.826	1.6	"
95	0.806	0.6	"
100	0.790	0.4	"

100 gms. 95% formic acid dissolve 0.99 (?) gm. Pb(C<sub>2</sub>H<sub>3</sub>O<sub>2</sub>)<sub>2</sub> at 19.8°. (Aschan, 1913.)

100 gms. glycerol dissolve about 20 gms. Pb(C<sub>2</sub>H<sub>3</sub>O<sub>2</sub>)<sub>2</sub> at 15°. (Ossendowski, 1907.)

100 gms. glycerol of d = 1.2326 (= 86.5%) dissolve 129.3 gms. Pb(CH<sub>3</sub>COO)<sub>2</sub> at 20°. (Holm, 1921, 1921a, 1922.)

100 gms. glycerol of d = 1.2645 (= 98.5%) dissolve 143.0 gms. Pb(CH<sub>3</sub>COO)<sub>2</sub> at 20°. (Holm, 1921, 1921a, 1922.)

100 gms. methyl alcohol (CH<sub>3</sub>OH) dissolve 74.75 gms. Pb(CH<sub>3</sub>COO)<sub>2</sub>·3H<sub>2</sub>O at 15° and 214.95 gms. at the boiling point.

100 gms. methyl alcohol (CH<sub>3</sub>OH) dissolve 102.75 gms. Pb(CH<sub>3</sub>COO)<sub>2</sub> at 66.1° (boiling point). (Henstock, 1934.)

100 gms. of a saturated solution in furfural at 25° contain 0.06 gms. Pb(C<sub>2</sub>H<sub>3</sub>O<sub>2</sub>)<sub>2</sub>.

100 gms. of a saturated solution in furfural at 25° contain 0.05 gms. Pb(C<sub>2</sub>H<sub>3</sub>O<sub>2</sub>)<sub>2</sub>·3H<sub>2</sub>O. (Trimble, 1941.)

100 gms. anhydrous lanolin (m. pt. 46°) dissolve 1.1 gm. Pb(C<sub>2</sub>H<sub>3</sub>O<sub>2</sub>)<sub>2</sub> at 45°. (Klose, 1907.)

SOLUBILITY OF LEAD ACETATE IN ACETIC ACID  
(Davidson and Chappell, 1933; Davidson and McAllister, 1930)

t°	Gm. mol. Pb(CH <sub>3</sub> COO) <sub>2</sub> per 100 gm. mols. sat. sol.		Solid Phase	t°	Gm. mol. Pb(CH <sub>3</sub> COO) <sub>2</sub> per 100 gm. mols. sat. sol.		Solid Phase	
16.5	0.0		CH <sub>3</sub> COOH	40.5	24.77		Pb· <sup>1</sup> / <sub>2</sub> H	
15.52	5.18		"	48.7	30.23		"	
14.24	8.42		"	52.9	33.55		"	
13.40	11.53		" + Pb· <sup>1</sup> / <sub>2</sub> H	56.4	36.6		" + Pb(CH <sub>3</sub> COO) <sub>2</sub>	
9.55	19.78*		"	49.0	35.69*		Pb(CH <sub>3</sub> COO) <sub>2</sub>	
8.05	21.99*		"	68.0	38.27		"	
-0.3	32.97*		"	100.5	44.95		"	CH
-3.1	37.48*		"	139.0	59.55		"	
20.3	14.67		Pb· <sup>1</sup> / <sub>2</sub> H	165.0	71.83		"	
32.8	20.57		"	204	100.00		"	

\*Metastable

Pb·<sup>1</sup>/<sub>2</sub>H = Pb(CH<sub>3</sub>COO)<sub>2</sub>·<sup>1</sup>/<sub>2</sub>CH<sub>3</sub>COOH. This branch of the curve could be located only by seeding the mixtures with crystals of the salt. The solubility of this hemisolvate in acetic acid is 16.75 mol. percent or 52.16 gms. per 100 gms. sat. solution at 25°.

LEAD ACETATE (ic) Pb(C<sub>2</sub>H<sub>3</sub>O<sub>2</sub>)<sub>4</sub>

SOLUBILITY OF PLUMBIC ACETATE IN ANHYDROUS ACETIC ACID  
(Davidson, Lanning, and Zeller, 1942)

t°	Mole % Pb(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>4</sub>		Solid Phase	t°	Mole % Pb(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>4</sub>		Solid Phase	t°	Mole % Pb(C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ) <sub>4</sub>		Solid Phase
16.60	0.0	A		29.9	0.512	B		68.4	1.64	B	
16.52	0.088	A		33.5	.582	B		74.6	1.96	B	
16.45	.193	A		37.0	.638	B		82.3	2.55	B	
16.40	.280	A		45.0	.798	B		90.7	3.31	B	
18.2	.354	B		53.0	1.03	B		94.4	3.74	B	
25.2	.427	B		59.8	1.29	B					

A = HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>      B = Pb(C<sub>2</sub>H<sub>3</sub>O<sub>2</sub>)<sub>4</sub>

**Pb LEAD**

**SOLUBILITY OF PLUMBIC ACETATE IN ACETIC ACID - SODIUM ACETATE SOLUTIONS**  
(Davidson, Lanning, and Zeller, 1942)

R = Mole %  $\text{NaC}_2\text{H}_3\text{O}_2$  in Solvent ( $\text{NaC}_2\text{H}_3\text{O}_2 + \text{HC}_2\text{H}_3\text{O}_2$ )

	Mole % $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_4$ in Sat. Sol.		Mole % $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_4$ in Sat. Sol.		Mole % $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_4$ in Sat. Sol.	
	t°		t°		t°	
CH	R = 0.003		T = 0.007		R = 0.015	
	0.390	24.1	0.404	25.2	0.394	25.7
	.417	26.2	.425	27.3	.445	28.3
	.460	28.3	.523	34.5	.457	30.2
	.501	31.7	.589	38.3	.489	31.6
	.525	32.8	.654	40.8	.524	34.7
	.560	34.7	.688	42.6	.586	38.1
	.638	38.8	.772	46.0	.607	39.3
	R = 0.025		R = 0.050		R = 0.07	
	0.321	22.5	0.266	23.1	0.339	32.1
	.446	32.7	.294	26.3	.368	34.3
	.507	36.2	.356	31.9	.379	36.3
	.597	41.3	.451	37.8	.429	40.5
	.634	43.2	.471	39.0	.461	42.8

Results in Solutions at 30°

R =	0.0	0.003	0.007	0.015	0.025	0.050	0.070
S =	0.51	0.48	0.46	0.45	0.41	0.33	0.31

**LEAD MONOCHLORACETATE  $\text{Pb}(\text{CH}_2\text{ClCO}_2)_2$**

**SOLUBILITY IN WATER**  
(Grillot, 1949)

The results were read from a curve drawn by the author.

	20°	40°	60°	80°
Moles $\text{Pb}(\text{CH}_2\text{ClCO}_2)_2$ per 100 cc.	0.005	0.012	0.020	0.029

**LEAD ETHYL XANTHATE  $\text{Pb}(\text{C}_2\text{H}_5\text{OCS}_2)_2$**

The solubility of lead ethyl xanthate is  $5.5 \times 10^{-6}$  moles per liter. (Taggart and Hassialis, 1946.)

**LEAD MALEATE  $\text{PbC}_4\text{H}_2\text{O}_4$**

100 gms.  $\text{H}_2\text{O}$  dissolve 0.052 gms.  $\text{PbC}_4\text{H}_2\text{O}_4$  at 30°. (Weiss and Downs, 1923.)

LEAD FUMARATE  $\text{PbC}_4\text{H}_2\text{O}_4$ 

100 gms.  $\text{H}_2\text{O}$  dissolve 0.025 gm.  $\text{Pb}(\text{C}_4\text{H}_2\text{O}_4)$  at  $30^\circ$ . (Weiss and Downs, 1923.)

LEAD MALATE  $\text{PbC}_4\text{H}_4\text{O}_5$ 

SOLUBILITY OF ACTIVE AND RACEMIC LEAD MALATES IN WATER  
(Duboux and Cuttat, 1921)

Results for Active Lead Malate			Results for Racemic Lead Malate			CH
Gms. Pb(C <sub>4</sub> H <sub>4</sub> O <sub>5</sub> ) per 100			Gms. Pb <sub>2</sub> C <sub>8</sub> H <sub>8</sub> O <sub>10</sub> per 100			
t°	gms. sat. sol.	Solid Phase	t°	gms. sat. sol.	Solid Phase	
0	0.015	Pb(C <sub>4</sub> H <sub>4</sub> O <sub>5</sub> )·2H <sub>2</sub> O	0	0.015	Pb <sub>2</sub> C <sub>8</sub> H <sub>8</sub> O <sub>10</sub> ·2H <sub>2</sub> O	
12.5	0.027	"	12.5	0.023	"	
25.0	0.052	"	25	0.035	"	
37.5	0.089	"	37.5	0.0545	"	

100 gms.  $\text{H}_2\text{O}$  dissolve 0.0288 gm.  $\text{PbC}_4\text{H}_4\text{O}_5 \cdot 3\text{H}_2\text{O}$  at  $18^\circ$ , and 0.06504 gm. at  $25^\circ$ . (Partheil and Hübner, 1903.)

100 cc. sat. solution of lead malate in water contain 0.0902 gm.  $\text{Pb}(\text{C}_4\text{H}_4\text{O}_5)$  at  $18^\circ$  and the solution has  $\text{pH} = 5.9$ . (Auerbach and Weber, 1925.)

100 gms.  $\text{H}_2\text{O}$  dissolve 0.21 gm. i lead malate at  $30^\circ$ . (Weiss and Downs, 1923.)

SOLUBILITY OF LEAD MALATE IN AQUEOUS SOLUTIONS AT  $18^\circ$   
(Auerbach and Weber, 1925)

Gms. $\text{Pb}(\text{C}_4\text{H}_4\text{O}_5)$ per liter		Gms. $\text{Pb}(\text{C}_4\text{H}_4\text{O}_5)$ per liter	
Aqueous solution	of sat. sol.	Aqueous solution	of sat. sol.
0.01n HCl	2.205	4.0n $\text{CH}_3\text{COONa}$	171.2
0.10n HCl	16.05	4.0n $\text{CH}_3\text{COONH}_4$	300.6
1.0 n $\text{CH}_3\text{COONa}$	23.52	50 wt. per cent $\text{C}_2\text{H}_5\text{OH}$	26.0
1.0 n $\text{CH}_3\text{COONH}_4$	36.3		

100 gms. 95% alcohol dissolve 0.0048 gm.  $\text{PbC}_4\text{H}_4\text{O}_5 \cdot 3\text{H}_2\text{O}$  at  $18^\circ$ - $25^\circ$ . Density of alcohol employed = 0.8092. (Partheil and Hübner, 1903.)

LEAD PICRATE  $\text{Pb}(\text{C}_6\text{H}_2(\text{NO}_2)_3\text{O})_2$ 

Lead picrate is soluble to the extent of 3% in acetonitrile at  $25^\circ$ . (Pleskov, 1948.)

**Pb LEAD**

**LEAD SUCCINATE  $\text{PbC}_4\text{H}_4\text{O}_4$**

**SOLUBILITY OF LEAD SUCCINATE IN WATER**  
(Cantoni and Diotallevi, 1905)

	10°	21°	32°	39°	50°
Gms. $\text{PbC}_4\text{H}_4\text{O}_4$ per 100 cc. sat. sol.:	0.015	0.019	0.024	0.027	0.029

**SOLUBILITY OF LEAD SUCCINATE IN WATER AND IN AQUEOUS SOLUTIONS AT 18°**  
(Auerbach and Weber, 1925)

CH	Gms. $\text{Pb}(\text{C}_4\text{H}_4\text{O}_4)$ per liter sat. sol.	
	Water	0.228 (the sat. sol. has pH = 6.1)
	Aqueous 0.01 n HCl	2.04
	Aqueous 0.10 n HCl	6.98
	Aqueous 1.0 n $\text{CH}_3\text{COONa}$	9.60
	Aqueous 1.0 n $\text{CH}_3\text{COONH}_4$	13.21
	Aqueous 50% $\text{C}_2\text{H}_5\text{OH}$	0.017

**SOLUBILITY IN WATER AND IN ALCOHOL**  
(Partheil and Hübner, 1903)

100 gms.  $\text{H}_2\text{O}$  dissolve 0.0253 gm.  $\text{PbC}_4\text{H}_4\text{O}_4$  at 18°, and 0.0285 gm. at 25°.

100 gms. 95% alcohol dissolve 0.00275 gm.  $\text{PbC}_4\text{H}_4\text{O}_4$  at 18°, and 0.003 gm. at 25°.

Density of alcohol used = 0.8092.

**LEAD TARTRATE  $\text{PbC}_4\text{H}_4\text{O}_6$**

**SOLUBILITY IN WATER**  
(Cantoni and Zachoder, 1905; Partheil and Hübner, 1903)

NOTE.--The positions of the decimal points here shown are just as given in the original communications.

t°	Gms. $\text{PbC}_4\text{H}_4\text{O}_6$ per 100 cc. Solution	t°	Gms. $\text{PbC}_4\text{H}_4\text{O}_6$ per 100 cc. Solution	t°	Gms. $\text{PbC}_4\text{H}_4\text{O}_6$ per 100 cc. Solution
18	0.010 (P. and H.)	50	0.00225	70	0.0032
25	0.0108 (P. and H.)	55	0.00295	75	0.0033
35	0.00105	60	0.00305	80	0.0038
40	0.0015	65	0.00315	85	0.0054

100 gms. alcohol at 0.8092 Sp. Gr. (about 95%) dissolve 0.0028 gm.  $\text{PbC}_4\text{H}_4\text{O}_6$  at 18°, and 0.00315 gm. at 25°. (Partheil and Hübner.)

SOLUBILITY OF ACTIVE AND RACEMIC LEAD TARTRATES IN WATER  
(Duboux and Cattat, 1921)

## Results for the Active salt

t°	Gms. $\text{PbC}_4\text{H}_4\text{O}_6$ per 100 gms. sat. sol.	Solid Phase
0	0.0027	$\text{Pb} \cdot \text{C}_4\text{H}_4\text{O}_6$
12.5	0.0030	"
25	0.0035	"
37.5	0.0046	"

## Results for the Racemic salt

t°	Gms. $\text{Pb}_2\text{C}_8\text{H}_8\text{O}_{12}$ per 100 gms. sat. sol.	Solid Phase
0	0.0038	$\text{Pb}_2\text{C}_8\text{H}_8\text{O}_{12} \cdot 4\text{H}_2\text{O}$
12.5	0.0020	"
25	0.0034	"
37.5	0.0066	"

SOLUBILITY OF LEAD TARTRATE IN WATER AND IN AQUEOUS SOLUTIONS AT 18°  
(Auerbach and Weber, 1925)

CH

Solvent	Gms. $\text{PbC}_4\text{H}_4\text{O}_6$ per liter sat. sol.	Solvent	Gms. $\text{PbC}_4\text{H}_4\text{O}_6$ per liter sat. sol.
Water	0.0125 ( $p_H = 5.6$ )	Aq. 4.0n $\text{CH}_3\text{COONa}$	14.64
Aq. 0.01n HCl	0.526	Aq. 1.0n $\text{CH}_3\text{COONH}_4$	1.95
Aq. 0.10n HCl	6.75	Aq. 4.0n $\text{CH}_3\text{COONH}_4$	13.02
Aq. 1.0 n $\text{CH}_3\text{COONa}$	1.38	Aq. 50 wt. % $\text{C}_2\text{H}_5\text{OH}$	0.00

Data for the solubility of lead tartarate in aqueous sodium tartarate solutions are given by Panova, 1956.

LEAD CITRATE  $\text{Pb}(\text{C}_6\text{H}_5\text{O}_7)_2 \cdot \text{H}_2\text{O}$ 

## SOLUBILITY IN WATER AND IN ALCOHOL

100 gms.  $\text{H}_2\text{O}$  dissolve 0.04201 gm.  $\text{Pb}(\text{C}_6\text{H}_5\text{O}_7)_2 \cdot \text{H}_2\text{O}$  at 18°, and 0.05344 gm. at 25°.

100 gms. alcohol (95%) dissolve 0.0156 gm.  $\text{Pb}(\text{C}_6\text{H}_5\text{O}_7)_2 \cdot \text{H}_2\text{O}$  at 18°, and 0.0167 gm. at 25°. (Partheil and Hübner, 1903).

SOLUBILITY OF LEAD CITRATE IN WATER AND IN AQUEOUS SOLUTIONS AT 18°  
(Auerbach and Weber, 1925)

Gms.  $\text{Pb}_2(\text{C}_6\text{H}_5\text{O}_7)_2$   
per liter sat. sol.

Water	0.159 (pH of sat. sol. = 6.3)
Aq. 0.01n HCl	1.466
Aq. 0.10n HCl	8.28
Aq. 1.00n $\text{CH}_3\text{COONa}$	6.70
Aq. 100n $\text{CH}_3\text{COONH}_4$	6.83
Aq. 50 wt. % $\text{C}_2\text{H}_5\text{OH}$	14.00



# **Pb LEAD**

Data for the solubility of lead citrate in sodium citrate solutions (0.02 - 1.4M) at 25° are given by Panova, 1957. The solubility of  $\text{Pb}_3(\text{C}_6\text{H}_5\text{O}_7)_2$  in water at 25° was found to be  $3.5 \times 10^{-5}$  moles/l.

## **LEAD salt (neutral) of racemic $\beta$ Methyl ADIPIC ACID**

100 gms. sat. solution in water contain 0.35 gm. of the salt at 20°. (Meurisse.)

## **CH LEAD GLUCONATE $\text{Pb}(\text{C}_6\text{H}_{11}\text{O}_7)_2$**

100 cc. sat. solution of lead gluconate in water contain 5.1 gms.  $\text{Pb}(\text{C}_6\text{H}_{11}\text{O}_7)_2$  at 25°. (May, Weisberg, and Herrick, 1929.)

## **LEAD BENZOATE $\text{Pb}(\text{C}_7\text{H}_5\text{O}_2)_2 \cdot \text{H}_2\text{O}$**

### **SOLUBILITY IN WATER** (Pajetta, 1906)

	18°	40.6°	49°
Gms. $\text{Pb}(\text{C}_7\text{H}_5\text{O}_2)_2$ per 100 gms. sat. sol.	0.149	0.249	0.310

### **SOLUBILITY OF LEAD BENZOATE IN WATER AND IN AQUEOUS SOLUTIONS AT 18°** (Auerbach and Weber, 1925)

	Gms. $\text{Pb}(\text{C}_6\text{H}_5\text{COO})_2$ per liter sat. sol.	Gms. $\text{Pb}(\text{C}_6\text{H}_5\text{COO})_2$ per liter sat. sol.
Water	1.647	16.70
Aq. 0.01n HCl	3.17	1892.0
Aq. 100 n $\text{CH}_3\text{COONa}$	14.18	
Aq. 1.0n $\text{CH}_3\text{COONH}_4$		
Aq. 50% $\text{C}_2\text{H}_5\text{OH}$		

The sat. sol. in water had pH = 6.0.

100 gms. methyl alcohol ( $\text{CH}_3\text{OH}$ ) dissolve 1.32 gms.  $\text{Pb}(\text{C}_6\text{H}_5\text{COO})_2$  at 15° and 2.65 gms. at 66° (b. pt.).

100 gms. acetone ( $(\text{CH}_3)_2\text{CO}$ ) dissolve 0.20 gms.  $\text{Pb}(\text{C}_6\text{H}_5\text{COO})_2$  at 15°. (Henstock, 1934.)

# LEAD Pb

## SOLUBILITY OF SEVERAL LEAD BENZOATES IN WATER AT 20° (Ephraim and Pfister, 1925)

		Gms. anhydrous cmpd. per 100 cc. sat. sol.
Lead Benzoate	$\text{Pb}(\text{C}_6\text{H}_5\text{COO})_2 \cdot \text{H}_2\text{O}$	0.179
Lead-4-Oxy benzoate	$\text{Pb}(\text{C}_6\text{H}_4\text{OH} \cdot \text{COO})_2 \cdot 2\text{H}_2\text{O}$	0.470
Lead-4-Nitro benzoate	$\text{Pb}(\text{C}_6\text{H}_4 \cdot \text{NO}_2 \cdot \text{COO})_2$	0.159
Lead-4-Chlor benzoate	$\text{Pb}(\text{C}_6\text{H}_4 \cdot \text{Cl} \cdot \text{COO}_2)_2 \cdot 2\text{H}_2\text{O}$	0.078
Lead-4-Methoxy benzoate	$\text{Pb}(\text{C}_6\text{H}_4 \cdot \text{OCH}_3 \cdot \text{COO})_2 \cdot \text{H}_2\text{O}$	0.0486

## LEAD TETRAPHENYL $\text{Pb}(\text{C}_6\text{H}_5)_4$

CH

Freezing-point data for  $\text{Pb}(\text{C}_6\text{H}_5)_4$  +  $\text{Si}(\text{C}_6\text{H}_5)_4$  are given by Pascal (1912).

## LEAD NITROSOPHENYL HYDROXYLAMINE (Cupferronate) $\text{Pb}[\text{C}_6\text{H}_5\text{N}(\text{NO}) \cdot \text{O}]_2$

One liter water dissolves 0.025 gm.  $\text{Pb}[\text{C}_6\text{H}_5\text{N}(\text{NO}) \cdot \text{O}]_2$  at 18°. (Pinkus and Martin, 1927.)

## TRICYCLOHEXYL LEAD $(\text{C}_6\text{H}_{11})_3\text{Pb}$

100 gms.  $\text{C}_2\text{H}_5\text{OH}$  dissolve 0.076 gm.  $(\text{C}_6\text{H}_{11})_3\text{Pb}$  at 30°. (Krause and Reiszhaus, 1921.)

100 gms.  $\text{C}_6\text{H}_6$  dissolve 2.28 gm.  $(\text{C}_6\text{H}_{11})_3\text{Pb}$  at 30°. (Krause and Reiszhaus, 1921.)

100 gms.  $\text{CHCl}_3$  dissolve 1.27 gm.  $(\text{C}_6\text{H}_{11})_3\text{Pb}$  at 30°. (Krause and Reiszhaus, 1921.)

## LEAD CINNAMATE $\text{Pb}(\text{C}_6\text{H}_5\text{CH}=\text{CHCOO})_2$

100 gms. sat. solution of lead cinnamate in water contain 0.141 gm.  $\text{Pb} \cdot \text{C}_{18}\text{H}_{14}\text{O}_4$  at 20°. (Ephraim and Pfister, 1925.)

Pb LEAD

LEAD QUINOLATES

Salt	Solvent	t°	Solubility	Ref.
Lead 8-hydroxyquinolate	benzene	25	mole fraction = 0.00013	(1)
Lead 8-hydroxyquinolate	dioxane	25	mole fraction = 0.0016	(1)
Lead 8-hydroxy-5-quinolinol sulfonate	water	25	pK <sub>a</sub> = 13.96	(2)
Lead 8-quinoline carboxylate	water	25	pK <sub>a</sub> = 3.274	(3)
Lead 2-quinoline carboxylate	water	25	pK = 2.582	(3)

(1) Charles and Freiser, 1951  
(3) Lunne, 1957

(2) Nasanen and Uusitalo, 1954

CH LEAD ISATIN OXIME  $PbC_8H_4N_2O_2$  [2]

At 18 - 20°, 1 mg. of coarse or 2 mg. of finely divided salt dissolve in one liter of water.

At 18 - 20°, about 6.4 mg. dissolve in dilute (1:30)  $NH_3$  [per liter] (coarse form).

At 18 - 20°, about 13 mg. dissolve in concentrated  $NH_3$  [per liter] (coarse form). (Hovorka and Divis, 1949.)

LEAD SULFONATES

SOLUBILITIES IN WATER

Name and Formula	t°	Gms. salt per 100 gms. H <sub>2</sub> O	Ref.
Lead 2·5 Diiodobenzenesulfonate $Pb(I_2C_6H_3SO_3)_2 \cdot 4H_2O$	20	0.77	E
Lead 2 Phenanthrene Monosulfonate $2-Pb(C_{14}H_9SO_3)_2 \cdot H_2O$	20	0.014	F
Lead 3 Phenanthrene Monosulfonate $3-Pb(C_{14}H_9SO_3)_2 \cdot 3H_2O$	20	0.08	F
Lead 10 Phenanthrene Monosulfonate $10-Pb(C_{14}H_9SO_3)_2 \cdot 4H_2O$	20	0.14	F
		Gms. salt per 100 gms. sat. sol.	
$\alpha$ -Lead Anthracene Sulfonate $\alpha-Pb(C_{14}H_9SO_3)_2 \cdot 2H_2O$	20 100	0.060 0.448	G G
$\beta$ -Lead Anthracene Sulfonate $\beta-Pb(C_{14}H_9SO_3)_2 \cdot 2H_2O$	20 100	0.007 0.041	G G

(Cont.)

E--Boyle, 1909 F--Sandquist, 1912 G--Federov and Lodygin, 1942

## SOLUBILITIES IN WATER--Cont.

Name and Formula	t°	Gms. salt per 100 gms. sat. sol.		Ref.
1,5-Lead Anthracene Sulfonate	20	0.218		G
1,5-PbC <sub>14</sub> H <sub>8</sub> S <sub>2</sub> O <sub>6</sub> ·2H <sub>2</sub> O	100	0.448		G
1,8-Lead Anthracene Sulfonate	20	0.019		G
1,8-PbC <sub>14</sub> H <sub>8</sub> S <sub>2</sub> O <sub>6</sub> ·2H <sub>2</sub> O	100	0.091		G
2,6-Lead Anthracene Sulfonate	20	0.048		G
2,6-PbC <sub>14</sub> H <sub>8</sub> S <sub>2</sub> O <sub>6</sub> ·4H <sub>2</sub> O	100	0.141		G
2,7-Lead Anthracene Sulfonate	20	0.797		G
2,7-PbC <sub>14</sub> H <sub>8</sub> S <sub>2</sub> O <sub>6</sub> ·3H <sub>2</sub> O	100	3.728		G
		Gms. salt per 100 cc. solution		CH
Lead m chloro benzene sulfonate Pb(C <sub>6</sub> H <sub>4</sub> ClSO <sub>3</sub> ) <sub>2</sub>	18	0.29		H
Lead p chloro benzene sulfonate Pb(C <sub>6</sub> H <sub>4</sub> ClSO <sub>3</sub> ) <sub>2</sub>	18	0.28		H
Lead β Naphthalene Sulfonate (C <sub>10</sub> H <sub>7</sub> SO <sub>3</sub> ) <sub>2</sub> ·Pb·H <sub>2</sub> O	25	0.4		I, J
Lead α Naphthalene Sulfonate (C <sub>10</sub> H <sub>7</sub> SO <sub>3</sub> ) <sub>2</sub> ·Pb·2H <sub>2</sub> O	24.9	4.195		J
		Gms. anhydrous compd. per		
		100 cc. sat. sol.	100 gms. H <sub>2</sub> O	
Lead Naphthalene-2-sulfonate Pb(C <sub>10</sub> H <sub>7</sub> SO <sub>3</sub> ) <sub>2</sub> ·H <sub>2</sub> O	16.5	0.541	-	A
α Lead Naphthalene mono sulfonate αPb(C <sub>10</sub> H <sub>7</sub> SO <sub>3</sub> ) <sub>2</sub> ·3H <sub>2</sub> O	10	-	3.7	B
β Lead Naphthalene mono sulfonate βPb(C <sub>10</sub> H <sub>7</sub> SO <sub>3</sub> ) <sub>2</sub> ·3H <sub>2</sub> O	10	-	0.87	B
Lead Naphthalene 2·6-disulfonate PbC <sub>10</sub> H <sub>6</sub> (SO <sub>3</sub> ) <sub>2</sub>	25	-	0.19	C
Lead Naphthalene 2·7-disulfonate PbC <sub>10</sub> H <sub>6</sub> (SO <sub>3</sub> ) <sub>2</sub>	25	-	8.2	C
Lead Naphthalene 5-chlor-1-sulfonate Pb(C <sub>10</sub> H <sub>6</sub> ·Cl·SO <sub>3</sub> ) <sub>2</sub> ·2H <sub>2</sub> O	20	0.20	-	A.
Lead Naphthalene 6-oxy-2-sulfonate Pb(C <sub>10</sub> H <sub>6</sub> OHSO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O	20	1.814	-	A
Lead Naphthylamine disulfonate-2·6·8 Pb(C <sub>10</sub> H <sub>6</sub> NH <sub>2</sub> ·SO <sub>3</sub> ) <sub>2</sub>	15	-	80.19	D
Lead Naphthylamine disulfonate-2·5·7 Pb(C <sub>10</sub> H <sub>5</sub> NH <sub>2</sub> ·SO <sub>3</sub> ) <sub>2</sub>	15	-	92.66	D

A--Ephraim and Pfister, 1925a

B--Merz and Mülhauser, 1870

C--Haller and Lynch, 1924

D--Braunschweig, 1922, 1926

G--Federov and Lodygin, 1942

H--Bollinger, 1928

I--Witte, 1915

J--Euwe, 1909

## Pb LEAD

### LEAD 10-CAMPHOR SULFONATE $\text{Pb}(\text{C}_{10}\text{H}_{15}\text{OSO}_3)_2 \cdot 2\text{H}_2\text{O}$

The solubility of the salt in water is 78.25% at room temperature. (Pirrone, 1942.)

### RECIPROCAL SOLUBILITY OF LEAD NAPHTHALENE $\alpha$ AND $\beta$ MONOSULFONATES AT 24.5° (Euwes, 1909)

These results were used as the basis of a method for the analysis of unknown mixtures of  $\alpha$  and  $\beta$  naphthalene mono sulfonic acids. The unknown mixture was converted to the lead salt and its solubility compared with the above results.

CH	Gms. $\alpha$ salt added per 100 cc.	Gms. total $\alpha$ and $\beta$ salt found per 100 cc.	Gms. $\beta$ salt dissolved per 100 cc. sat. sol.
	0.00	0.407	0.407
	0.095	0.468	0.373
	0.189	0.539	0.350
	0.284	0.604	0.320
	0.473	0.738	0.265
	0.945	1.114	0.169
	1.890	1.969	0.079

### RECIPROCAL SOLUBILITY OF LEAD NAPHTHALENE 2,6 AND 2,7 DISULFONATES AT 25° (Haller and Lynch, 1924)

An excess of the 2.6 salt was constantly agitated in a thermostat for 24 hours with 100 cc. of  $\text{H}_2\text{O}$  containing increasing amounts of the 2.7 salt.

Gms. anhydrous Lead 2.7 salt per 100 cc.	Gms. total 2.7 and 2.6 salt per 100 cc. sat. sol.	Gms. dissolved 2.6 salt per 100 cc.
0.0	0.188	0.188
0.395	0.483	0.088
0.98	1.045	0.065
1.58	1.595	0.015
1.966	2.008	0.042
1.966	2.043	0.077
2.97	2.98	0.010
8.23 (sat.)	8.20	-

### LEAD PHTHALATE $\text{PbC}_6\text{H}_4(\text{COO})_2$ (ortho)

Data for the solubility of lead phthalate in water are given by Bleeta, 1919.

### NORMAL LEAD TRINITRO RESORCINOLATE

100 gms. glycol diacetate ( $\text{CH}_3 \cdot \text{COO} \cdot \text{CH}_2 \text{--} \text{CH}_2 \text{OOC} \cdot \text{CH}_3$ ) dissolve 0.1 gm. normal lead trinitro resorcinolate at 20-25°. (Taylor and Rinkenbach, 1926.)

LEAD HYDNOCARPATE  $\text{Pb}[\text{CH}=\text{CH}\cdot\text{CH}_2\cdot\text{CH}_2\text{CH}(\text{CH}_2)_{10}\text{COO}]_2$

LEAD CHAULMOOGRATE  $\text{Pb}[\text{CH}=\text{CH}\cdot\text{CH}_2\text{CH}_2\cdot\text{CH}(\text{CH}_2)_{12}\text{COO}]_2$

SOLUBILITY OF EACH SEPARATELY IN SEVERAL SOLVENTS  
(Cole, 1932)

Solvent	t°	Gms. Hydnocarpate per 100 cc. solvent	Gms. Chaulmoograte per 100 cc. solvent
95% Ethyl Alcohol	15	0.11	0.08
"	30	0.20	0.19
"	b.pt.	1.13	0.91
Ethyl Ether	15	0.16	0.05
"	30	0.32	0.10
"	b.pt.	0.98	0.29
Benzene	15	0.09	0.05
"	30	0.15	0.06
"	b.pt.	2.92	2.42
Petroleum Ether (b.pt. 30-60°)	30	0.014	0.008

CH

LEAD 1,8-ANTHRAQUINONE SULFINATE,  $\text{PbC}_{14}\text{H}_6\text{O}_2(\text{SO}_2)_2\cdot\text{H}_2\text{O}$

At 20°, 650 gms.  $\text{H}_2\text{O}$  dissolve 1 gm. of the salt. At 100°, 275 gms.  $\text{H}_2\text{O}$  dissolve 1 gm. of the salt. (Kozlov and Smolin, 1949.)

LEAD HELIANTHATE  $\text{Pb}(\text{C}_{14}\text{H}_{14}\text{N}_3\text{SO}_3)_2\cdot 4\text{H}_2\text{O}$

1000 cc.  $\text{H}_2\text{O}$  dissolve 0.111 gm. lead helianthate (= 0.08 gm. helianthine) at 20°-25°. (Stark and Dehn, 1918.)

LEAD LIGNOCERATE

100 gms. anhydrous ether dissolve 0.025 gm. lead lignocerate at 25°. (Thomas and Yu, 1923.)

LEAD CAPROATE, CAPRYLATE, CAPRATE, NONYLATE, HEPTYLATE

SOLUBILITY OF EACH IN ETHER AND IN PETROLEUM ETHER  
(Neave, 1912)

The ethyl ether was distilled over sodium. Petroleum ether distilling between 40°-60° was used. The solutions were stirred constantly at 20°. A definite volume of the sat. solution was evaporated to dryness and residue weighed in each case.

(Cont.)

# Pb LEAD

## SOLUBILITY OF EACH IN ETHER AND IN PETROLEUM ETHER--Cont.

Lead Salt	Melting point	Solubility in Ethyl Ether		Solubility in Petroleum Ether	
		Gms. Salt per 100 cc. Sat. Sol.		Gms. Salt per 100 cc. Sat. Sol.	
		At 20°	At B. Pt. of Sat. Sol.	At 20°	At B. Pt. of Sat. Sol.
Pb Caproate	73-74	--	1.364	--	0.0608
Pb Heptylate	90.5-91.5	0.2397	1.490	0.020	0.0528
Pb Caprylate	83.5-84.5	0.0938	0.546	practically insol.	
Pb Nonylate	94-95	0.1115	0.2404	"	0.0450
Pb Caprate	100	0.0290	0.4285	"	0.0170

## LEAD LAURATE, MYRISTATE, PALMITATE, STEARATE

### SOLUBILITY OF EACH IN SEVERAL SOLVENTS (Jacobson and Holmes, 1916)

See under Lithium Laurate for formulas and other details.

Solvent	t°	Gms. of Each Salt (Determined Separately) per 100 Gms. Solvent			
		Pb Laurate	Pb Myristate	Pb Palmitate	Pb Stearate
Water	35	0.009	0.005	0.005	0.005
"	50	0.007	0.006	0.007	0.006
Abs. Ethyl Alcohol	25	0.009	0.004	0	0
" " "	35	0.032	0.004	0.001	0.001
" " "	50	0.264	0.052	0.012	0.004
Methyl Alcohol	15.5	0.061	0.056	0.051	0.039
" "	25	0.096	0.078	0.069	0.051
" "	35	0.113	0.082	0.076	0.062
" "	50	0.280	0.119	0.093	0.083
Ether	14.5	0.010	0.013	0.010	0.007
	25	-	-	-	0.021 <sup>b</sup>
	B.pt.	0.0205 <sup>a</sup>	0.0555 <sup>a</sup>	0.0261 <sup>a</sup>	0
Pet. Ether	B.pt.	0	0.0210 <sup>a</sup>	0	0.0170 <sup>a</sup>
Ethyl Acetate	14	0.017	0.010	0.009	0.007
" "	35.5	0.035	0.015	0.009	0.008
" "	50	0.201	0.077	0.033	0.020
Benzene	15	0.011	0.010	0.009	0.008
Chloroform	room	-	-	-	{ 0.0056 - 0.0094 <sup>c</sup>
Turpentine	15	-	-	0.106 <sup>d</sup>	

Data for the solubilization of lead stearate in chloroform by amines and glycols are given by Chatterjee and Palit, 1954.

<sup>a</sup>Results of Neave, 1912 in gms. per 100 cc. sat. sol.

<sup>b</sup>Thomas and Yu, 1923

<sup>c</sup>Strauli, 1918, 1926

<sup>d</sup>Marrell, 1918

LEAD Pb

LEAD OLEATE  $\text{Pb}(\text{C}_{18}\text{H}_{33}\text{O}_2)_2$ 

CH

100 gms. anhydrous ether dissolve 9.59 gms.  $\text{Pb}(\text{C}_{18}\text{H}_{33}\text{O}_2)_2$  at 25°. (Thomas and Yu, 1923.)

LEAD TETRAPHENYL  $\text{Pb}(\text{C}_6\text{H}_5)_4$ 

Data for the distribution of lead tetraphenyl between silicon and tin tetraphenyls are reported by Nefedov and Varshav, 1954.

LEAD CYANIDE  $\text{Pb}(\text{CN})_2$ 

CN

100 gms. liquid sulfur dioxide ( $\text{SO}_2$ ) dissolve 0.01 gm.  $\text{Pb}(\text{CN})_2$  at 0°. (Jander and Ruppolt, 1937.)

LEAD FERROCYANIDE  $\text{Pb}_2[\text{Fe}(\text{CN})_6]$ 

A saturated solution in water contains  $3.0 \times 10^{-5}$  gm. ions  $\text{Pb}^{++}$  per liter. (Tananaev, Glushokova and Seifer, 1956.)

The  $K_{sp}$  ( $-2\text{Pb}^{++} + \text{Fe}(\text{CN})_6^{--}$ ) at 20° is  $8.4 \times 10^{-17}$ . (Bovalini and Casini, 1953.)

## LEAD DOUBLE CYANIDES

SOLUBILITY IN WATER  
(Schuler, 1879)

Double Salt	Formula	t°	Gms. per 100 Gms. H <sub>2</sub> O
Lead Cobalticyanide	$\text{Pb}_3[\text{Co}(\text{CN})_6]_2 \cdot 7\text{H}_2\text{O}$	18	56.5
Lead Cobalticyanide	$\text{Pb}_3[\text{Co}(\text{CN})_6]_2 \cdot 7\text{H}_2\text{O}$	19	61.3
Lead Potassium Cobalticyanide	$\text{PbKCo}(\text{CN})_6 \cdot 3\text{H}_2\text{O}$	18	14.8
Lead Cobalticyanide Nitrate	$\text{Pb}_3[\text{Co}(\text{CN})_6]_2 \cdot \text{Pb}(\text{NO}_3)_2 \cdot 12\text{H}_2\text{O}$	18	5.9
Lead Ferricyanide Nitrate	$\text{Pb}_3[\text{Fe}(\text{CN})_6]_2 \cdot \text{Pb}(\text{NO}_3)_2 \cdot 12\text{H}_2\text{O}$	16	7.5
Lead Potassium Ferricyanide	$\text{PbKFe}(\text{CN})_6 \cdot 3\text{H}_2\text{O}$	16	21.0

LEAD THIOCYANATE  $\text{Pb}(\text{SCN})_2$ 

SCN

One liter water dissolves 0.0137 gm. mol.  $\text{Pb}(\text{SCN})_2$  at 18°, as determined by E.M.F. measurements. (Masaki, 1931.)



## Pb LEAD

The Ksp of  $\text{Pb}(\text{SCN})_2$ , as determined in KSCN solutions at 25° is  $2.00 \times 10^{-5}$ . (Yatmirskii, 1951.)

100 gms. liquid sulfur dioxide ( $\text{SO}_2$ ) dissolve 0.012 gm.  $\text{Pb}(\text{SCN})_2$  at 0°. (Jander and Ruppolt, 1937.)

## CO LEAD CARBONATE $\text{PbCO}_3$

SOLUBILITY IN WATER BY ELECTRICAL CONDUCTIVITY METHOD  
(Kohlrausch and Rose, 1893; Böttger, 1903)

1 liter of water dissolves 0.0011 - 0.0017 gm.  $\text{PbCO}_3$  at 20°.

SOLUBILITY OF LEAD CARBONATE (NEUTRAL) IN AQUEOUS SOLUTIONS OF  
CARBON DIOXIDE AT 18°  
(Pleissner, 1907)

Millimols per Liter		Milligrams per Liter	
$\text{CO}_2$	$\text{PbCO}_3$	$\text{CO}_2$	$\text{PbCO}_3$
0	0.008	0	1.75
0.064	0.029	2.8	6
0.123	0.034	5.4	7
0.328	0.040	14.4	8.2
0.592	0.048	26	9.9
0.988	0.053	43.5	10.9
2.40	0.076	106	15.4

100 gms. of a sat. solution of lead carbonate in water at 18° and in contact with  $\text{CO}_2$  at a pressure of 1 atmosphere, contain 0.014 gm.  $\text{PbCO}_3$ . At a pressure of 56 atmospheres of  $\text{CO}_2$ , 0.015 gm.  $\text{PbCO}_3$  are dissolved. (Haehnel, 1924.)

SOLUBILITY OF LEAD CARBONATE AND OTHER LEAD SALTS IN BLOOD SERUM AT 25°  
(Fairhall, 1924a)

An excess of metallic lead or of the lead salt was added to 250 cc. bottles containing fresh horse serum preserved with a small amount of thymol. The bottles were rotated for 24 hours in a thermostat at 25°. The undissolved solid was thrown down by centrifugation and portions of the clear sat. solution were analyzed by evaporating, ashing, converting the lead to chromate and titrating with 0.005 N thiosulfate solution.

Lead compound employed	Gms. lead compd. per liter of Serum at 25°	Comparative solubility in Water		
Lead carbonate ( $\text{PbCO}_3$ )	0.0333 (0.0125)	0.0017	at 18°	(Pleissner)
Lead sulfate ( $\text{PbSO}_4$ )	0.0437 (0.0300)	0.044	at 24°.95	(Böttger)
Lead chromate $\text{PbCrO}_4$	-	0.00001	at 25°	(von Hevesy)
Lead oxide $\text{PbO}$	1.1520 (1.1600)	0.0171	at 20°	(Pleissner)
Lead Pb	0.578 (0.193)			

The results in parentheses were obtained by saturating the fresh serum suspensions of the solid with  $\text{CO}_2$  at 25°, and determining the

solubility as above. The high value for  $PbO$  is due to the formation of lead hydroxide, which is removed by protein, with which it combines to form an alkali metaprotein.

### LEAD CARBONATE (Basic) $Pb_3(CO_3)_2(OH)_2$

CO

Results for the solubility of basic lead carbonate and of lead oxides in aqueous potassium hydroxide solutions at  $25^\circ$  are given by Randall and Spencer, 1928. The change of the stoichiometrical equilibrium constant with concentration shows that the activity coefficient of the plumbite ion is about the same as that of the nitrate ion in dilute solutions. From the extrapolated values of the equilibrium constants, the free energies of the solutions have been calculated.

A determination of the solubility of basic lead carbonate in water gave 1.6 mg.  $Pb_3(CO_3)_2(OH)_2$  per liter = 1.3 mg. Pb or 0.006 millimol Pb. (Pleissner, 1907.)

Data for the solubility of basic lead carbonate in various salt solutions of very low concentration is given by Ruchoff and Kachmar, 1942.

### LEAD OXALATE $PbC_2O_4$

CO

One liter of water dissolves 0.0015 gm.  $PbC_2O_4$  at  $18^\circ$  (conductivity method). (Böttger, 1903; Kohlrausch, 1904-05.)

#### SOLUBILITY OF LEAD OXALATE IN OXALIC ACID AND POTASSIUM CHLORIDE SOLUTIONS AT $25^\circ$ (Kurashvili, 1939)

moles $H_2C_2O_4$ per liter	$PbC_2O_4$		moles KCl per liter	$PbC_2O_4$	
	gms./liter	moles/liter		gms./liter	moles/liter
0.001	0.0009	$3.10 \times 10^{-6}$	0.1	0.0029	$1.00 \times 10^{-5}$
0.010	0.0019	$6.20 \times 10^{-6}$	0.3	0.0398	$1.35 \times 10^{-4}$
0.100	0.0029	$1.00 \times 10^{-5}$	0.5	0.0569	$1.93 \times 10^{-4}$
0.300	0.0288	$1.3 \times 10^{-4}$	1.0	0.0770	$2.27 \times 10^{-4}$
0.500	0.0667	$2.3 \times 10^{-4}$			
1.000	0.0572	$1.9 \times 10^{-4}$			

Results for the solubility of  $PbC_2O_4$  in aqueous  $HNO_3$  with added  $Pb^{++}$  or  $C_2O_4^{--}$  are reported by Tananaev, Chrelashvili and Salukvadze, 1939.

# Pb LEAD

## SOLUBILITY OF LEAD OXALATE IN POTASSIUM OXALATE SOLUTIONS AT 26° (Kolthoff, Perlich, and Weiblen, 1942)

Moles $K_2C_2O_4$ per liter	Moles $\times 10^5$ $PbC_2O_4$ per liter	Mg. Pb per liter	Moles $K_2C_2O_4$ per liter	Moles $\times 10^5$ $PbC_2O_4$ per liter	Mg. Pb per liter
0.0	2.2	4.5	0.075	12	24
.001	1.8	3.7	.100	16	32
.005	1.5	3.0	.200	35	72
.010	2.2	4.3	.400	66	135
.025	4.1	8.4	.500	85	175
.050	8.5	17.4			

## SOLUBILITY OF LEAD OXALATE IN AQUEOUS ETHANOL SOLUTIONS AT 25° (Kolthoff, Perlich, and Weiblen, 1942)

% Alcohol	10	20	30
Moles $PbC_2O_4$ per liter	$8.2 \times 10^{-5}$	$4.2 \times 10^{-6}$	$1.2 \times 10^{-6}$
Mg. Pb per liter	1.7	0.85	0.24

# Cl LEAD SUB CHLORIDE $PbCl$

1000 cc. sat. solution of lead subchloride in water contain 2.2 milli equivalents  $PbCl$  at 25° as determined by the conductivity method. (Denham, 1918.)

# Cl LEAD CHLORIDE $PbCl_2$

## SOLUBILITY IN WATER

(1) Demassieux, 1923; (2) Flöttmann, 1928; (3) Deacon, 1927; (4) Weber, 1929; (5) Burvage, 1926; (6) Herz and Hellebrandt, 1923; (7) Sowerby, 1927; (8) Lichty, 1903; (9) Carmody, 1929; (10) Lewin, Vance and Nelson, 1953; (11) Benrath, Gjedebo, Schiffers and Wunderlich, 1937; (12) Goulden and Hill, 1945.

For more recent data on the solubility between 100 - 370° see Malinin, 1957.

Solid phase is anhydrous

t°	Gms. $PbCl_2$ 100 gms. sat. sol.	t°	Gms. $PbCl_2$ per 100 gms. sat. sol.	t°	Gms. $PbCl_2$ per 100 gms. sat. sol.
0	0.668 (8)	15	0.866 (12)	25	1.076 (2) <sup>c</sup>
15	0.902 (8)	20	0.971 (2) <sup>b</sup>		1.075 (3)
	0.85 (1)		0.968 (12)		1.059 (10)
	0.876 (2) <sup>a</sup>	25	1.073 (8)(9)		1.028 (4)

(Cont.)

<sup>a</sup>d. = 1.0071

<sup>b</sup>d. = 1.0070

<sup>c</sup>d. = 1.0069

## SOLUBILITY IN WATER--Cont.

(1) Demassieux, 1923; (2) Flöttmann, 1928; (3) Deacon, 1927;  
 (4) Weber, 1929; (5) Burvage, 1926; (6) Herz and Hellebrandt, 1923;  
 (7) Sowerby, 1927; (8) Lichty, 1903; (9) Carmody, 1929; (10) Lewin,  
 Vance and Nelson, 1953; (11) Benrath, Gjedebo, Schiffrs and Wunderlich,  
 1937; (12) Goulden and Hill, 1945.

Solid phase is anhydrous

t°	Gms. PbCl <sub>2</sub> per 100 gms. sat. sol.		t°	Gms. PbCl <sub>2</sub> per 100 gms. sat. sol.		t°	Gms. PbCl <sub>2</sub> per 100 gms. sat. sol.		Cl
20	1.083	(5)(6)	65	2.082	(8)	230	11.3	(11)	
	1.075	(12)	80	2.555	(8)	257	14.3	(11)	
30	1.17	(8)	95	3.068	(8)	276	16.7	(11)	
	1.179	(12)	100	3.234	(8)	287	18.4	(11)	
35	1.307	(8)		3.10	(1)	345	24 - 76*	(11)	
	1.298	(12)	141	4.74	(11)	351	81.2	(11)	
45	1.543	(8)	160	5.67	(11)	362	87.8	(11)	
50	1.75	(1)	187	7.39	(11)	407	84.4	(11)	
55	1.709	(8)	195	8.47	(11)				

\*Two liquid layers are formed and there is present salt solution,  
 melt and vapor.

SOLUBILITY OF LEAD CHLORIDE IN WATER - DEUTERIUM OXIDE MIXTURES AT 25°  
 (Noonan, 1948)

% D <sub>2</sub> O	Moles PbCl <sub>2</sub> per 100 moles Solvent
91.6	0.0471
100.0	.0449

SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS SOLUTIONS OF HYDROCHLORIC ACID

The values of Ditte, 1881 at several temperatures between 0° and  
 80° seem too high. Data for the solubility of PbCl<sub>2</sub> as a function of  
 pH in aqueous HCl solutions are given by Tira, 1954.

Results at 0°

(Engel, 1889)\*

Results at 18°

(Fleissner, 1907)

Gms. per liter		Gms. per liter		Normality of HCl	Gms. PbCl <sub>2</sub> per liter
HCl	PbCl <sub>2</sub>	HCl	PbCl <sub>2</sub>		
0	5.83	10	1.2	0.0	9.34
0.5	4.5	100	1.2	0.0001	9.305
1.0	3.6	200	5.2	0.0002	9.300
2.0	2.2	250	10.5	0.0005	9.243
3.0	1.6	300	17.5	0.00102	9.200
6	1.4	400	40.0	0.0102	8.504

\*The results may be somewhat  
 low, but are given for com-  
 parison.

(Cont.)

Pb LEAD

SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS SOLUTIONS OF  
HYDROCHLORIC ACID--Cont.

Results at 25°

	(Kendall and Sloan, 1925)		(von Ende, 1901, at 25.2°)		(Noyes, 1892)			
	Gm. equiv. per liter		Gm. equiv. per liter		Normality of HCl	Millimols PbCl <sub>2</sub> per liter	Gms. per liter	
	HCl	PbCl <sub>2</sub>	HCl	PbCl <sub>2</sub>			HCl	PbCl <sub>2</sub>
					0	38.8	0	10.79
	0.20	0.01320	2.90	0.01180	0.0045	37.35	0.5	9.0
	0.30	0.01180	3.25	0.01247	0.0151	33.75	1.0	7.6
	0.50	0.01020	3.52	0.01330	0.0452	25.46	2.0	6.0
	0.08	0.00984	3.58	0.01340	0.1850	10.25	3.0	5.0
	1.00	0.00981	4.02	0.01495	0.5142	5.37	6	3.1
	1.30	0.00985	4.30	0.01604	1.026	4.41	10	1.8
	1.72	0.01014	4.70	0.01812	2.051	5.18		
	1.86	0.01023	5.16	0.02161	3.085	7.78		
	2.04	0.01042	5.50	0.02500	5.0	19.38		
	2.09	0.01060	5.60	0.02611	7.5	65.86		
	2.57	0.01126	5.78	0.02802	12.05	164.30		

Results at 50°

(Wilkerson, Bathurst and Parton,  
1937)

Gms. per 1000 gms. H <sub>2</sub> O		Gms. per 1000 gms. H <sub>2</sub> O	
HCl	PbCl <sub>2</sub>	HCl	PbCl <sub>2</sub>
0.138	16.30	81.86	3.99
0.639	14.35	165.40	7.82
1.917	11.57	184.00	9.27
3.98	9.24	365.00	18.31
14.20	4.46	331.80	27.50
38.91	3.46	377.80	38.16
45.52	3.25	444.4	54.12
		476.0	61.23

Results at 80°

(Wilkerson, Bathurst and Parton,  
1937)

Gms. per 1000 gms. H <sub>2</sub> O		Gms. per 1000 gms. H <sub>2</sub> O	
HCl	PbCl <sub>2</sub>	HCl	PbCl <sub>2</sub>
0.563	23.71	89.45	8.95
0.786	23.05	114.0	11.71
2.375	19.50	147.0	14.24
5.058	15.00	201.2	20.21
10.90	11.49	221.3	22.71
18.90	9.59	286.8	34.77
33.16	7.52	372.5	54.23
67.82	7.57	378.1	58.37

SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS SOLUTIONS OF ACETIC ACID AT 25°

Results of Hill, 1917

Normality of Acetic Acid	Dissolved PbCl <sub>2</sub>		Normality of Acetic Acid	Dissolved PbCl <sub>2</sub>	
	Gms. per Liter	Equiv. per Liter		Gms. per Liter	Equiv. per Liter
0	10.77	0.07753	0.465	10.27	0.07392
0.05	10.82	0.07782	0.929	9.45	0.06803
0.10	10.85	0.07717	1.845	7.90	0.05686
0.20	10.70	0.07703	3.680	5.26	0.03788

SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS SOLUTIONS  
OF ACETIC ACID AT 25°--Cont.

Results of Herz and Martin, 1924

Titrametric Conc. of CH <sub>3</sub> COOH	Mols. Pb per liter	Titrametric Conc. of CH <sub>3</sub> COOH	Mols. Pb per liter	Titrametric Conc. of CH <sub>3</sub> COOH	Mols. Pb per liter
0.0	0.03895	5.16	0.01446	10.17	0.00363
1.02	0.03365	5.87	0.01163	11.24	0.00258
2.05	0.02796	7.06	0.00887	12.20	0.00191
3.04	0.02266	7.93	0.00660	13.28	0.00136
3.94	0.01837	8.94	0.00505	14.44	0.00123
				14.90	0.00120

Cl

Results of Sanved, 1929

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
PbCl <sub>2</sub>	CH <sub>3</sub> COOH		PbCl <sub>2</sub>	CH <sub>3</sub> COOH	
1.060	0.0	PbCl <sub>2</sub>	0.481	24.83	PbCl <sub>2</sub>
1.024	1.28	"	0.372	30.32	"
0.983	2.33	"	0.213	42.20	"
0.883	6.01	"	0.147	51.72	"
0.793	9.58	"	0.084	60.40	"
0.627	17.27	"	0.047	78.30	"
0.547	21.31	"	0.013	96.60	"

The author also gives results at 25° for the quarternary system  
PbCl<sub>2</sub> + Pb(CH<sub>3</sub>COO)<sub>2</sub> + CH<sub>3</sub>COOH + H<sub>2</sub>O.

Data are given by Tira, 1954 in terms of the pH of the solutions.

THE SYSTEM LEAD CHLORIDE - LEAD IODIDE - WATER AT 30°  
(Sowerby, 1927)

Gms. per 100 cc sat. sol.		Solid Phase	Gms. per 100 cc sat. sol.		Solid Phase
PbI <sub>2</sub>	PbCl <sub>2</sub>		PbI <sub>2</sub>	PbCl <sub>2</sub>	
0.0	1.171	PbCl <sub>2</sub>	0.0520	0.550	PbI <sub>2</sub>
0.0081	1.171	"	0.0602	0.518	" + PbI <sub>2</sub>
0.0168	1.171	"	0.0606	0.417	PbI <sub>2</sub>
0.0235	1.171	" + PbI <sub>2</sub>	0.0620	0.352	"
0.0241	1.140	PbI <sub>2</sub>	0.0647	0.209	"
0.0278	0.958	"	0.0712	0.100	"
0.0390	0.717	"	0.0788	0.046	"
0.0432	0.631	"	0.0910	0.00	"

Pb LEAD

SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS SOLUTIONS OF LEAD NITRATE AT 25°

Results by Harkins, 1911			Results by Armstrong and Eyre, 1913		
Gms. per Liter Sat. Sol.		$d_{25}^4$ of Sat. Sol.	Aq. $Pb(NO_3)_2$ Sol., Gms. per 1000 Gms. $H_2O$		Gms. $PbCl_2$ per 1000 Gms. Sat. Sol.
$Pb(NO_3)_2$	$PbCl_2$				
0	10.81	1.0069	0		10.89
3.31	10.67	1.0095	3.31		10.96
8.28	10.65	1.0139	6.62		10.53
16.56	10.84	1.0210	33.12		11.15
33.12	11.57	-	82.80		12.95

C1 SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS SOLUTIONS  
OF BARIUM CHLORIDE AT 25°

Results of Herz and Hellebrandt, 1923			Results of Kendall and Sloan, 1925					
Normality $BaCl_2$ 2	Mols. Pb per liter		Gm. equiv. per liter		Gm. equiv. per liter		Gm. equiv. per liter	
			$BaCl_2$	$PbCl_2$	$BaCl_2$	$PbCl_2$	$BaCl_2$	$PbCl_2$
0.32	0.00699		0.10	0.02322	1.54	0.02820	2.56	0.04600
0.64	0.00553		0.20	0.02000	1.86	0.03275	2.76	0.05135
1.38	0.01089		0.50	0.01966	2.02	0.03524	2.90	0.05598
2.08	0.02388		0.96	0.02180	2.10	0.03662	2.98	0.05922
			1.09	0.02322	2.30	0.04030	3.12	0.06600
			1.35	0.02600	2.45	0.04361	3.26	0.07362

Solid Phase  $BaCl_2 \cdot PbCl_2$  in all cases.

SOLUBILITY OF LEAD CHLORIDE IN CALCIUM CHLORIDE SOLUTIONS

Results at 25°

Results of Kendall and Sloan, 1925				Results of Tschischikoff and Schachoff, 1936		Results of Herz and Hellebrandt, 1923	
Gm. equiv. per liter		Gm. equiv. per liter		$CaCl_2$	$PbCl_2$	Normality of $CaCl_2$ 2	Mols. Pb per liter
$CaCl_2$	$PbCl_2$	$CaCl_2$	$PbCl_2$				
				0.0	1.031 <sup>a</sup>		
				0.35	0.576 <sup>a</sup>		
				0.653	0.382 <sup>a</sup>		
				1.25	0.227 <sup>a</sup>	0.52	0.00696
0.20	0.02402	3.44	0.03227	2.44	0.164 <sup>a</sup>	0.95	0.00563
0.50	0.02144	3.63	0.03660	4.83	0.12 <sup>a</sup>	1.91	0.00771
0.70	0.02100	4.06	0.03655	9.16	0.156 <sup>a</sup>	3.03	0.01268
0.94	0.02122	4.60	0.04260	17.18	0.31 <sup>a</sup>	4.12	0.02057
1.18	0.02106	5.02	0.04903	29.9	2.226 <sup>a</sup>		
1.52	0.02208	5.18	0.05202	42.3	6.36 <sup>b</sup>		
1.84	0.02350	5.27	0.05400				
2.10	0.02480	5.43	0.05831				
2.19	0.02522	5.62	0.06500				
2.38	0.02601	5.68	0.06821				
2.80	0.02807						

<sup>a</sup>Solid Phase  $PbCl_2$

<sup>b</sup>Solid Phase  $PbCl_2 + CaCl_2$

Solid Phase  $CaCl_2 \cdot PbCl_2 \cdot 6H_2O$  in  
all cases.

## SOLUBILITY OF LEAD CHLORIDE IN CALCIUM CHLORIDE SOLUTIONS--Cont.

## Results at 60°

(Tschischikoff and Schachoff, 1936)

Sat. Sol. Wt. %		Sat. Sol. Wt. %	
CaCl <sub>2</sub>	PbCl <sub>2</sub>	CaCl <sub>2</sub>	PbCl <sub>2</sub>
0.0	1.887	4.17	0.478
0.35	1.368	10.51	0.489
0.67	1.068	17.43	0.914
1.28	0.757	19.46	3.69
2.56	0.520	44.48	7.265

Cl

Data for the solubility of PbCl<sub>2</sub> in solutions containing varying amounts of CaCl<sub>2</sub> + NaCl from 17° to 84° are reported by Kuz'minykh and Vladmirova, 1952.

## SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS SOLUTIONS OF MERCURIC CHLORIDE AT 25°

(Kendall and Sloan, 1925)

Gm. equiv. per liter

HgCl <sub>2</sub>	PbCl <sub>2</sub>	Solid Phase
0.06	0.0885	HgCl <sub>2</sub> ·PbCl <sub>2</sub>
0.10	0.0983	"
0.15	0.1074	"
0.50	0.1384	"

THE SYSTEM PbCl<sub>2</sub> - KCl - H<sub>2</sub>O

## Results at 20°

(Brønsted, 1912)

Gm. Equivalents per 1000 Gms. Solution		Solid Phase	Gm. Equivalents per 1000 Gms. Solution		Solid Phase
KCl	PbCl <sub>2</sub>		KCl	PbCl <sub>2</sub>	
0.195	0.01900	PbCl <sub>2</sub>	2.10	0.01022	2PbCl <sub>2</sub> ·KCl
0.299	0.01452	"	2.20	0.01060	"
0.375	0.01324	"	2.29	0.01184	"
0.483	0.01236	"	2.36	0.01300	2PbCl <sub>2</sub> ·KCl+PbCl <sub>2</sub> ·KCl· <sup>1</sup> / <sub>2</sub> H <sub>2</sub> O
0.510	0.0125	" + 2PbCl <sub>2</sub> ·KCl	2.45	0.01308	PbCl <sub>2</sub> ·KCl· <sup>1</sup> / <sub>2</sub> H <sub>2</sub> O
0.575	0.01068	2PbCl <sub>2</sub> ·KCl	2.66	0.01396	"
0.639	0.00954	"	2.77	0.01476	"
0.930	0.00770	"	2.91	0.01550	"
1.224	0.00736	"	3.05	0.01656	"
1.575	0.00786	"	3.18	0.01780	"
1.884	0.00894	"	4.57*	0.0280*	" : KCl

\* = Gm. equivalents per 1000 Gms. H<sub>2</sub>O

(Cont.)



Pb LEAD

THE SYSTEM  $\text{PbCl}_2$  -  $\text{KCl}$  -  $\text{H}_2\text{O}$ ---Cont.

Results at 25°

(Burrage, 1926)			(Burrage, 1932; Allmand and Burrage, 1933)		
Cl	Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Solid Phase
	KCl	PbCl <sub>2</sub>	KCl	PbCl <sub>2</sub>	
	0.0	1.083	0.0	10.94	PbCl <sub>2</sub>
	0.037	1.008	7.5	4.70	"
	0.075	0.961	15.0	3.05	"
	0.152	0.877	30.0	2.31	"
	0.296	0.747	35.0	2.22	"
	0.735	0.462	40.0	2.18	"
	1.469	0.301	47.0	2.30	"
	3.022	0.205	52.5	2.39	"
	4.969	0.227	55.0	2.49	"
	7.048	0.128	59.0	2.70	" + 2PbCl <sub>2</sub> · KCl
	9.787	0.127	75.0	2.35	2PbCl <sub>2</sub> · KCl
	12.93	0.142	130	1.49	"
	18.74	0.236	182	2.04	"
	22.54	0.303	231	2.91	" + PbCl <sub>2</sub> · KCl · $\frac{1}{3}\text{H}_2\text{O}$
	26.43	0.386	265	3.41	PbCl <sub>2</sub> · KCl · $\frac{1}{3}\text{H}_2\text{O}$
	26.52	0.267	299	4.04	"
	26.44	0.122	330	4.65	"
	26.53	0.00	361	5.25	" + KCl
			362.5	4.0	KCl
			361	2.0	"
			360	1.0	"
			359	0.125	"

(Kendall and Sloan, 1925)

(von Ende, 1901)

Gms. equiv. per liter		Solid Phase	Normality of KCl	Gm. Equiv. PbCl <sub>2</sub> per Liter
KCl	PbCl <sub>2</sub>			
0.25	0.01850	PbCl <sub>2</sub>	0	0.07760
0.37	0.01600	"	0.001	0.07664
0.46	0.01422	"	0.0025	0.07570
0.52	0.01362	"	0.0049	0.07404
0.54	0.01354	"	0.0099	0.07056
0.63	0.01277	1.2	0.0200	0.06432
0.74	0.01102	"	0.0599	0.04524
0.78	0.01063	"	0.05999	0.02380
0.97	0.00981	"	0.5006	0.01480
1.10	0.00960	"	0.7018	0.01476
1.20	0.00960	"	0.9991	0.00980
1.30	0.00965	"	1.5018	0.00996
1.55	0.01025	"	2.0024	0.01112
1.80	0.01134	"	3.0036	0.01948
2.07	0.01287	"		
2.17	0.01388	"		
2.26	0.01489	1.1		
2.41	0.01480	"	1.2 = KCl · 2PbCl <sub>2</sub>	
2.65	0.01601	"		
2.98	0.01943	"		
3.00	0.01966	"		
3.20	0.02402	"		

THE SYSTEM  $\text{PbCl}_2 - \text{KCl} - \text{H}_2\text{O}$ —Cont.

Results at 14°, 50°, 100°

(Demassieux, 1923)

The author's numerous determinations were plotted and the following values read from the average curve.

Results at 14°		Results at 50°		Results at 100°		Solid Phase at each temp.	Cl
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.			
KCl	PbCl <sub>2</sub>	KCl	PbCl <sub>2</sub>	KCl	PbCl <sub>2</sub>		
0.0	0.91	0.0	1.75	0.0	3.10	PbCl <sub>2</sub>	
1.37	0.18	2.0	0.65	2.0	2.00	"	
2.44	0.14	4.0	0.5	4.0	1.75	"	
3.43	0.13	6.0	0.57	6.0	1.78	"	
-	-	-	-	8.0	2.00	"	
-	-	-	-	10.0	2.38	"	
3.79	0.15	6.4	0.62	10.6	2.57	" + 2.1	
4.0	0.13	12.0	0.50	12.0	2.42	2.1	
4.7	0.08	14.0	0.52	14.0	2.32	"	
12.75	0.08	16.0	0.55	16.0	2.35	"	
15.65	0.10	18.0	0.62	18.0	2.50	"	
15.87	0.11	20.0	0.70	20.0	2.75	"	
16.26	0.11	22.0	0.85	22.0	3.10	"	
-	-	-	-	24.0	3.50	"	
-	-	-	-	26.0	4.25	"	
16.83	0.12	22.8	0.97	27.2	5.00	" + 1.1. <sup>1</sup> / <sub>3</sub>	
17.57	0.13	28.0	1.10	28.0	4.90	1.1. <sup>1</sup> / <sub>3</sub>	
18.64	0.14	30.0	1.27	30.0	5.10	"	
18.97	0.15	-	-	32.0	5.45	"	
22.45	0.17	-	-	34.0	5.80	"	
24.61	0.20	31.24	1.5	35.3	6.05	" + KCl	
-	-	31.0	1.0	35.0	3.5	KCl	
-	-	31.0	0.5	35.2	1.25	"	
24.52	0.0	31.07	0.0	35.5	0.0	"	

2.1 =  $2\text{PbCl}_2 \cdot \text{KCl}$ 1.1. <sup>1</sup>/<sub>3</sub> =  $\text{PbCl}_2 \cdot \text{KCl} \cdot \frac{1}{3}\text{H}_2\text{O}$ 

## SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS SOLUTIONS OF LITHIUM CHLORIDE

At 25° (Kendall and Sloan, 1925)

Gm. equiv. per liter		Gm. equiv. per liter	
LiCl	PbCl <sub>2</sub>	LiCl	PbCl <sub>2</sub>
0.28	0.02565	2.10	0.04300
0.32	0.02500	2.26	0.04729
0.52	0.02384	2.40	0.05144
0.74	0.02449	2.58	0.05723
0.91	0.02582	2.68	0.06086
1.28	0.02945	2.72	0.06317
1.55	0.03306	2.75	0.06507
1.81	0.03720	2.82	0.06930

Solid Phase  $\text{LiCl} \cdot 2\text{PbCl}_2$  in all cases

(Cont.)

Pb LEAD

SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS SOLUTIONS  
OF LITHIUM CHLORIDE--Cont.

At 50° (Demassieux, 1923)

	Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
	LiCl	PbCl <sub>2</sub>	LiCl	PbCl <sub>2</sub>
Cl	2.06	0.45	37.51	7.53
	4.79	0.35	38.52	7.55
	5.07	0.37	39.40	7.62
	9.59	0.49	40.50	7.45
	16.10	0.83	43.99	7.42
	24.64	2.31	45.51	6.66
	30.61	5.08	46.22	6.50
	35.05	6.80	47.72	3.39
	36.69	7.46	48.41	2.22

A double salt was not found.

SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS SOLUTIONS OF  
MAGNESIUM CHLORIDE AT 25°  
(Kendall and Sloan, 1925)

Gm. equiv. per liter		Gm. equiv. per liter		Gm. equiv. per liter		Gm. equiv. per liter	
MgCl <sub>2</sub>	PbCl <sub>2</sub>	MgCl <sub>2</sub>	PbCl <sub>2</sub>	MgCl <sub>2</sub>	PbCl <sub>2</sub>	MgCl <sub>2</sub>	PbCl <sub>2</sub>
0.12	0.01084	1.83	0.00723	4.86	0.01832	7.08	0.04844
0.27	0.00802	2.62	0.00915	5.42	0.02303	7.58	0.05944
0.60	0.00625	3.54	0.01205	5.94	0.02902	7.98	0.07000
0.85	0.00618	3.87	0.01329	6.36	0.03489	8.12	0.07360
1.58	0.00689	4.36	0.01564	6.78	0.04251		

Solid Phase MgCl<sub>2</sub>.PbCl<sub>2</sub>.6H<sub>2</sub>O in all cases.

SOLUBILITY OF LEAD CHLORIDE IN VARIOUS SALT SOLUTIONS AT 25°  
(Noyes; in HgCl<sub>2</sub> solutions at 20°, Formanek, 1887)

In Aqueous Solutions of:

HCl, KCl, MgCl <sub>2</sub> , CaCl <sub>2</sub> , MnCl <sub>2</sub> and ZnCl <sub>2</sub> Gram Equivalents per Liter of		In CdCl <sub>2</sub> Gram Equiv. per Liter		In HgCl <sub>2</sub> Gram Equiv. per Liter		In Pb(NO <sub>3</sub> ) <sub>2</sub> Gram Equiv. per Liter	
Salt	PbCl <sub>2</sub>	CdCl <sub>2</sub>	PbCl <sub>2</sub>	HgCl <sub>2</sub>	PbCl <sub>2</sub>	Pb(NO <sub>3</sub> ) <sub>2</sub>	PbCl <sub>2</sub>
0.0	0.0777	0.00	0.0777	0.0	0.0777	0.0	0.0777
0.05	0.050	0.05	0.0601	0.1	0.0992	0.2	0.0832
0.10	0.035	0.10	0.0481				
0.20	0.021	0.20	0.0355				

The above results were calculated to grams per liter plotted on cross-section paper, and the figures in the following table read from the curves.

## SOLUBILITY OF LEAD CHLORIDE IN VARIOUS SALT SOLUTIONS AT 25°--Cont.

Gms. Salt per Liter	Grams PbCl <sub>2</sub> per Liter in Aqueous Solutions of:									
	HCl	KCl	MgCl <sub>2</sub>	CaCl <sub>2</sub>	MnCl <sub>2</sub>	ZnCl <sub>2</sub>	CdCl <sub>2</sub>	HgCl <sub>2</sub>		Pb(NO <sub>3</sub> ) <sub>2</sub>
0	10.79	10.79	10.79	10.79	10.79	10.79	10.79	10.79 <sup>a</sup>	9.71 <sup>b</sup>	10.79
1	8.5	9.3	7.7	8.7	9.5	-	10.2	11.0	9.8	10.8
2	6.5	8.2	6.5	7.6	8.3	-	9.7	11.4	10.0	10.85
3	5.2	7.2	5.7	6.7	7.3	-	9.2	11.7	10.3	10.87
4	4.3	6.5	5.2	6.0	6.3	-	8.6	12.0	10.5	10.90
6	3.2	5.3	4.4	4.8	5.0	-	7.7	12.7	11.0	10.95
8	2.5	4.5	-	3.9	4.1	-	7.0	13.3	11.6	11.00
10	2.1	3.9	-	3.3	3.5	-	6.3	14.0	12.2	11.05
14	-	3.1	-	-	2.8	3.0	5.4	-	13.2	11.15
20	-	-	-	-	-	-	4.7	-	14.8	11.20
40	-	-	-	-	-	-	-	-	19.0	11.70

<sup>a</sup>Noyes    <sup>b</sup>Formanek

## THE SYSTEM LEAD CHLORIDE - AMMONIUM CHLORIDE - WATER

## Results of Brönsted, 1911 at 22°

Gm. Equiv. per Liter		Solid Phase	Gm. Equiv. per Liter		Solid Phase
NH <sub>4</sub> Cl	PbCl <sub>2</sub>		NH <sub>4</sub> Cl	PbCl <sub>2</sub>	
0	0.0749	PbCl <sub>2</sub>	0.8	0.0087	NH <sub>4</sub> Cl·2PbCl <sub>2</sub>
0.1	0.0325	"	1	0.0080	"
0.2	0.0194	"	1.5	0.0073	"
0.4	0.0138	"	2.5	0.0092	"
0.5	0.0130	"	4	0.0182	"
0.52	0.0127	" + NH <sub>4</sub> Cl·2PbCl <sub>2</sub>	6	0.0473	"
0.55	0.0123	NH <sub>4</sub> Cl·2PbCl <sub>2</sub>	7.29	0.0898	" + NH <sub>4</sub> Cl
0.65	0.0105	"	7.29	0	NH <sub>4</sub> Cl

## Results of Kendall and Sloan, 1925 at 25°

(For additional results at 25.2° see von Ende, 1901)

Gm. equiv. per liter		Gm. equiv. per liter		Gm. equiv. per liter		Gm. equiv. per liter	
NH <sub>4</sub> Cl	PbCl <sub>2</sub>	NH <sub>4</sub> Cl	PbCl <sub>2</sub>	NH <sub>4</sub> Cl	PbCl <sub>2</sub>	NH <sub>4</sub> Cl	PbCl <sub>2</sub>
0.20	0.02207	1.96	0.00923	4.22	0.02220	5.46	0.03645
0.50	0.01305	2.57	0.01142	4.64	0.02620	5.66	0.04000
0.56	0.01224	3.18	0.01462	4.83	0.02836	6.00	0.04723
0.80	0.00878	3.47	0.01643	5.00	0.03030	6.28	0.05507
1.00	0.00765	3.60	0.01721	5.09	0.03142	6.30	0.05601
1.20	0.00769	3.90	0.01982	5.20	0.03264		

The solid phase at all concentrations above 0.6 n is 2PbCl<sub>2</sub>·NH<sub>4</sub>Cl.

(Cont.)

Pb LEAD

THE SYSTEM LEAD CHLORIDE - AMMONIUM CHLORIDE - WATER--Cont.

Results of Demassieux, 1923 at 17, 50, 100°

	Results at 17°		Results at 50°		Results at 100°		Solid Phase at each Temperature
	Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
	PbCl <sub>2</sub>	NH <sub>4</sub> Cl	PbCl <sub>2</sub>	NH <sub>4</sub> Cl	PbCl <sub>2</sub>	NH <sub>4</sub> Cl	
Cl	0.89	0.0	1.09	0.50	3.10	0.0	PbCl <sub>2</sub>
	0.27	0.96	0.67	1.51	2.0	1.31	"
	0.14	2.40	0.50	3.85	1.75	5.47	"
	0.07	4.19	0.54	4.28	1.76	6.01	"
	0.08	4.31	0.58	4.45	1.78	8.62	" + 1.2
	0.07	4.98	0.49	4.84	1.73	9.66	1.2
	0.09	12.30	0.39	7.27	2.90	19.77	"
	0.34	22.34	0.72	19.42	4.50	26.00	"
	-	-	1.76	27.15	8.40	34.63	"
	-	-	3.29	31.25	11.40	36.29	"
	-	-	-	-	12.67	37.38	" + 1.2
	-	-	-	-	12.51	37.92	1.2
	-	-	-	-	10.68	38.82	"
	-	-	-	-	9.53	41.90	" + NH <sub>4</sub> Cl
	0.64	26.49	3.96	33.55	-	-	2.1 + NH <sub>4</sub> Cl
	0.33	27.23	1.69	33.90	4.21	42.96	NH <sub>4</sub> Cl
0.0	27.35	0.32	34.14	3.06	43.40	"	
-	-	0.0	34.25	0.71	43.88	"	



THE SYSTEM LEAD CHLORIDE - SODIUM CHLORIDE - WATER

Results at 25°

(Herz and Hellebrandt, 1923)		(Kendall and Sloan, 1923)					
Normality of NaCl	Mol. Pb per liter	Gm. equiv. per liter		Gm. equiv. per liter		Gm. equiv. per liter	
		NaCl	PbCl <sub>2</sub>	NaCl	PbCl <sub>2</sub>	NaCl	PbCl <sub>2</sub>
0.0	0.03895	0.25	0.01603	1.56	0.01468	3.06	0.03188
0.51	0.00648	0.40	0.01370	1.85	0.01725	3.29	0.03545
1.02	0.00631	0.50	0.01300	1.96	0.01807	3.54	0.03966
2.05	0.00961	0.70	0.01192	2.25	0.02100	3.78	0.04407
3.03	0.01279	0.86	0.01205	2.46	0.02370	4.04	0.05008
4.10	0.04377	1.14	0.01261	2.66	0.02606	4.18	0.05431
		1.46	0.01403	2.90	0.02944	4.39	0.06302
						4.50	0.07009

Solid phase above 0.5 N NaCl is NaCl.2PbCl<sub>2</sub>.

(Cont.)

## THE SYSTEM LEAD CHLORIDE - SODIUM CHLORIDE - WATER--Cont.

Results at other temperatures

(Demassieux, 1922)

Results at 13°		Results at 50°		Results at 100°		Solid Phase at each Temperature
Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
NaCl	PbCl <sub>2</sub>	NaCl	PbCl <sub>2</sub>	NaCl	PbCl <sub>2</sub>	
0.0	0.82	2.07	0.57	2.01	1.65	PbCl <sub>2</sub>
1.0	0.18	5.36	0.38	5.00	1.53	"
4.97	0.09	9.57	0.58	13.12	2.54	"
13.39	0.19	17.22	1.20	19.55	4.95	"
16.46	0.31	22.94	2.41	24.01	9.00	"
23.46	1.10	25.51	4.04	25.21	10.47	"
26.17	1.88	26.46	4.94	26.27	11.92	" + NaCl
26.29	0.75	26.48	3.88	27.05	6.86	NaCl
26.33	0.0	26.89	1.50	27.09	2.82	"

Cl

SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS SOLUTIONS OF  
STRONTIUM CHLORIDE AT 25°(Herz and  
Hellebrandt, 1923)

(Kendall and Sloan, 1923)

Normality of $\frac{\text{SrCl}_2}{2}$	Mol. Pb per liter	Gm. equiv. per liter		Gm. equiv. per liter		Gm. equiv. per liter	
		SrCl <sub>2</sub>	PbCl <sub>2</sub>	SrCl <sub>2</sub>	PbCl <sub>2</sub>	SrCl <sub>2</sub>	PbCl <sub>2</sub>
0.51	0.00678	0.20	0.02633	1.70	0.02985	2.96	0.04304
1.02	0.00640	0.32	0.02502	2.06	0.03260	3.32	0.05032
1.38	0.00824	0.60	0.02480	2.12	0.03303	3.36	0.05118
2.66	0.01418	0.80	0.02522	2.55	0.03705	3.47	0.05440
3.09	0.01578	1.12	0.02620	2.66	0.03869	3.64	0.06009
4.13	0.02698	1.46	0.02821	2.80	0.04027	3.78	0.06502
						3.88	0.06940

Solid Phase SrCl<sub>2</sub>.PbCl<sub>2</sub> in all cases.SOLUBILITY OF LEAD CHLORIDE IN ZINC CHLORIDE SOLUTIONS  
(Tschischikoff and Schachoff, 1936)Results at 25°

Gms. per 100 gms. Sat. Sol.		Solid Phase	Gms. per 100 gms. Sat. Sol.		Solid Phase
ZnCl <sub>2</sub>	PbCl <sub>2</sub>		ZnCl <sub>2</sub>	PbCl <sub>2</sub>	
0.0	1.031	PbCl <sub>2</sub>	26.00	.08	PbCl <sub>2</sub>
0.49	0.513	"	37.21	.10	"
.8	.3	"	47.91	.14	"
.727	.252	"	55.33	.17	"
.846	.22	"	66.68	.184	"
12.54	.161	"	76.68	.696	"
16.72	.09	"	80.05	.78	PbCl <sub>2</sub> + ZnCl <sub>2</sub>

Pb LEAD

SOLUBILITY OF LEAD CHLORIDE IN ZINC CHLORIDE SOLUTIONS--Cont.

Results at 60°

Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.		
ZnCl <sub>2</sub>	PbCl <sub>2</sub>	Solid Phase	ZnCl <sub>2</sub>	PbCl <sub>2</sub>	Solid Phase
0.0	1.887	PbCl <sub>2</sub>	43.71	.147	PbCl <sub>2</sub>
2.05	0.69	"	47.41	.195	"
3.96	.54	"	66.16	.215	"
7.68	.48	"	69.29	.345	"
14.52	.45	"	80.96	3.86	PbCl <sub>2</sub> + ZnCl <sub>2</sub>
26.52	.31	"			

Cl

SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS BROMIDE SOLUTIONS AT 25°  
(Herz and Hellebrandt, 1923)

Aqueous BaBr <sub>2</sub>		Aqueous KBr		Aqueous NaBr		Aqueous SrBr <sub>2</sub>	
Nor- mality BaBr <sub>2</sub>	Moles Pb per liter	Nor- mality KBr	Moles Pb per liter	Nor- mality NaBr	Moles Pb per liter	Nor- mality SrBr <sub>2</sub>	Moles Pb per liter
0.43	0.00603	0.53	0.00789	0.48	0.00697	0.52	0.00629
0.91	0.01096	1.07	0.00888	0.97	0.01210	1.04	0.01139
1.83	0.03858	2.14	0.02597	1.94	0.05932	2.08	0.04875
2.70	0.1267	3.21	0.06705	2.82	0.14310	3.12	0.1397
3.67	0.2960	4.28	0.1774	3.78	0.31855	4.16	0.3993

SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS ETHANOL SOLUTIONS AT 25°

(Noble and Garrett, 1944)

(Kernot and Pomilio, 1912)

Wt. % C <sub>2</sub> H <sub>5</sub> OH in solvent	Gms. PbCl <sub>2</sub> per 100 gms. solvent	Gms. per Liter Solution	
		C <sub>2</sub> H <sub>5</sub> OH	PbCl <sub>2</sub>
0	1.086		
10	0.662	0	10.75
20	0.392	5.75	10.16
30	0.246	11.51	9.36
40	0.158	23.02	9.14
50	0.100	46.05	8.25
60	0.0598	92.10	7.12
70	0.0309	184.20	4.76
80	0.0139		
90	0.0058		
100	0.0021		

SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS ETHYLENE GLYCOL SOLUTIONS AT 25°  
(Garrett, Noble, Kiefer, and Bryant, 1943)

Wt. % Glycol in Solvent	Gms. PbCl <sub>2</sub> per 100 gms. Solvent	Wt. % Glycol in Solvent	Gms. PbCl <sub>2</sub> per 100 gms. Solvent	Wt. % Glycol in Solvent	Gms. PbCl <sub>2</sub> per 100 gms. Solvent
0.0	1.086	20.00	1.065	81.6	1.293
5.44	1.073	21.75	1.065	85.4	1.326
6.54	1.073	30.00	1.079	87.3	1.360*
7.62	1.068	40.00	1.106	89.4	1.277*
8.72	1.065	42.57	0.945	91.7	1.188*
9.80	1.065	50.00	1.141	93.3	1.129*
10.00	1.058	60.0	1.175	94.8	1.070*
10.88	1.068	62.4	1.195	96.5	1.001*
11.97	1.065	70.0	1.226	100	0.859*
13.07	1.068	80.0	1.270		

Cl

\*Solid Phase: PbCl<sub>2</sub>·2C<sub>2</sub>H<sub>4</sub>(OH)<sub>2</sub>. Solid Phase in all other solutions is PbCl<sub>2</sub>.

SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS ETHYLENE GLYCOL SOLUTIONS  
CONTAINING POTASSIUM CHLORIDE AT 25°  
(Garrett, Bryant, and Kiefer, 1943)

Moles per 1000 gms. Solvent		Moles per 1000 gms. Solvent		Moles per 1000 gms. Solvent	
PbCl <sub>2</sub>	KCl	PbCl <sub>2</sub>	KCl	PbCl <sub>2</sub>	KCl
Solvent: 21.75 Wt. % Glycol		Solvent: 42.57 Wt. % Glycol		Solvent: 62.44 Wt. % Glycol	
0.03821	0.0	0.04016	0.0	0.04296	0.0
.03187	0.0196	.03440	0.0192	.02429	.0756
.02690	.0392	.02882	.0382	.01518	.1879
.01951	.0783	.02158	.0765	.00524	.4750
.01733	.0995	.01456	.1534	.00336	.7678
.01080	.1968	.01288	.1922	.00323	1.1678
.00682	.4972	.00700	.3868		
.00482	.8098	.00400	.7837		
.00402	1.222	.00345	1.194	Solvent: 81.64 Wt. % Glycol	
.00496	2.096	.00395	2.054	0.04635	0.0
Solvent: 100% Ethylene Glycol				.04043	0.0185
0.03086	0.0	0.01566	0.0910	.03578	.0370
.02506	0.0189	.01319	.1452	.02856	.0735
.01999	.0440	.01227	.1821	.01491	.1848
.01672	.0727			.00493	.4668



**Pb LEAD**

**SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS 1,2-PROPYLENE GLYCOL SOLUTIONS AT 25°**

(Garrett, Noble, Kiefer, and Bryant, 1943)

Wt. % Glycol in Solvent:	20.5	40.8	60.8	80.5	100.0
Gms. PbCl <sub>2</sub> per 100 gms. Solvent:	0.812	0.606	0.481	0.345	0.253

**SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS GLYCEROL SOLUTIONS**  
(Noble and Garrett, 1944)

	Wt. % Glycerol in solvent	Gms. PbCl <sub>2</sub> per 100 gms. solvent	Wt. % Glycerol in solvent	Gms. PbCl <sub>2</sub> per 100 gms. solvent
Cl	0	1.086	50	1.332
	10	1.124	60	1.401
	20	1.168	70	1.482
	30	1.220	80	1.573
	40	1.270	90	1.689
			100	1.822

**SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS MANNITOL SOLUTIONS AT 25°**  
(Kernot and Pomillo, 1912)

Gms. per Liter Solution	
$(\text{CH}_2\text{OH})_2(\text{CHOH})_4$	PbCl <sub>2</sub>
0	10.75
2.84	10.42
5.69	10.67
11.38	10.64
22.76	10.91
45.53	11.16
91.06	11.29

**SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS DIOXANE SOLUTIONS**

Pederson, 1941 at 18°		Noble and Garrett, 1944 at 25°	
Moles Dioxane per liter Solvent	Moles PbCl <sub>2</sub> per liter Sat. Sol.	Wt. % Dioxane in solvent	Gms. PbCl <sub>2</sub> per 100 gms. solvent
0.0	0.03360	0	1.086
0.167	.03232	10	0.807
.333	.03113	20	0.604
.500	.02992	30	0.401
.667	.02875	40	0.259
1.000	.02647	50	0.153
		60	0.0898
		70	0.0584
		80	0.0334
		90	0.0167
		100	0.0036

SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS DIOXANE SOLUTIONS  
CONTAINING POTASSIUM SALTS AT 25°  
(Noble and Garrett, 1944)

All concentrations are moles salt per 1000 gms. of Solvent

KCl	PbCl <sub>2</sub>	KCl	PbCl <sub>2</sub>	KCl	PbCl <sub>2</sub>
In 20 Wt. % Dioxane		In 40 Wt. % Dioxane		In 60 Wt. % Dioxane	
0.0	0.02173	0.0	0.00932	0.0	0.00323
0.01005	.0184	0.0098	.00660	0.010	.00208
.03016	.0133	.0294	.00442	.030	.00204
.0695	.00874	.0688	.00348	.050	.00210
.0995	.00725	.099	.00336	.070	.00207
.199	.00537	.199	.00335	.085	.00198
.299	.00509	.295	.00312	.100	.00154
.401	.00437	.399	.00252	.300	.00135
.553	.00353	.693	.00225		
.711	.00325	.859	.00211		
.868	.00314	1.008	.00254		
.970	.00312	1.224	.00283		
1.180	.00323				
1.455	.00371				
1.674	.00418				

Cl

KNO <sub>3</sub>	PbCl <sub>2</sub>		
	20 Wt. % Dioxane	40 Wt. % Dioxane	60 Wt. % Dioxane
0.005	-	0.00932	0.00505
.010	-	.01011	.00756
.030	0.02323	.01222	-
.050	.02445	.01352	-
.070	.02584	.01486	-
.085	.02772	.01539	-
.100	.02869	.01605	-
.300	.03145	.02382	-

SOLUBILITY OF PbCl<sub>2</sub> IN AQUEOUS UREA SOLUTIONS

(Pederson, 1941 at 18°)

(Dunning and Shutt, 1938 at 25°)

Moles Urea per liter Solvent	Moles PbCl <sub>2</sub> per liter Sat. Sol.
0.0	0.03367
0.250	.03542
.500	.03728
.750	.03922
1.000	.04120

Moles per liter	
Urea	PbCl <sub>2</sub>
0.0	0.03850
1.0	.04669
2.5	.06131
5.0	.09539

Pb LEAD

SOLUBILITY OF  $\text{PbCl}_2$  IN AQUEOUS ACETONE SOLUTIONS AT  $25^\circ$   
(Noble and Garrett, 1944)

Wt. % acetone in solvent	Gms. $\text{PbCl}_2$ per 100 gms. solvent	Wt. % acetone in solvent	Gms. $\text{PbCl}_2$ per 100 gms. solvent
0	1.086	60	0.0456
10	0.737	70	0.0178
20	0.484	80	0.0045
30	0.301	90	0.0026
40	0.178	100	0.0011
50	0.0973		

C1

SOLUBILITY OF  $\text{PbCl}_2$  IN AQUEOUS GLYCINE SOLUTIONS AT  $25^\circ$   
(Dunning and Shutt, 1938)

Moles per liter	
Glycine	$\text{PbCl}_2$
0.2	0.03851
.4	.05765
.5	.07840
.6	.08775
.8	.1115

SOLUBILITY OF LEAD CHLORIDE IN AQUEOUS SOLUTIONS OF  
SEVERAL COMPOUNDS AT  $25^\circ$   
(Armstrong and Eyre, 1913)

Aqueous Solution of	Gms. Cmpd. per 1000 Gms. $\text{H}_2\text{O}$	Gms. $\text{PbCl}_2$ per 1000 Gms. Sat. Sol.	Aqueous Solution of	Gms. Cmpd. per 1000 Gms. $\text{H}_2\text{O}$	Gms. $\text{PbCl}_2$ per 1000 Gms. Sat. Sol.
Water alone	0	10.89	Ethyl Alcohol	11.51	10.43
Glycol	15.51	10.75	Glycerol	23.01	10.98
Glycol	62.04	10.90	Propyl Alcohol	15.01	10.08
Acetaldehyde	11.01	10.54	Propyl Alcohol	60.06	9.37
Acetaldehyde	33.03	9.82	Methyl Acetanilide	29.82	10.25
Paraldehyde	11.01	10.50	Hydrochloric Acid	9.12	4.23
Paraldehyde	33.02	9.96	Hydrochloric Acid	18.23	3.60

SOLUBILITY OF LEAD CHLORIDE IN PYRIDINE  
(Heise, 1912)

t°	Gms. $\text{PbCl}_2$ per 100 Gms. Pyridine	Solid Phase	t°	Gms. $\text{PbCl}_2$ per 100 Gms. Pyridine	Solid Phase
-20	0.303	$\text{PbCl}_2 \cdot 2\text{C}_5\text{H}_5\text{N}$	76	0.893	$\text{PbCl}_2 \cdot 2\text{C}_5\text{H}_5\text{N}$
0	0.364	"	90	1.07	"
+22	0.459	"	94	1.12	"
44	0.559	"	102	1.31	"
65	0.758	"			

100 cc. anhydrous hydrazine dissolve 3 gms.  $PbCl_2$  at ord. temp. with decomposition. (Welsh and Broderick, 1915.)

100 gms. liquid sulfur dioxide ( $SO_2$ ) dissolve 0.019 gm.  $PbCl_2$  at  $0^\circ$ . (Jander and Ruppolt, 1937.)

Melting point data are given for:

$PbCl_2 + PbF_2$	(Sandonnini, 1911; Pelabon and Lande, 1928; Anosov and Patsukova, 1956)
$PbCl_2 + PbI_2$	(Monkemeyer, 1906; Pelabon and Lande, 1928; Sumarokova and Modestova, 1956; Delgrey, 1946)
$PbCl_2 + PbO$	(Ruer, 1906; Baroni, 1934; Pelabon and Lande, 1928)
$PbCl_2 + Pb_3(PO_4)_2$	(Amadori, 1918; 1919)
$PbCl_2 + Pb_3(VO_4)_2$	(Amadori, 1919)
$PbCl_2 + PbS$	(Truthe, 1912)
$PbCl_2 + AgCl$	(Tubaudt and Eggert, 1920)
$PbCl_2 + KCl$	(Tries, 1914; Lorenz and Ruckstuhl, 1906; Ugai and Shatillo, 1949)
$PbCl_2 + NaCl$	(Tries, 1914; Demassieux, 1923)
$PbCl_2 + RbCl$	(Tries, 1914)
$PbCl_2 + SrCl$	(Sandonnini, 1911, 1914)
$PbCl_2 + TiCl$	(Korring, 1911; Sandonnini, 1911, 1914)
$PbCl_2 + SnCl_2$	(Hermann, 1911; Sandonnini, 1911, 1914)
$PbCl_2 + ZnCl_2$	(Hermann, 1911; Ugai and Shatillo, 1949)
$PbCl_2 + Cd = Pb + CdCl_2$	(Elagina and Palkin, 1956)
$PbCl_2 + CdI_2 = PbI_2 + CdCl_2$	(Ilyasov and Bergman, 1957)
$PbCl_2 + ZnCl_2 + KCl$	(Ugai and Shatillo, 1949)

The solubility of  $PbCl_2$  in  $AgCl$  and  $AgCl + CdCl_2$  at  $270^\circ$  was determined by Wagner and Zimens, 1947, Wagner, 1956.

## LEAD TETRACHLORIDE $PbCl_4$

Cl

Melting points in the systems  $PbCl_4 + CCl_4$ ,  $PbCl_4 + SiCl_4$ ,  $PbCl_4 + TiCl_4$  and  $PbSO_4 + SnCl_4$  are given by Seckmann, 1955, 1957.

## LEAD FLUOROCHLORIDE $PbFCl$

### SOLUBILITY OF LEAD FLUOROCHLORIDE IN WATER AND IN AQUEOUS SOLUTIONS (Stark, 1911)

Solubility in Water      Solubility in Aqueous Solutions at  $25^\circ$

$t^\circ$	Gms. $PbFCl$ per 100 Gms. $H_2O$	Aqueous Solution of:	Gms. $PbFCl$ per 100 cc. Sat. Sol.
		0.0535 n HCl	0.0758
0	0.0211	0.1069 n HCl	0.1006
18	0.0325	0.0518 n $CH_3COOH$	0.0512
25	0.0370	0.1055 n $CH_3COOH$	0.0561
100	0.1081	0.00996 n $PbCl_2$	0.0030
		0.0195 n $PbCl_2$	0.0008
		0.0392 n $PbCl_2$	0.0005

Pb LEAD

Cl LEAD CHLORIDE (Basic)

SOLUBILITY OF BASIC LEAD CHLORIDES IN WATER AT 18°  
(Pleissner, 1907)

Compound	Formula	Gms. per Liter Sat. Aq. Solution	
		Pb	= Pb Salt
$\frac{1}{2}$ Basic Lead Chloride	$\text{PbCl}_2 \cdot \text{PbO} \cdot \text{H}_2\text{O}$	0.079	0.099
$\frac{3}{4}$ Basic Lead Chloride	$\text{PbCl}_2 \cdot 3\text{PbO} \cdot \text{H}_2\text{O}$	0.021	0.025

Deschamps and Charreton, 1951 report the following solubility product constants:

$$[\text{Pb}^{++}] [\text{OH}^-]^2 = 3 \times 10^{-20}$$

$$[\text{Pb}^{++}] [\text{Cl}^-] [\text{OH}^-] = 1.7 - 9.7 \times 10^{-14}$$

$$[\text{Pb}^{++}] [\text{Cl}^-]^{1/2} [\text{OH}^-]^{5/2} = 10^{-17}$$

ClO LEAD CHLORITE  $\text{Pb}(\text{ClO}_2)_2$

SOLUBILITY OF LEAD CHLORITE IN WATER  
(Levi, 1923)

t°	Gms. $\text{Pb}(\text{ClO}_2)_2$ per 100 gms. sat. sol.	Solid Phase
0	0.035	$\text{Pb}(\text{ClO}_2)_2$
25	0.12	"
50	0.19	"
75	0.32	"
100	0.41	"

ClO LEAD CHLORATE  $\text{Pb}(\text{ClO}_3)_2 \cdot \text{H}_2\text{O}$

100 grams  $\text{H}_2\text{O}$  dissolve 151.3 gms.  $\text{Pb}(\text{ClO}_3)_2$ , or 100 gms. sat. solution contain 60.2 gms.  $\text{Pb}(\text{ClO}_3)_2$  at 18°. Density of solution, 1.947. (Mylius and Funk, 1897.)

100 gms.  $\text{H}_2\text{O}$  dissolve 440 gms.  $\text{Pb}(\text{ClO}_3)_2$  at 18°,  $d_{18} = 1.63$ . (Carlson, 1910.)

LEAD PERCHLORATE  $Pb(ClO_4)_2$ 

ClO

Solvent	t°	Solubility
Water	25	81.47 gms. $Pb(ClO_4)_2$ per 100 gms. sat. sol. ( $d_{25} = 2.7753$ ) (solid phase $Pb(ClO_4)_2 \cdot 3H_2O$ ) (Willard and Kassner, 1926)
Furfural	20	25 gms. $Pb(ClO_4)_2$ per 100 cc solvent (Chaney and Mann, 1931)
Cellosolve	20	105 gms. $Pb(ClO_4)_2$ per 100 cc solvent (Chaney and Mann, 1931)
Acetonitrile	25	10 gms. $Pb(ClO_4)_2$ per 100 gms. sat. sol. (Pleskov, 1948)

LEAD HEXA ANTIPYRINE PERCHLORATE  $[Pb(COC_{10}H_{12}N_2)_6](ClO_4)_2$ 

100 cc sat. solution of lead hexa antipyrine perchlorate in water contain 5.44 gms.  $[Pb(COC_{10}H_{12}N_2)_6](ClO_4)_2$  at 20°. (Wilke-Dörfurt and Schliephake, 1929.)

LEAD CHROMATE  $PbCrO_4$ 

CrO

## SOLUBILITY OF LEAD CHROMATE IN WATER

t°	Mols. $PbCrO_4$ per Liter	Gms. $PbCrO_4$ per Liter	Method	Authority
18	$3.0 \cdot 10^{-7}$	0.00010	Solution equilibrium	(Beck and Stegmüller, 1910)
--	$1.4 \cdot 10^{-7}$	0.00004	Solution equilibrium	(Auerbach and Pick)
18	$3.2 \cdot 10^{-7}$	0.00010	Conductivity	(Kohlrausch, 1908)
20	$2.1 \cdot 10^{-7}$	0.00007	Radio Indicators	(v. Hevesy and Rona, 1915)
20	$5.4 \times 10^{-7}$	0.00017	(pH of water 6.27)	(Huybrechts and Degard, 1933)
25	$5.3 \times 10^{-7}$	0.00017	(Kolthoff, Perlich and Weiblen, 1942)	

$1.27 \times 10^{-4}$  moles of  $PbCrO_4$  dissolve in one liter of 0.1 M  $HClO_4$ . (May and Kolthoff, 1948.) The authors found the solubility of freshly precipitated  $PbCrO_4$  to be considerably greater than that of aged samples, and measured the specific surface area of each type.

Pb LEAD

SOLUBILITY OF LEAD CHROMATE IN AQUEOUS SOLUTIONS OF PERCHLORIC ACID  
AND OF MIXTURES OF PERCHLORIC ACID AND LEAD PERCHLORATE AT 25°  
(Willard and Kassner, 1926)

Solvent mola. per liter		Dissolved PbCrO <sub>4</sub>		Solvent mola. per liter		Dissolved PbCrO <sub>4</sub>	
HClO <sub>4</sub>	PbClO <sub>4</sub>	Gms. per 100 cc	Millimols. per 100 cc	HClO <sub>4</sub>	PbClO <sub>4</sub>	Gms. per 100 cc	Millimols. per 100 cc
0.1	+	0.0041	0.0127	5.0	+	0.0191	0.0591
0.5	+	0.0120	0.0371	0.5	+ 0.005	0.0005	0.0015
1.0	+	0.0140	0.0433	1.0	+ 0.005	0.0013	0.0040
2.0	+	0.0199	0.0616	2.0	+ 0.010	0.0012	0.0037
3.0	+	0.0211	0.0668	2.0	+ 0.015	0.0006	0.0019
4.0	+	0.0213	0.0659	5.0	+ 0.020	0.0001	0.0003

CrO

SOLUBILITY OF LEAD CHROMATE IN AQUEOUS SOLUTIONS OF HYDROCHLORIC  
AND OF NITRIC ACIDS  
(Beck and Stegmüller, 1910, 1911)

Solubility in Aq. HCl

Solubility in Aq. HNO<sub>3</sub> at 18°

Normality of HCl	Milligrams Pb per 100 cc. Sat. Sol. at:			Normality of HNO <sub>3</sub>	Milligrams Pb per 100 cc. Sat. Sol.
	18°	25°	37°		
0.1	3.86	4.96	7.40	0.1	2.67
0.2	8.15	10.06	15.40	0.2	4.70
0.3	13.56	17.38	27.30	0.3	6.46
0.4	22.14	27.78	43.60	0.4	8.31
0.5	32.30	42.60	68	0.5	10.31
0.6	46.60	61.06	97.20	0.6	12.39

Results are also given for the solubility of mixtures of lead chromate and lead sulfate in aqueous hydrochloric acid at 25° and 37°.

SOLUBILITY OF LEAD CHROMATE IN AQUEOUS SOLUTIONS OF NITRIC ACID AND  
OF MIXTURES OF NITRIC ACID AND LEAD NITRATE AT 25°  
(Willard and Kassner, 1926)

The solubility of lead chromate in perchloric acid increases up to a molar concentration of the acid of about 4.0 and then begins to decrease, while in nitric acid the solubility continues to increase with increasing concentration of acid. It is also noted that lead chromate is much less soluble in perchloric than in nitric acid of the same concentration.

SOLUBILITY OF LEAD CHROMATE IN AQUEOUS SOLUTIONS OF NITRIC ACID AND OF MIXTURES OF NITRIC ACID AND LEAD NITRATE AT 25°--Cont.

Mols. per liter solvent		Dissolved PbCrO <sub>4</sub>		Mols. per liter solvent		Dissolved PbCrO <sub>4</sub>	
HNO <sub>3</sub> Pb(NO <sub>3</sub> ) <sub>2</sub>		Gms. per 100 cc	Millimols. per 100 cc	HNO <sub>3</sub> Pb(NO <sub>3</sub> ) <sub>2</sub>		Gms. per 100 cc	Millimole. per 100 cc
0.1 + 0.0		0.0063	0.0195	0.1 + 0.005		0.0001	0.0003
0.5 + 0.0		0.0177	0.0548	0.5 + 0.005		0.0018	0.0055
1.0 + 0.0		0.0385	0.1190	1.0 + 0.010		0.0038	0.0117
2.0 + 0.0		0.0889	0.2752	3.0 + 0.020		0.0381	0.1179
3.0 + 0.0		0.1701	0.5265	2.0 + 0.15		0.0012	0.0037
4.0 + 0.0		0.2810	0.8700	2.0 + 0.25		0.0002	0.0006
5.0 + 0.0		0.4367	1.3510	2.0 + 0.3*		0.0002	0.0006

CrO

\*Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> instead of Pb(NO<sub>3</sub>)<sub>2</sub>.

SOLUBILITY OF LEAD CHROMATE IN AQUEOUS SOLUTIONS OF ACETIC ACID AND OF AMMONIUM ACETATE AT 20°  
(Ruybrachts and Degard, 1933)

Results for Aqueous Solutions of:

Acetic Acid		Ammonium Acetate	
Normality of Aq. CH <sub>3</sub> COOH	Gms. PbCrO <sub>4</sub> per liter sat. sol.	Normality of Aq. NH <sub>4</sub> CH <sub>3</sub> COO	Gms. PbCrO <sub>4</sub> per liter sat. sol.
0.025	0.00130	0.05	0.00093
0.05	0.00234	0.10	0.00136
0.10	0.00429	0.20	0.00210
0.20	0.00468	0.50	0.00936
0.50	0.00616		

The solubility of lead chromate is greatly reduced in presence of soluble chromates. In aqueous 0.0001 normal K<sub>2</sub>CrO<sub>4</sub> only 0.00006 gms. PbCrO<sub>4</sub> per liter was present. Results are given showing the solubility of PbCrO<sub>4</sub> in aqueous solutions of mixtures of acetic acid and ammonium acetate and of the reduction of the solubility of PbCrO<sub>4</sub> in aqueous acetic acid, ammonium acetate and of their mixtures, caused by the simultaneous presence of calcium chromate. The application of these results to the titrametric determination of lead is discussed.

SOLUBILITY OF LEAD CHROMATE IN AQUEOUS POTASSIUM HYDROXIDE SOLUTIONS  
(Lacland and Lepierre, 1891)

t° Grams KOH per 100 cc. Grams PbCrO<sub>4</sub> per 100 cc.

15	2.308	1.19
60	2.308	1.62
86	2.308	2.61
102	2.308	3.85

Fusion point data for mixtures of lead chromate and lead sulfate, lead chromate and lead molybdate, and lead chromate and lead tungstate are given by Jaeger and Germs, 1921.



## Pb LEAD

### BASIC LEAD CHROMATE

Charreton, 1952 reports the solubility product  $[Pb^{++}]^2 [OH^-]^2 [CrO_4^{=}] = 2.1 \times 10^{-32}$  at room temperature.

## F LEAD FLUORIDE $PbF_2$

### SOLUBILITY IN WATER

t°

9	0.6 gms. per liter (conductivity method)	(Kohlrausch, 1908)
18	0.64 gms. per liter (conductivity method)	(Kohlrausch, 1908)
25	0.66 gms. per liter (pH of solution = 5.3)	(Carter, 1928)
26.6	0.68 gms. per liter	(Kohlrausch, 1908)

Experiments upon the influence of the size of grain upon the solubility of lead fluoride in water are given by Duncan, 1923.

Data for the solubility of  $PbF_2$  in  $AlF_3$  solutions at 25° are given by Scott, 1947.

Data for the solubility of  $PbF_2$  in 0.086 - 12.82 molar KF solutions, and in 0.059 - 0.89 molar NaF solutions at 25° are reported by Talipov and Kutumov, 1956.

### SOLUBILITY OF LEAD FLUORIDE IN AQUEOUS SALT SOLUTIONS AT 18° - 20° (Golovatyj, 1940)

KF (N)	Millimoles $PbF_2$ per liter		
	0.1 N $KNO_3$	0.2 N $KNO_3$	0.5 N $KNO_3$
0.0	2.148	2.353	3.431
0.008	1.438	2.030	2.816
.016	1.154	1.526	2.723
.032	0.715	0.992	.880
.064	.342	.603	.732
.128	.224	.412	.438
.256	.239	.573	.504
.362	.315	.514	.527

100 cc. anhydrous hydrazine dissolve 6 gms.  $PbF_2$  at room temp. with decomposition. (Welsh and Broderson, 1915.)

100 gms. liquid sulfur dioxide ( $SO_2$ ) dissolve 0.053 gm.  $PbF_2$  at 0°. (Jander and Ruppolt, 1937.)

Melting point data are given for

$PbF_2 + PbI_2$	(Sandonnini, 1911)
$PbF_2 + PbO$	(Sandonnini, 1914)
$PbF_2 + Pb_3(PO_4)_2$	(Amadori, 1912, 1918, 1919)
$PbF_2 + Pb_3(VO_4)_2$	(Amadori, 1919)
$PbF_2 + NaF$	(Puchin and Baskow, 1913)
$PbF_2 + PbSO_4$	(Gladushchenko and Bergman, 1955)
$PbF_2 + CsF$	(Schmitz-Dumont, Bergerhoff and Hartet)
$PbF_2 + RbF$	(Schmitz-Dumont, Bergerhoff and Hartet)
$PbF_2 + Li_2SO_4 = PbSO_4 + 2LiF$	(Gladushchenko and Bergman, 1956)

SOLUBILITY OF TRIMETHYL, TRIETHYL, ETC. LEAD FLUORIDES IN  
SEVERAL SOLVENTS

(Krause and Pohland, 1922)

F

Compound and Formula	t°	Gms. compd. per 100 gms. of:			
		H <sub>2</sub> O	CH <sub>3</sub> OH	C <sub>2</sub> H <sub>5</sub> OH	C <sub>6</sub> H <sub>6</sub>
Tri methyl lead fluoride (CH <sub>3</sub> ) <sub>3</sub> PbF	30	5.51	8.24	6.89	0.028
	50	26.3	99.5	82.0	0.87
Tri ethyl lead fluoride (C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub> PbF	30	1.3	7.24	6.11	0.185
	50	7.04	90.0	75.1	0.60
Tri <u>n</u> propyl lead fluoride ( <u>n</u> C <sub>3</sub> H <sub>7</sub> ) <sub>3</sub> PbF	30.1	0.17	2.01	1.21	0.055
	50	0.23	4.94	3.53	0.082
Tri <u>iso</u> butyl lead fluoride ( <u>i</u> C <sub>4</sub> H <sub>9</sub> ) <sub>3</sub> PbF	30	0.12	1.76	1.09	0.042
	50	0.18	2.96	2.13	0.071
Tri <u>iso</u> amyl lead fluoride ( <u>i</u> C <sub>5</sub> H <sub>11</sub> ) <sub>3</sub> PbF	30.1	0.019	2.34	1.173	0.063
	50	0.022	6.32	4.55	0.004
Tri phenyl lead fluoride (C <sub>6</sub> H <sub>5</sub> ) <sub>3</sub> PbF	30	0.031	0.36	0.15	0.080
	50	0.10	1.45	0.24	0.092
Tri cyclo hexyl lead fluoride (C <sub>6</sub> H <sub>11</sub> ) <sub>3</sub> PbF	30	0.096	0.66	0.39	0.11

LEAD ANTIPYRINE FLUOBORATE [Pb(COC<sub>10</sub>H<sub>12</sub>N<sub>2</sub>)<sub>6</sub>](BF<sub>4</sub>)<sub>2</sub>

100 cc sat. solution of lead antipyrine boro fluoride in water contain 15.1 gm Pb(COC<sub>10</sub>H<sub>12</sub>N<sub>2</sub>)<sub>6</sub> (HF<sub>4</sub>)<sub>2</sub> at 20°. (Wilke-Dörfurt and Mureck, 1929.)

LEAD POTASSIUM HYDROGEN FLUORIDE 3KF·HF·PbF<sub>4</sub>

LEAD SODIUM FLUORIDE 2NaF·PbF<sub>4</sub>

Data for the solubility of these two salts in water and in aqueous solutions of H<sub>2</sub>F<sub>2</sub> at 25° are given by Clark, 1919.

LEAD FLUOPHOSPHATE  $\text{PbPO}_3\text{F}$ 

F

One liter sat. solution of lead fluophosphate in water contains 0.0099 gm.  $\text{PbPO}_3\text{F}$  per liter. (Lang, 1929.)

LEAD FLUOSILICATE  $\text{PbSiF}_6$ 

SOLUBILITY OF LEAD FLUOSILICATE IN WATER  
(Jatlov and Pinaevskaja, 1938)

t°	Gms. $\text{PbSiF}_6$ per 100 gms. sat. sol.		Solid Phase	t°	Gms. $\text{PbSiF}_6$ per 100 gms. sat. sol.		Solid Phase
0	65.48		$\text{PbSiF}_6 \cdot 4\text{H}_2\text{O}$	60	80.11		$\text{PbSiF}_6 \cdot 2\text{H}_2\text{O}$
20	68.97		"	65	80.75		"
20*	67.90 <sup>a</sup>		"	80	81.06		"
50	74.16		"	100	82.25		"
57	77.70		"				

\*d. = 2.4314

<sup>a</sup>Worthington and Haring, 1931

THE SYSTEM LEAD FLUOSILICATE - FLUOSILICIC ACID - WATER AT 20°  
(Jatlov and Pinaevskaja, 1938)

Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
$\text{H}_2\text{SiF}_6$	$\text{PbSiF}_6$			$\text{H}_2\text{SiF}_6$	$\text{PbSiF}_6$		
0.0	68.97		$\text{PbSiF}_6 \cdot 4\text{H}_2\text{O}$	13.93	43.10		$\text{PbSiF}_6 \cdot 4\text{H}_2\text{O}$
0.98	67.96		"	25.82	23.95		"
7.34	56.50		"	39.65	10.38		"

LEAD SUB IODIDE  $\text{PbI}$ 

1000 cc. sat. solution of lead sub iodide in water contain 0.35 milliequivalents  $\text{Pb I}$  at 25° as determined by the conductivity method. (Denham, 1918.)

LEAD IODIDE  $PbI_2$ SOLUBILITY IN WATER  
(Lichty, 1903)

t°	Density (H <sub>2</sub> O at 0°)	Grams $PbI_2$ per 100		
		cc. Solution	Grams H <sub>2</sub> O	Gms. Sat. Sol.
0	1.0006	0.0442	0.0442	-
13	-	-	-	0.041 (1)
15	0.9998	0.0613	0.0613	0.05 (2)
18-20	-	0.0665	-	- (3)
20	-	-	-	0.06 (2)
25	0.9980	0.0762	0.0764	-
-	-	-	-	0.076 (4)
-	-	-	-	0.077 (1)
-	-	0.0756	-	- (5)
30	-	-	-	0.09 (6)
35	0.9951	0.1035	0.1042	-
45	0.9915	0.1440	0.1453	-
50	-	-	-	0.17 (2)
55	0.9872	0.1726	0.1755	-
65	0.9827	0.2140	0.2183	-
80	0.9745	0.2937	0.3023	-
95	0.9671	0.3814	0.3960	-
100	-	0.420	0.436	-

(1) Boger, 1944

(4) Burrage, 1926

(2) Demassieux, 1923

(5) Lanford and Kiehl, 1941

(3) Golovatyj, 1940

(6) Sowerby, 1927

For additional data see Böttger, 1903; Kohlranach, 1904-5; Denhem, 1917; Näsänen, 1944, 1945.

SOLUBILITY OF LEAD IODIDE IN WATER AT TEMPERATURES ABOVE 100°  
(Benrath, Gjedebo, Schiffers and Wunderlich, 1937)

t°	Gms. $PbI_2$ per 100		Solid Phase	t°	Gms. $PbI_2$ per 100		Solid Phase
	gas.	sat. sol.			gas.	sat. sol.	
175	1.42		$PbI_2$	291	8.43		$PbI_2$
234	3.65		"	334	12.0 - 82		" + solution + melt
280	6.37		"	338	87.5		"
281	6.44		"	360	95.3		"

Data for the solubility of  $PbI_2$  in  $Pb(NO_3)_2$  and in  $Cd(NO_3)_2$  solutions are given by Yatsindrakli and Shatov, 1953. The  $K_{sp}$  was found to be  $1.05 \times 10^{-9}$ .

**Pb LEAD**

**SOLUBILITY OF LEAD IODIDE IN POTASSIUM IODIDE SOLUTIONS AT 25°**  
(Lanford and Kiehl, 1941)

Moles per 1000 gms. H <sub>2</sub> O		Moles per 1000 gms. H <sub>2</sub> O		Moles per 1000 gms. H <sub>2</sub> O	
KI	PbI <sub>2</sub>	KI	PbI <sub>2</sub>	KI	PbI <sub>2</sub>
0.0	164.1 x 10 <sup>-5</sup>	0.125	4.06 x 10 <sup>-5</sup>	0.275	7.30 x 10 <sup>-5</sup>
.010	28.1	.150	4.42	.300	8.17
.030	6.53	.175	4.90	.325	9.20
.060	4.60	.200	5.49	.350	10.23
.080	4.23	.225	5.98	.400	13.32
.100	4.01	.250	6.75		

**SOLUBILITY OF LEAD IODIDE IN AQUEOUS SALT SOLUTIONS AT 18° - 20°**  
(Golovatyj, 1940)

Millimoles PbI<sub>2</sub> per liter

KI(N)	KNO <sub>3</sub>						Ca(NO <sub>3</sub> ) <sub>2</sub>	
	0	0.1 N	0.2 N	0.5 N	1 N	1.5 N	0.1 N	0.2 N
0.0	1.442	1.601	1.917	2.296	2.632	3.240	2.662	2.534
0.008	0.347	0.554	0.862	1.686	1.965	2.940	1.632	1.594
.016	.154	.328	.609	1.432	1.692	2.659	0.995	.912
.032	.206	.214	.462	0.950	1.284	1.973	.404	.400
.064	.286	.322	.382	.742	0.862	1.328	.485	.494
.128	.307	.480	.501	.583	.742	0.918	.562	.532
.256	.413	.612	.654	.714	.624	.890	.930	.918
.340	.473				.649	.898		

**THE SYSTEM LEAD IODIDE - AMMONIUM IODIDE - WATER**  
(Demassieux, 1923)

Results at 20°			Results at 50°		
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
NH <sub>4</sub> I	PbI <sub>2</sub>		NH <sub>4</sub> I	PbI <sub>2</sub>	
3.54	0.029	PbI <sub>2</sub>	6.13	0.14	PbI <sub>2</sub>
6.06	0.03	"	9.91	0.15	"
7.02	0.10	" + PbI <sub>2</sub> ·NH <sub>4</sub> I·2H <sub>2</sub> O	13.47	0.29	" + PbI <sub>2</sub> ·NH <sub>4</sub> I·2H <sub>2</sub> O
14.50	0.20	PbI <sub>2</sub> ·NH <sub>4</sub> I·2H <sub>2</sub> O	18.07	0.34	PbI <sub>2</sub> ·NH <sub>4</sub> I·2H <sub>2</sub> O
33.34	0.30	"	24.08	0.50	"
45.80	0.92	"	45.87	3.49	"
51.66	1.63	"	54.79	8.51	"
56.71	2.96	"	61.35	16.06	" + NH <sub>4</sub> I
61.10	4.90	" + NH <sub>4</sub> I	61.95	9.88	NH <sub>4</sub> I
61.50	2.10	NH <sub>4</sub> I	63.98	6.24	"
61.72	0.0	"	66.46	0.0	"

SOLUBILITY OF LEAD IODIDE IN AQUEOUS SOLUTIONS OF SODIUM CHLORIDE AT 25°  
(Burrage, 1926)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
NaCl	PbI <sub>2</sub>		NaCl	PbI <sub>2</sub>	
0.00	0.0758	PbI <sub>2</sub>	0.234	0.110	PbI <sub>2</sub>
0.029	0.0778	"	0.586	0.141	"
0.059	0.0859	"	1.170	0.164	"
0.116	0.0951	"	2.980	0.179	"

Data for the solubility of PbI<sub>2</sub> in aqueous CdI<sub>2</sub> solutions are given by Monod-Herzen and Nguyen, 1958.

One liter sat. aqueous solution of iodine dissolves 0.00216 gm. mols. PbI<sub>2</sub> (0.996 gms.) at 20°. (Fedotieff, 1911-12.)

SOLUBILITY OF LEAD IODIDE IN ACETONE, ANILINE AND AMYL ALCOHOL  
(von Laszczynski, 1894)

Solvent	t°	Gms. PbI <sub>2</sub> per 100 Gms. Solvent
(CH <sub>3</sub> ) <sub>2</sub> CO	59	0.02
C <sub>6</sub> H <sub>5</sub> NH <sub>2</sub>	13	0.50
C <sub>6</sub> H <sub>5</sub> NH <sub>2</sub>	184	1.10
C <sub>5</sub> H <sub>7</sub> OH	133.5	0.02

SOLUBILITY OF LEAD IODIDE IN PYRIDINE  
(Heise, 1912)

t°	Gms. PbI <sub>2</sub> per 100 Gms. Pyridine	Solid Phase	t°	Gms. PbI <sub>2</sub> per 100 Gms. Pyridine	Solid Phase
-43.5 <sup>f</sup>	-	PbI <sub>2</sub> ·3C <sub>5</sub> H <sub>5</sub> N	35	0.188	PbI <sub>2</sub> ·2C <sub>5</sub> H <sub>5</sub> N
-37	0.166	"	57	0.190	"
-20	0.175	"	77	0.228	"
-9	0.186	"	92	0.290	"
0	0.200	"	98	0.340	"
+3	0.215	"	105	0.370	"
6 <sup>t</sup>	0.225	PbI <sub>2</sub> ·3C <sub>5</sub> H <sub>5</sub> N+PbI <sub>2</sub> ·2C <sub>5</sub> H <sub>5</sub> N	108	0.410	"
15	0.208	PbI <sub>2</sub> ·2C <sub>5</sub> H <sub>5</sub> N	112	0.445	"

<sup>f</sup>freezing point      <sup>t</sup>transfer point

100 gms. 95% formic acid dissolve 0.25 gm. PbI<sub>2</sub> at 19.8°. (Aschan, 1913.)

100 cc. anhydrous hydrazine dissolve 2 gms. PbI<sub>2</sub> at room temp. with decomposition. (Welsh and Brodersen, 1915.)

100 gms. liquid sulfur dioxide (SO<sub>2</sub>) dissolve 0.009 gm. PbI<sub>2</sub> at 0°. (Jander and Ruppolt, 1937.)

# Pb LEAD

Fusion-point data are given for:

$PbI_2 + AgI$  (Matthes, 1911; Tubaudt and Eggert, 1920)  
 $PbI_2 + PbO$  (Baroni, 1934; Van Klooster and Owens, 1935)

## 10 LEAD IODATE $Pb(IO_3)_2$

### SOLUBILITY IN WATER

$t^\circ$		
9.2	0.0134 gms. $Pb(IO_3)_2$ per liter	(Böttger, 1903)
18	0.019 gms. $Pb(IO_3)_2$ per liter	(Kohlrausch, 1908)
25	0.0307 gms. $Pb(IO_3)_2$ per liter	(Harkins and Winninghoff, 1911)
	0.0201 gms. $Pb(IO_3)_2$ per liter	(LaMer and Goldman, 1930)
	See also Keefer and Reiber, below	
25.8	0.023 gms. $Pb(IO_3)_2$ per liter	(Böttger, 1903)

### SOLUBILITY OF LEAD IODATE IN WATER AND AMINO ACID SOLUTIONS AT $25^\circ$ (Keefer and Reiber, 1941)

Two samples of lead iodate were prepared; one (I) by mixing  $Pb(NO_3)_2$  solution with  $KIO_3$  in a total volume of about 3 liters. The other (II) was prepared by the method of LaMer and Goldman (Vol. I, p. 1400) in which a much larger volume of water is used and no excess of  $K^+NO_3^-$  is allowed to accumulate. The solubility of the first sample in water was  $5.34 \times 10^{-5}$  moles per liter, in agreement with that found by Kohlrausch and by Harkins and Winninghoff (both above). The solubility of the second sample was identical with the similarly prepared sample of LaMer and Goldman:  $3.61 \times 10^{-5}$  L. and G. attributed this difference to the increased purity of their salt. The present authors feel that the difference in particle size explains the variation. Results given below are in moles per 1000 gms. of water.

Results in Glycine Solutions				Results in Alamine Solutions			
Preparation I		Preparation II		Preparation I		Preparation II	
$Pb(IO_3)_2$		$Pb(IO_3)_2$		$Pb(IO_3)_2$		$Pb(IO_3)_2$	
Glycine	$\times 10^5$	Glycine	$\times 10^5$	Alamine	$\times 10^5$	Alamine	$\times 10^5$
0.00502	5.47	0.0249	4.05	0.0	5.34	0	3.61
0.01003	5.63	0.0499	4.45	0.0181	5.56	0.0248	4.05
0.01505	5.65	0.0749	4.81	0.01521	5.65	0.0495	5.66
0.02510	6.15	0.100	5.09	0.02163	5.69	0.075	5.06
0.05026	6.40			0.02704	6.08	0.100	5.57
0.08052	6.75			0.05419	6.30		
0.10074	7.51			0.08142	7.17		
0.1210	7.70						
0.2023	9.41						

SOLUBILITY OF LEAD IODATE IN AQUEOUS SALT SOLUTIONS AT 25°  
(H. and W., 1911)

Gms. per Liter		Gms. per Liter		Gms. per Liter	
KNO <sub>3</sub>	Pb(IO <sub>3</sub> ) <sub>2</sub>	KIO <sub>3</sub>	Pb(IO <sub>3</sub> ) <sub>2</sub>	Pb(NO <sub>3</sub> ) <sub>2</sub>	Pb(IO <sub>3</sub> ) <sub>2</sub>
0.202	0.0318	0.0113	0.0199	0.0165	0.0242
1.011	0.0363	0.0227	0.0122	0.165	0.0115
5.055	0.0567			1.656	0.0052
20.220	0.0708			16.561	0.0045
				82.805	0.0078
				496.83	0.0418

SOLUBILITY OF LEAD IODATE IN AQUEOUS SALT SOLUTIONS AT 25°  
(LaMer and Goldman, 1930)

10

Aqueous Solvent Gm. Mols. Pb(IO<sub>3</sub>)<sub>2</sub> per liter

Water alone	0.0000361
0.1 normal NaNO <sub>3</sub>	0.0000699
0.1 normal KNO <sub>3</sub>	0.0000694
0.1 normal KCl	0.0000829
0.1 normal NaCl	0.0000830

SOLUBILITY OF LEAD IODATE IN AMMONIUM ACETATE - PERCHLORATE  
SOLUTIONS AT 25°  
(Edmonds and Birnbaum, 1940)

The solutions were prepared of unit ionic strength.

Moles per liter			Moles per liter		
NH <sub>4</sub> C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>	NH <sub>4</sub> ClO <sub>4</sub>	Pb(IO <sub>3</sub> ) <sub>2</sub>	NH <sub>4</sub> C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>	NH <sub>4</sub> ClO <sub>4</sub>	Pb(IO <sub>3</sub> ) <sub>2</sub>
0.0	1.00	1.950 x 10 <sup>-4</sup>	0.10	0.90	4.370 x 10 <sup>-4</sup>
.01	0.99	2.842	.20	.80	5.584
.02	.98	3.036	.50	.50	7.265
.05	.95	3.557	1.00	0.0	9.11

Data for the solubility of Pb(IO<sub>3</sub>)<sub>2</sub> in sodium propionate, lactate, and monochloroacetate solutions at 35° are given by Mohanty and Aditya, 1955. Solubilities in aqueous HNO<sub>3</sub> and NaNO<sub>3</sub> solutions are given by Misra and Pani, 1957, 1957a.

LEAD PERMANGANATE (BASIC) Pb(MnO<sub>4</sub>)<sub>2</sub>·3PbO

MnO

The K<sub>sp</sub> is given as [Pb<sup>++</sup>] [OH<sup>-</sup>]<sup>3/2</sup> [MnO<sub>4</sub><sup>-</sup>]<sup>1/2</sup> = 10<sup>-19</sup> at room temperature by Charreton, 1953.



Pb LEAD

MnO LEAD MOLYBDATE  $PbMoO_4$

SOLUBILITY OF LEAD MOLYBDATE IN AQUEOUS SOLUTIONS OF PERCHLORIC ACID  
AND OF MIXTURES OF PERCHLORIC ACID AND SALTS AT 25°  
(Willard and Kassner, 1930a)

Composition of solvent in mols. per liter	Dissolved $PbMoO_4$	
	Gms. per 100 cc.	Millimols. per 100 cc.
0.01 mol. $HClO_4$	0.0016	0.0043
0.5 " "	0.0136	0.0370
1.0 " "	0.0373	0.1016
2.0 " "	0.1176	0.3204
3.0 " "	0.2436	0.6639
0.01 " " + 0.01 mol. $Pb(ClO_4)_2$	0.0002	0.0005
0.5 " " + 0.01 " "	0.0005	0.0013
0.5 " " + 0.05 " "	0.0004	0.0011
0.5 " " + 0.10 " "	0.00006 (1)	0.0001 (1)
0.5 " " + 0.20 " "	0.00004 (1)	0.0001 (1)
0.5 " " + 0.02 " $Na_2MoO_4$	0.0004 (2)	0.0011 (2)
0.5 " " + 0.05 " "	0.00027 (2)	0.0007 (2)

Above 3.0 mol.  $HClO_4$ ,  $PbMoO_4$  decomposes to form solid  $MoO_3$ .

SOLUBILITY OF LEAD MOLYBDATE IN AQUEOUS SOLUTIONS OF NITRIC ACID AND  
OF MIXTURES OF NITRIC ACID AND SALTS AT 25°  
(Willard and Kassner, 1930a)

Composition of solvent in mols. per liter	Dissolved $PbMoO_4$	
	Gms. per 100 cc.	Millimols. per 100 cc.
0.1 mol. $HNO_3$	0.0020	0.0060
0.5 " "	0.0244	0.0665
1.0 " "	0.1086	0.2958
0.5 " " + 0.1 mol. $Pb(NO_3)_2$	0.00032 (1)	0.0009 (1)
0.5 " " + 0.2 " "	0.002 (1)	0.0005 (1)
0.5 " " + 0.02 " $Na_2MoO_4$	0.00064 (2)	0.0017 (2)
0.5 " " + 0.05 " "	0.0007 (2)	0.0019 (2)

Above 1.0 mol.  $HNO_3$ ,  $PbMoO_4$  decomposes to form solid  $MoO_3$ .

- (1) Molybdenum determined colorimetrically. (2) Lead determined colorimetrically.

Fusion-point data for mixtures of  $PbMoO_4$  +  $PbSO_4$  are given by Germs, 1907, Belyaev, 1952 and Jaeger and Germs, 1921.

LEAD AZIDE  $Pb(N_3)_2$   
 $Pb(N_3)_2 \cdot PbO$

N

The solubility in water at 20° is  $8.5 \times 10^{-4}$  moles per liter. The  $K_{sp}$  of the basic azide is  $[Pb^{++}][a_{OH^-}][N_3^-] = 3 \times 10^{-15}$  at 20°. (Feitknecht and Sahli, 1954.)

## BASIC LEAD NITRITE - NITRATE

NO

SOLUBILITY OF LEAD NITRITE - NITRATE,  $Pb(NO_2)_2 \cdot Pb(NO_3)_2 \cdot 2Pb(OH)_2 \cdot 2H_2O$ ,  
 IN AQUEOUS SOLUTIONS OF ACETIC ACID AT 13.3°  
 (Chilesotti, 1908)

Normality of Acetic Acid	Gms. PbO per 100 cc. Sat. Sol.	Normality of Acetic Acid	Gms. PbO per 100 cc. Sat. Sol.
0	0.601	0.25	5.450
0.05	1.323	0.50	9.690
0.10	2.185	0.75	15.874

LEAD NITRATE  $Pb(NO_3)_2$ 

NO

## SOLUBILITY OF WATER

- |                                  |                               |
|----------------------------------|-------------------------------|
| (1) Kremers, 1954                | (6) Akerloff and Turck, 1935  |
| (2) Euler, 1904                  | (7) Richards and Schumb, 1918 |
| (3) Fedotieff, 1911-12           | (8) LeBlanc and Noyes, 1890   |
| (4) Glasstone and Saunders, 1923 | (9) Mulder, 1864              |
| (5) Fock, 1897                   | (10) Malquori, 1928d          |

t°	Gms. $Pb(NO_3)_2$ per 100 gms. $H_2O$	density	Ref	t°	Gms. $Pb(NO_3)_2$ per 100 gms. $H_2O$	density	Ref
0	38.8	-	(1)	30	66	-	(1)
	40.25	-	(4)	40	75	-	(1)
10	48.3	-	(1)		69.4	-	(9)
17	54.0	-	(1)	50	85	-	(1)
	52.76	1.405	(2)		81.1	-	(4)
20	56.5	-	(1)		78.7	-	(9)
	55.11	1.419	(3)	60	95	-	(1)
	55.8	-	(8)		88	-	(9)
25	60.6	-	(1)	80	115	-	(1)
	59.60	-	(7)		107.6	-	(9)
	61.2	1.459	(5)	100	138.8	-	(1)
	59.7	-	(6)		125.5	-	(4)
	58.9	-	(10)		127	-	(9)

SOLUBILITIES OF THE NITRATES OF LEAD ISOTOPES IN WATER AT 25°.02  
(Richards and Schumb, 1918)

The two samples of nitrate were prepared, one from salt made from "test lead" free from silver and tin, and the other from pure Australian uranio-lead nitrate. Saturation was approached from above and below the selected temperature, by constant rotation of a large excess of the solid with distilled water. Saturation was reached with extreme slowness. At least 24 hours were required. Weighed portions of the saturated solution were evaporated with  $\text{H}_2\text{SO}_4$  and the lead sulfate weighed after heating to constant weight at 350°.

Sample of Lead Nitrate from:	Gms. $\text{Pb}(\text{NO}_3)_2$ per 100 gms.	
	Sat. sol.	Water
Common Lead	37.342	59.597
Uranio Lead	37.280	59.439
Difference	0.062	0.158

An experiment similar to the above is reported by Fajans, Fischler and Lambert, 1916. These authors prepared very pure nitrate from ordinary commercial lead of at. wt. 207.15 and from lead prepared from Colorado carnotite, and having an at. wt. of 206.59. Saturation was approached from above and below by constant agitation for at least two days at 24°.43. Very accurate specific gravity determinations of the saturated solutions were also made. The determination of the lead was made as sulfate.

Sample of Lead Nitrate from:	$d_{24}^{45}$ of sat. sol.	$\text{PbSO}_4$ found in 3.0445 cc. of sat. sol.	Mol. Solubility
Ordinary Lead	$1.444499 \pm 0.000013$	1.4693	= 0.004855
Carnotite	$1.443587 \pm 0.000016$	1.4740	= 0.004861
Joachimsthaler Pechblend	$1.443586 \pm 0.0000015$		
		Difference	0.000006

The authors conclude from the density experiment that a difference exists in the sp. gr. of the saturated solutions of the nitrates of lead isotopes which is slightly greater than that calculated. The difference in the molecular solubility is less than 1%, while the difference in atomic weight is 2.7%.

THE SYSTEM LEAD OXIDE - NITROGEN PENTOXIDE - WATER  
(Denham and Kidson, 1931)

Results at 25°

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{N}_2\text{O}_5$	$\text{PbO}$			$\text{N}_2\text{O}_5$	$\text{PbO}$	
1.022	0.71	2.09	$2 \cdot 1 \cdot 2^{1/2}$	1.257	12.06	14.09	$\text{Pb}(\text{NO}_3)_2$
1.134	4.67	9.77	"	1.194	14.30	8.16	"
1.223	7.68	15.03	"	1.192	14.60	7.40	"
1.287	8.80	18.39	"	1.236	30.59	1.59	"
1.452	12.27	26.38	" + $\text{Pb}(\text{NO}_3)_2$	1.243	30.70	1.38	"
1.408	11.54	23.61	$\text{Pb}(\text{NO}_3)_2$	1.290	40.05	0.49	"
1.328	11.83	18.88	"				

## THE SYSTEM LEAD OXIDE - NITROGEN PENTOXIDE - WATER--Cont.

## Results at 50°

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	N <sub>2</sub> O <sub>5</sub>	PbO			N <sub>2</sub> O <sub>5</sub>	PbO	
1.022	0.60	2.69	2·1·2 <sup>1</sup> / <sub>2</sub>	1.420	14.33	23.42	Pb(NO <sub>3</sub> ) <sub>2</sub>
1.117	4.39	8.99	"	1.357	14.22	19.77	"
1.229	7.24	15.81	"	1.279	15.08	15.64	"
1.322	9.55	20.47	"	1.234	17.92	10.08	"
1.436	11.60	25.45	"	1.211	23.75	4.27	"
1.590	14.47	31.00	" + Pb(NO <sub>3</sub> ) <sub>2</sub>	1.244	32.32	1.74	"
1.511	14.22	26.05	Pb(NO <sub>3</sub> ) <sub>2</sub>	1.308	45.33	0.04	"



## BASIC LEAD NITRATES

NO

Composition Wt. %			Solubility at 30° Gms. per 100 gms. H <sub>2</sub> O
Pb	NO <sub>3</sub>	OH	
72.5	21.5	6.0	1.42
79.6	8.1	11.3	0.25

(Pauley and Testerman, 1954)

SOLUBILITY OF LEAD NITRATE IN AQUEOUS SOLUTIONS OF COPPER NITRATE AT 20°  
(Fedotieff, 1911-12)

Gms. per 100 Gms. H <sub>2</sub> O		d <sub>20</sub> of Sat. Sol.	Gms. per 100 Gms. H <sub>2</sub> O		d <sub>20</sub> of Sat. Sol.
Cu(NO <sub>3</sub> ) <sub>2</sub>	Pb(NO <sub>3</sub> ) <sub>2</sub>		Cu(NO <sub>3</sub> ) <sub>2</sub>	Pb(NO <sub>3</sub> ) <sub>2</sub>	
0	55.11	1.419	37.96	13.08	1.360
7.7	39.34	1.354	60.32	8.19	1.451
15.04	27.80	1.322	83.11	5.37	1.546
24.63	19.05	1.321	100.29	3.53	1.622
33.25	14.70	1.343	127.70*	2.33*	1.700

\*Solid phase in contact with this solution = Pb(NO<sub>3</sub>)<sub>2</sub> + Cu(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O.100 gms. H<sub>2</sub>O sat. with Pb(NO<sub>3</sub>)<sub>2</sub> + KNO<sub>3</sub> at 20° dissolve 95.39 gms. Pb(NO<sub>3</sub>)<sub>2</sub> + 61.05 gms. KNO<sub>3</sub>. (LeBlanc and Noyes, 1890.)

Pb LEAD

THE SYSTEM LEAD NITRATE - SODIUM NITRATE - WATER  
(Glasstone and Saunders, 1923)

	Results at 0°		Results at 25°		Results at 50°		Solid Phase at each Temperature
	Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		
	NaNO <sub>3</sub>	Pb(NO <sub>3</sub> ) <sub>2</sub>	NaNO <sub>3</sub>	Pb(NO <sub>3</sub> ) <sub>2</sub>	NaNO <sub>3</sub>	Pb(NO <sub>3</sub> ) <sub>2</sub>	
	0.0	28.70	6.02	30.89	0.0	44.79	
NO	2.91	25.80	10.04	27.86	4.32	40.27	Pb(NO <sub>3</sub> ) <sub>2</sub>
			20.94	22.33	8.75	35.77	"
	Results at 100°		30.08	18.99	17.55	29.22	"
			36.43	16.86	29.87	22.88	"
	0.00	55.65	40.32	15.47	43.84	17.25	" + NaNO <sub>3</sub>
	4.24	50.78	41.32	13.17	47.09	11.35	NaNO <sub>3</sub>
			45.71	4.30	49.80	6.35	"
			47.86	0.00	53.29	0.00	"

100 gms. H<sub>2</sub>O sat. with Pb(NO<sub>3</sub>)<sub>2</sub> + NaNO<sub>3</sub> at 20° dissolve 38.42 gms.  
Pb(NO<sub>3</sub>)<sub>2</sub> + 84.59 gms. NaNO<sub>3</sub>. (LeBlanc and Noyes, 1890.)

Results at various temperatures

(Isaac, 1908)

(The several mixtures were enclosed in sealed tubes and heated until only one or two very small crystals remained undissolved. The temperature was then determined at which the edges of these crystals just showed a change from sharp to round or vice versa.)

Results for Lead Nitrate as  
Solid Phase

t° of Saturation	Gms. per 100 Gms. Sat. Sol.	
	NaNO <sub>3</sub>	Pb(NO <sub>3</sub> ) <sub>2</sub>
32	34.42	19.69
35.5	34.15	20.33
39.5	33.71	21.35
44	33.35	22.19
49.1	32.94	23.15
55	32.60	23.93
58	32.47	24.24
62	32.33	24.57
65	32.19	24.89

Results for Sodium Nitrate as  
Solid Phase

t° of Saturation	Gms. per 100 Gms. Sat. Sol.	
	NaNO <sub>3</sub>	Pb(NO <sub>3</sub> ) <sub>2</sub>
21	40.97	13.62
26.5	42.04	13.38
31	43.18	12.88
38.8	44.63	12.78
41	45.11	12.94
44.25	46.03	12.45
51	47.28	12.50
58	49.03	11.76
64	49.92	11.56

SOLUBILITY OF MIXED CRYSTALS OF LEAD NITRATE AND STRONTIUM NITRATE  
IN WATER AT 25°  
(Fock, 1897)

Mol. % in Solution		Gms. per 100 cc. Solution		Sp. Gr. of Solutions	Mol. % in Solid Phase	
Pb(NO <sub>3</sub> ) <sub>2</sub>	Sr(NO <sub>3</sub> ) <sub>2</sub>	Pb(NO <sub>3</sub> ) <sub>2</sub>	Sr(NO <sub>3</sub> ) <sub>2</sub>		Pb(NO <sub>3</sub> ) <sub>2</sub>	Sr(NO <sub>3</sub> ) <sub>2</sub>
100	0	46.31	0	1.4472	100	0
87.41	12.39	50.47	4.56	1.4336	99.05	0.95
78.68	21.32	53.92	8.14	1.4288	98.11	1.89
56.39	43.61	45.34	17.81	1.4263	97.02	2.98
60.29	39.71	44.48	18.74	1.4245	96.06	3.94
33.70	36.30	25.23	35.03	1.4468	83.84	16.16
24.58	75.42	19.13	37.54	1.4867	32.88	67.12
0	100	0	71.04	1.5141	0	100

NO

SOLUBILITY OF LEAD NITRATE IN AQUEOUS SOLUTIONS OF METHYL ALCOHOL AT 25°  
(Akerlof and Turck, 1935)

Wt. % CH <sub>3</sub> OH in solvent	Gm. Mols. Pb(NO <sub>3</sub> ) <sub>2</sub> per 1000 gms. solvent	Wt. % CH <sub>3</sub> OH in solvent	Gm. Mols. Pb(NO <sub>3</sub> ) <sub>2</sub> per 1000 gms. solvent
0.0	1.799	60.0	0.2800
20.08	0.8768	70.0	0.1905
30.0	0.6730	80.1	0.1237
40.0	0.5151	90.02	0.0752
50.05	0.3820	100.00	0.0423

SOLUBILITY OF LEAD NITRATE IN ETHYL AND METHYL ALCOHOL

	Gms. Pb(NO <sub>3</sub> ) <sub>2</sub> per 100 Gms. Solvent at				
	4°	8°	22°	40°	50°
Aq. C <sub>2</sub> H <sub>5</sub> OH (Sp. Gr. 0.9282)	4.96	5.82	8.77	12.8	14.9 (G)
Abs. C <sub>2</sub> H <sub>5</sub> OH	-	-	0.04 (20.5°)	-	- (De B)
Abs. CH <sub>3</sub> OH	-	-	1.37 "	-	- "

(Gerardin, 1865; de Bruyn, 1892)

SOLUBILITY OF LEAD NITRATE IN PYRIDINE  
(Walton and Judd, 1911)

t°	Gms. Pb(NO <sub>3</sub> ) <sub>2</sub> per 100 Gms. Pyridine	Solid Phase	t°	Gms. Pb(NO <sub>3</sub> ) <sub>2</sub> per 100 Gms. Pyridine	Solid Phase
-19.4	2.93	Pb(NO <sub>3</sub> ) <sub>2</sub> ·4C <sub>5</sub> H <sub>5</sub> N	14.72	6.13	Pb(NO <sub>3</sub> ) <sub>2</sub> ·4C <sub>5</sub> H <sub>5</sub> N
-14.5	2.14	"	19.97	6.78	"
-10	1.90	"	24.75	8.56	"
0	3.54	"	25	5.46 <sup>a</sup>	"
	4.39 <sup>a</sup>	"	30.03	10.98	"
5.4	3.93	"	34.97	13.20	"
8.7	5.39	"	40.03	16.94	"

# Pb LEAD

## SOLUBILITY OF LEAD NITRATE IN PYRIDINE--Cont.

t°	Gms. Pb(NO <sub>3</sub> ) <sub>2</sub> per 100 gms. Pyridine		Solid Phase	t°	Gms. Pb(NO <sub>3</sub> ) <sub>2</sub> per 100 gms. Pyridine		Solid Phase
45	22.03		Pb(NO <sub>3</sub> ) <sub>2</sub> ·4C <sub>5</sub> H <sub>5</sub> N	89.93	90.21		Pb(NO <sub>3</sub> ) <sub>2</sub> ·3C <sub>5</sub> H <sub>5</sub> N
49.97	29.37		"	94.94	128.06		"
51 <sup>t</sup>	-		" + Pb(NO <sub>3</sub> ) <sub>2</sub> ·3C <sub>5</sub> H <sub>5</sub> N	96 <sup>t</sup>	-		" + 3Pb(NO <sub>3</sub> ) <sub>2</sub> ·2C <sub>5</sub> H <sub>5</sub> N
59.52	36.70		Pb(NO <sub>3</sub> ) <sub>2</sub> ·3C <sub>5</sub> H <sub>5</sub> N	99.89	143.36		3Pb(NO <sub>3</sub> ) <sub>2</sub> ·2C <sub>5</sub> H <sub>5</sub> N
70	47.29		"	104.90	152		"
80	61.60		"	109.90	163.80		"

NO

<sup>t</sup>transfer point

0.39 gms. Pb(NO<sub>3</sub>)<sub>2</sub> are dissolved in 100 gms. of saturated solution in tri-n-butyl phosphate (Wendlandt and Bryant, 1956).

100 cc. anhydrous hydrazine dissolve 52 gms. lead nitrate at room temperature with formation of a yellow precipitate. (Welsh and Broderson, 1915.)

Fusion-point data are given for mixtures of Pb(NO<sub>3</sub>)<sub>2</sub> + TlNO<sub>3</sub> by Glass, Laybourne and Madgin, 1932.

# NbO LEAD NIOBATES Pb(NbO<sub>3</sub>)<sub>2</sub> PbNb<sub>12</sub>O<sub>37</sub>

The Ksp of Pb(NbO<sub>3</sub>)<sub>2</sub> at 20° is 2.4 x 10<sup>-17</sup>. (Lapitskii and Pchelkin, 1956.)

The solubility of Pb<sub>7</sub>Nb<sub>12</sub>O<sub>37</sub>·23H<sub>2</sub>O is 0.025 mg. per liter at 25°. (Efimov, Pchelkin and Lapitskii, 1954.) For data at 20° see Pchelkin and Lapitskii, 1956.

# O LEAO MONOXIDES PbO

## SOLUBILITY IN WATER (Bottger; Ruer, 1906)

No.	Description of Oxide	Gm. Equiv. per Liter	Gms. per Liter
1.	Yellow Oxide, by boiling Pb hydroxide with 10% NaOH	1.03 x 10 <sup>-4</sup>	0.023
2.	Red Oxide, by boiling Pb hydroxide with conc. NaOH	0.56 x 10 <sup>-4</sup>	0.012
3.	Yellow Oxide, by heating No. 1 to 630°	1.05 x 10 <sup>-4</sup>	0.023
4.	Yellow Oxide, by heating No. 2 to 740°	1.00 x 10 <sup>-4</sup>	0.022

(Cont.)

## SOLUBILITY IN WATER--Cont.

No.	Description of Oxide	Gm. Equiv. per Liter	Gms. per Liter
5.	Yellow Oxide, by heating com. yellow brown oxide to 620°	$1.09 \times 10^{-4}$	0.024
6.	Yellow Brown Oxide commercially pure	$1.10 \times 10^{-4}$	0.024
7.	Yellow Brown Oxide, by long rubbing of No. 5	$1.12 \times 10^{-4}$	0.025

Bottger gives for three samples of lead oxide, 0.017, 0.021, and 0.013 gm. per liter respectively.

One liter  $H_2O$  dissolves 0.068 gm.  $PbO$  at 18°, solid phase  $PbO$  and 0.1005 gm.  $PbO$  at 18°, solid phase  $Pb_2O_2(OH)_2$ . (Pleasner, 1907.)

0

SOLUBILITY OF LEAD OXIDE ( $PbO$ ) IN WATER  
(Remy and Kuhlmann, 1924; Remy, 1925)

Millimols. $PbO$ per liter at 18°	Milligrams. $PbO$ per liter at 20°	Method
0.055	12.34	Calc. from electrolytic conductivity.
0.055	12.39	Conducto titrametric determination of used amt. of acid for saturation

The SOLUBILITY PRODUCT of red lead monoxide in water at 25° is  $1.17 \times 10^{-15}$  and the solubility is  $0.26 \times 10^{-3}$  gm. mol. per liter (Glasstone, 1921). The author states that this rough comparison emphasizes the uncertainty of the ionization of lead monoxide in water and the futility of determining the solubility of lead monoxide or hydroxide in water by the conductivity method.

100 cc. anhydrous hydrazine dissolve 1 gm. lead oxide (red) at room temp. (Welsh and Brodersen, 1915.)

Data are given for the following systems:

$PbO + PbS$	(Kohlmeyer and Monzer, 1943)
$PbO + PbS + Pb$ at 1050°	(Kohlmeyer and Monzer, 1943)
$PbO + PbSO_4 + Pb$ at 1050°	(Kohlmeyer and Monzer, 1943)
$PbO + MoO_3$	(Jaeger and Germs, 1921)
$PbO + SO_3$	(Jaeger and Germs, 1921)
$PbO + WO_3$	(Jaeger and Germs, 1921)
$PbO + P_2O_5$	(Amadori, 1916-17)
$PbO + V_2O_5$	(Amadori, 1916-17)
$PbO + Pb_3(PO_4)_2$	(Amadori, 1914)
$PbO + Pb_3(VO_4)_2$	(Amadori, 1914)
$PbO + PbSO_4$	(Lander, 1949; Schenck and Albers, 1919; Schenck and Rossbach, 1908)
$PbO + SiO_2$	(Weiller, 1911; Cooper, Shaw and Loomis, 1909; Geller, Creamer and Bunting, 1934)
	(Shartis, Spinner, and Smock, 1948)
	(McMurdie and Bunting, 1939)
$PbO + B_2O_3$	(McMurdie, 1941; Shartis, Spinner, and Smock, 1948; Geller and Bunting, 1939)



# Pb LEAD

## OH LEAD HYDROXIDE $Pb(OH)_2$ or $PbO \cdot xH_2O$

Oka, 1940 reports the solubility of  $Pb(OH)_2$  in water to be  $4.8 \times 10^{-6}$  moles per liter.

Results for the solubility of hydrated lead oxide in water and dilute  $H_2SO_4$  solutions are given by Sehna1 (1909). The results are considerably higher than the above, viz. 0.1385 gm. Pb per 1000 cc.  $H_2O$  at  $20^\circ$ ; with increase of  $H_2SO_4$  the solubility decreases rapidly.

Data for the formation of lead hydroxide by hydrolysis of lead iodate and the solubility in perchloric acid solutions at  $35^\circ$  are reported by Pattanaik and Pani, 1957.

Korenman, Frum and Chebakova, 1952 report the Ksp of  $Pb(OH)_2$ , as determined by potentiometric titrations [ $NaOH$  vs.  $Pb(NO_3)_2$ ] to be  $1.1 \times 10^{-20}$  at  $22^\circ$ ,  $3.2 \times 10^{-20}$  at  $40^\circ$ , and  $3.5 \times 10^{-20}$  at  $60^\circ$ .

### THE SYSTEM $PbO - NaOH - H_2O$

#### Results of Sokolova and Chizhikov, 1957

Results at $18^\circ$			Results at $60^\circ$			Results at $95^\circ$		
Sat.	Sol. Wt. %	Solid Phase	Sat.	Sol. Wt. %	Solid Phase	Sat.	Sol. Wt. %	Solid Phase
PbO	$Na_2O$		PbO	$Na_2O$		PbO	$Na_2O$	
0.7	0.465	A	0.21	0.48	A	5.9	0.9	A
1.5	1.22	A	2.71	1.66	A	9.8	3.1	A
2.66	2.68	A	3.75	4.2	A	13.7	5.0	A
3.15	6.95	A	5.7	7.5	A	15.6	8.87	A
3.1	9.4	A	5.8	9.93	A	15.4	11.35	A
3.1	12.8	A	6.3	11.3	A	15.2	12.68	A
2.7	15.1	A	6.7	13.3	A	13.25	15.5	A
2.38	15.2	A	5.95	13.4	A	11.8	16.2	A
1.94	16.9	A	6.7	14.5	A	10.8	18.01	A
1.8	18.9	A	7.0	16.5	A	8.7	19.5	A
2.15	19.8	A	6.4	17.8	A	7.2	20.2	D
1.2	20.8	B	5.6	20.3	A	9.4	21.8	D
1.6	24.9	B	4.53	21.7	A	12.0	24.2	D
1.54	28.2	B	6.03	21.9	C	14.3	24.33	D
1.48	30.5	B	7.92	23.1	C	16.3	27.94	D
1.92	31.2	B	9.95	25.33	C	15.8	28.9	D
1.66	31.5	B	8.4	25.4	C	15.7	31.55	D
1.8	34.0	B	8.1	30.8	C	13.8	35.9	D
			8.6	33.1	C	12.1	36.0	D
			4.98	35.4	C	10.8	37.8	D

A = PbO

B =  $PbO \cdot 2Na_2O \cdot 17H_2O$

C =  $PbO \cdot Na_2O \cdot 10H_2O$

D =  $2PbO \cdot Na_2O \cdot 7H_2O$

SOLUBILITY OF DIFFERENT FORMS OF LEAD HYDROXIDE IN AQUEOUS NORMAL  
SOLUTIONS OF SODIUM HYDROXIDE

Form of PbO used	Manner of attaining saturation	t°	Gm. mol. PbO per liter sat. sol.
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Results of Glasstone, 1921:

Ordinary	Gentle shaking (14 days)	20	0.045 (aver of 8 det.)	
Ordinary	Vigorous shaking (14 days)	20	0.047	
Reddish-brown-yellow	Stirring gently with air bubbles	20	0.039	
Red	Stirring gently with air bubbles	20	0.035	OH

Results of Appleby and Reid, 1922

Yellow	Stirring gently with air bubbles	20	0.0237*
Red	Stirring gently with air bubbles	20	0.0140*

\*Mean values obtained after stirring with slow stream of air up to 5 months. According to Glasstone the differences are explainable on the grounds of the varying size of the particles. Appelby and Reid consider that the results indicate that the yellow and red forms are polymorphic modifications of lead monoxide.

SOLUBILITY OF LEAD HYDROXIDE IN AQUEOUS SOLUTIONS OF SODIUM HYDROXIDE  
(Rubenbauer, 1902)

(Moist lead hydroxide used, temperature not given.)

Amount of Na in 20 cc.	Amount of Pb in 20 cc.	Mol. Dilution of NaOH	Grams per 100 cc. Solution	
			NaOH	Pb(OH) <sub>2</sub>
0.2024	0.1012	2.27	1.759	0.590
0.3196	0.1736	1.44	2.778	1.010
0.5866	0.3532	0.785	5.10	2.056
0.9476	0.4071	0.485	8.235	2.370
1.7802	0.5170	0.258	15.470	3.010

SOLUBILITY OF HYDRATED LEAD MONOXIDE AT 25° IN AQUEOUS SOLUTIONS OF:  
(Glasstone, 1922)

Sodium Hydroxide

Normality of Aq. NaOH	Gm. mols. per liter sat. sol.		
	PbO·xH <sub>2</sub> O	Na plumbite	Residual NaOH
0.0499	0.00392	0.00347	0.0464
0.1177	0.00881	0.00836	0.1093
0.2496	0.0178	0.01735	0.2323
0.4993	0.0345	0.03405	0.5653
0.7489	0.0484	0.04795	0.7010
0.9985	0.0620	0.06155	0.9370

(Cont.)

# Pb LEAD

## Potassium Hydroxide

Normality of Aq. KOH	Gm. mols. $PbO \cdot xH_2O$ per liter sat. sol.
0.1177	0.00892
0.9985	0.0631

The above repetition of Herz, 1901, experiments fail to confirm his results. Pleissner's (1907) hydrated oxide was used.

Results similar to the above for the solubility of the several polymorphic forms of lead oxide in aqueous NaOH solutions up to 20 normal and at both 20° and 84° are given by Applebey and Powell, 1931. The black modification was shown to owe its color to metallic lead.

More recent very careful determinations of the solubility of lead oxides in water and in aqueous solutions of sodium hydroxide at 25°, are given by Garrett, Vellenger and Fontana, 1939. The numerous determinations as plotted by the authors show that most of those made with red lead oxide fall in one curve and the determinations made with yellow, white, and black lead oxide fall more or less close to another curve. The approximate values read from these curves are as follows.

Gm. Mols. per 1000 gms. $H_2O$			Gm. Mols. per 1000 gms. $H_2O$		
NaOH	Red PbO	yellow, white and black PbO	NaOH	Red PbO	yellow, white and black PbO
0.000	0.000226	0.000477	0.004	0.00022	0.0004
0.0005	0.0001	0.0003	0.005	0.00027	0.0005
0.0010	0.0001	0.00022	0.006	0.00032	0.00057
0.002	0.00013	0.00026	0.008	0.0004	0.0007
0.003	0.00017	0.00036	0.010	0.0005	0.00085

The data were used by the authors for various theoretical calculations.

Data for the equilibrium in the system lead oxide + lead hydroxide + plumbite + NaOH +  $H_2O$  are given by Erich Muller, 1924a.

## OH LEAD HYDROXIDE (ic) $Pb(OH)_4$

The solubility in water is  $2.6 \times 10^{-14}$  moles per liter (Oka, 1940).

The  $K_{sp}$  of  $Pb_3O_4$  in water at 20° is reported to be  $10^{-50.3}$  by Bovalini and Casini, 1953.

LEAD SESQUIOXIDE  $Pb_3O_4$ SOLUBILITY OF LEAD SEAQUIOXIDE ( $Pb_2O_3$ ) IN AQUEOUS SODIUM HYDROXIDE SOLUTIONS  
(Glasstone, 1922a)

Solution of plumbite, plumbate and dilute alkali or water were mixed in various proportions and kept 4 or 5 weeks at room temperature. The supernatant solution above the precipitated sesquioxide was removed and analyzed. Equilibrium was reached very slowly.

Gram mols. per liter sat. sol.

NaOH	Plumbite $\times 10^3$	Plumbate $\times 10^3$	$\frac{[HPbO_2^-][PbO_3^-]}{[OH^-]^3} \times 10^6$
1.20	8.75	0.412	2.09
1.26	12.12	0.35	2.08
1.79	1.60	11.50	3.20
2.41	20.0	1.20	1.72
2.63	21.5	2.65	3.12

LEAD PEROXIDE  $PbO_2$ 

0

The two forms of lead superoxide, (a) amorphous and (b) crystalline, differ in their solubilities in sulphuric acid. One liter of very concentrated  $H_2SO_4$  dissolves about 0.010 mol.  $PbO_2$  (b) at  $22^\circ$ . One liter of conc.  $H_2SO_4$  containing 1720 gms. per liter, dissolves 0.0995 mol.  $PbO_2$  (a) at  $22^\circ$ . The solid phase is slowly converted to  $Pb(SO_4)_2$ . One liter of  $H_2SO_4$  containing 1097 gms.  $H_2SO_4$  per liter dissolves 0.004 mol.  $PbO_2$  at  $22^\circ$ . The solid phase is converted more quickly to  $Pb(SO_4)_2$ . In more dilute  $H_2SO_4$  solutions no solubility can be detected. (Dolezalek and Finckli, 1906.)

LEAD PHOSPHATE (Ortho)  $Pb_3(PO_4)_2$ 

PO

One liter water dissolves 0.000135 gm. lead phosphate at  $20^\circ$  by conductivity method. (Böttger, 1903.)

One liter of 4.97 per cent aqueous acetic acid solutions dissolves 1.27 gms.  $Pb_2(PO_4)_2$ . (Bertrand, 1868.)

The Ksp at  $20^\circ$  is reported as  $1 \times 10^{-32}$  by Bovalini and Casini, 1953.

More recent studies of the solubility of lead phosphates in water, using electrometric methods, are described by Millett and Jowett, 1929, and Jowett and Price, 1932. Their earlier results were found to be in error. Their final determinations for primary lead phosphate,  $Pb_3(PO_4)_2$  secondary lead phosphate,  $PbHPO_4$ , and lead pyromorphite,  $Pb_3(PO_4)_3Cl$ , the stable salt in presence of chloride ion, have been used for calculating the solubility products of each compound.

## Pb LEAD

### PO LEAD PHOSPHATES, Primary, $\text{PbH}_4(\text{PO}_4)_2$ ; Secondary, $\text{PbHPO}_4$

EQUILIBRIUM IN THE SYSTEM LEAD OXIDE, PHOSPHORIC ANHYDRIDE AND WATER AT 25°  
(Fairhall, 1924)

The mixtures were rotated in a thermostat for several weeks, and the solutions analyzed from time to time until equilibrium was reached. The composition of the solid phases was determined by the Schreinemaker residue method.

$d_{25}^{25}$ of sat. sol.	Gms. per 100 cc.		Solid Phase	$d_{25}^{25}$ of sat. sol.	Gms. per 100 cc.		Solid Phase
	Sat.	Sol.			Sat.	Sol.	
	$\text{P}_2\text{O}_5$	PbO			$\text{P}_2\text{O}_5$	PbO	
1.036	5.273	0.138	$\text{PbHPO}_4$	1.302	45.335	1.175	$\text{PbHPO}_4$
1.074	10.675	0.245	"	1.375	54.944	1.495	"
1.113	16.060	0.366	"	1.448	66.231	2.142	"
1.151	21.684	0.587	"	1.516	76.906	1.971	$\text{PbH}_4(\text{PO}_4)_2$
1.190	27.263	0.821	"	1.549	82.190	1.547	"
1.227	32.809	0.954	"	1.576	86.406	1.190	"
1.264	39.184	1.001	"	1.635	95.696	0.774	"

Zharovskii, 1951 gives the  $K_{sp}$  of  $\text{PbHPO}_4$  at 18-20° as  

$$[\text{Pb}^{++}][\text{HPO}_4^-] = 1.4 \times 10^{-10}.$$

## S LEAD SULFIDE PbS

### SOLUBILITY OF LEAD SULFIDE IN WATER

t°	Gm. Mols. PbS per liter	Authority
18	$3.6 \times 10^{-6}$	(Weigel, 1907)
25	$0.94 \times 10^{-6}$	(Nims and Bonner, 1929)
25	$4.3 \times 10^{-4}$ (1)	(Karaoglanov and Sagortschev, 1929)
25	$5.7 \times 10^{-4}$ (2)	(Karaoglanov and Sagortschev, 1929)
25	$3.62 \times 10^{-11}$ (3)	(Ravitz, 1936)
25	$6.8 \times 10^{-4}$ (4)	(Micwitz, 1928)

(1) Solid Phase amorphous PbS; (2) Solid Phase Cryst. PbO;  
 (3) Value recommended on the basis of a study of the published determinations of others (4) Gms. PbS per 1000 gms. sat. solution.

The solubility product, calculated from thermodynamic data, was found by Kapustinsky, 1940 to be  $6.8 \times 10^{-29}$ . The calculated solubility in solutions of varying acidity is as follows: (25°)

pH:	3	5	7	9	11
Gm. moles per liter	$7.9 \times 10^{-7}$	$8 \times 10^{-9}$	$1.1 \times 10^{-10}$	$8.2 \times 10^{-12}$	$8.2 \times 10^{-13}$

Goates, Gordon and Faux, 1952 calculate the  $K_{sp}$  at  $25^\circ$  to be  $8 \times 10^{-28}$  from thermodynamic data.

Fusion-point data are given for:

PbS + $Ag_2S$	(Friedrich, 1908)
PbS + $ZnS$	(Friedrich, 1908)
PbS + $Sb_2S_3$	(Wagemann, 1912; Savul, 1940)
PbS + $Tl_2S$	(Cannieri and Fernandes, 1925)
PbS + $SiS_2$	(Cambi, 1912)

LEAD SULFITE  $PbSO_3$ 

SO

EQUILIBRIUM IN THE SYSTEM LEAD OXIDE, SULFUR DIOXIDE AND WATER  
(Terres and Ruhl, 1934)

The determinations were made by the synthetic method. The results are given in the present paper only in the form of a small diagram from which the following approximate values were read.

Results at  $15^\circ$ 

Mol. % in sat. sol.		Solid Phase
PbO	SO <sub>2</sub>	
0.005	1.0	$PbSO_3 \cdot H_2O$
0.02	3.0	"
0.04	5.0	"
0.07	7.0	"
0.09	8.0	"
0.115	9.0	"
0.12	9.2	" + $Pb(HSO_3)_2(?)$
0.09	10.0	$Pb(HSO_3)_2(?)$
0.12	11.0*	"

Results at  $25^\circ$ 

Mol. % in sat. sol.		Solid Phase
PbO	SO <sub>2</sub>	
0.005	2.0	$PbSO_3 \cdot H_2O$
0.01	3.0	"
0.02	5.0	"
0.04	7.0	"
0.05	8.0	"
0.06	9.0	"
0.07	9.6	" + $Pb(HSO_3)_2(?)$
0.06	10.0	$Pb(HSO_3)_2(?)$
0.065	11.0*	"

\*Between 11 and 95 Mol. Percent  $SO_2$  the mixtures separate into liquid layers.

SOLUBILITY OF  $PbSO_3$  IN AQUEOUS AMMONIUM ACETATE SOLUTIONS  
(Mangan, 1949)

Moles $NH_4OAc$ per liter	Mmol. $PbSO_3$ per liter	Moles $NH_4OAc$ per liter	Mmol. $PbSO_3$ per liter
0.5	3.86	3.0	34.12
1.0	8.00	4.0	54.00
1.5	13.24	5.0	80.24
2.0	19.98		

Data for the solubility of  $PbSO_3$  in aqueous ammonium acetate solutions at different temperatures and pH are also given by Mangan, 1949.

**Pb LEAD**

**SO LEAD SULFATE PbSO<sub>4</sub>**

**SOLUBILITY IN WATER**

(Average curve from gravimetric results of Dibbitts (1874), Beck and Stegmüller (1910) and Pleissner (1907) and conductivity results of Böttger (1903) and Kohlrausch (1904-05).

t°	Gms. PbSO <sub>4</sub> per Liter	t°	Gms. PbSO <sub>4</sub> per Liter
0	0.028	20	0.041
5	0.031	25	0.045
10	0.035	30	0.049
15	0.038	35	0.052
18	0.040	40	0.056

Later determinations of the solubility of lead sulfate in water by Crockford and Brawleys, 1934; Purdum and Rutherford, 1933; Kolthoff and Rosenblum, 1933; and Huybrechts and de Langeron, 1930, gave an average curve from which the following values were taken.

t°	Gms. PbSO <sub>4</sub> per Liter	t°	Gms. PbSO <sub>4</sub> per liter
0	0.0330	25	0.0452
5	0.0354	30	0.0476
10	0.0380	35	0.0500
15	0.0403	40	0.0526
20	0.0427	50	0.0574

Koizumi, 1950 reports that the effect of dissolved CO<sub>2</sub> on the solubility of PbSO<sub>4</sub> is negligible.

**SOLUBILITY OF LEAD SULFATE IN SULFURIC ACID SOLUTIONS**

Results of Crockford and Brawley, 1936; Crockford and Addlestone, 1936

In agreement with Donk, 1916, analyses of the solid phases showed that PbSO<sub>4</sub> is the only one at these temperatures. The eutectic temperature for PbSO<sub>4</sub> + H<sub>2</sub>SO<sub>4</sub> was found to be 5.4°. The acid concentration of 104 percent H<sub>2</sub>SO<sub>4</sub> corresponds to 80.5 percent SO<sub>3</sub>.

Gms. H <sub>2</sub> SO <sub>4</sub> per 1000 gms. aq. solvent	Gms. PbSO <sub>4</sub> per 1000 gms. sat. solution at:			
	0°	25°	35°	50°
0.0	0.033	0.0445	0.0497	0.0577
0.05	0.008	0.0100	0.0110	0.0240
0.1	0.007	0.0080	0.0100	0.0210
0.2	0.0064	0.0070	0.0080	0.0180
0.5	0.0052	0.0060	0.0066	0.0150
1.0	0.0046	0.0052	0.0051	0.0130
2.0	0.0034	0.0038	0.0045	0.0120
5.0	0.0020	0.0025	0.0043	0.0115
10.0	0.0018	0.0022	0.0042	0.0113
50.0	0.0016	0.0020	0.0040	0.0103

(Cont.)

## SOLUBILITY OF LEAD SULFATE IN SULFURIC ACID SOLUTIONS

Results of  
Crockford and Brawley, 1936; Crockford and Addlestone, 1936--Cont.

Gms. H <sub>2</sub> SO <sub>4</sub> per 1000 gms. aq. solvent	Gms. PbSO <sub>4</sub> per 1000 gms. sat. solution at:			
	0°	25°	35°	50°
100.0	0.0012	0.0016	0.0038	0.0096
200.0	0.0005	0.0012	0.0028	0.0080
300.0	0.0004	0.0012	0.0020	0.0046
600.0	0.0004	0.0012	0.0020	0.0028
700.0	0.0012	0.0018	0.0024	0.0030
750.0	0.0028	0.0030	0.0038	0.0066
800.0	0.0065	0.0115	0.0240	0.0420
850.0	-	0.0600	0.1000	0.130
900	0.0420	0.200	0.318	0.380
950	0.680 (940)	0.800	1.060	1.260
970	3.000	-	-	-
1000	-	18.000	22.000	27.600
1010	-	31.000	36.000	42.000
1020	-	47.000	52.000	56.000
1030	-	63.000	68.000	72.000

SO

## Results at 20°

The only fairly closely agreeing results of Pleissner, 1907; Sehnal, 1909; Dawkins and Weldon, 1932; Huybrechts and Ramelot, 1926 and Purdum and Rutherford, 1933, were plotted and the following values were read from the average curve.

Gms. per liter		Gms. per liter		Gms. per liter	
H <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>
0.0	0.042	0.5	0.0055	10.0	0.0050
0.05	0.013	1.0	0.0040	20.0	0.0060
0.10	0.010	2.5	0.0040	50.0	0.0075
0.25	0.007	5.0	0.0045	100.0	0.0100

The available results at 30° are approximately one unit in the third place higher than the above values for the flat portion of the curve corresponding to concentrations of sulfuric acid above 0.25 gms. per liter.

## Results of Craig and Vinal, 1939 at 0°, 25°

The purest lead sulfate and water were used. Analysis for lead was made by a carefully checked dithizone method, and the original data fall on a smooth curve. The following rounded results are given by the authors. The data agree with and extend those of Purdam and Rutherford, below.



Pb LEAD

SOLUBILITY OF LEAD SULFATE IN SULFURIC ACID SOLUTIONS

Results of Craig and Vinal, 1939 at 0°, 25°--Cont.

Wt. % H <sub>2</sub> SO <sub>4</sub>	Mg. PbSO <sub>4</sub> per liter Saturated Solution		Wt. % H <sub>2</sub> SO <sub>4</sub>	Mg. PbSO <sub>4</sub> per liter Saturated Solution	
	25°	0°		25°	0°
0.1	4.99	2.37	6.0	6.33	2.58
0.2	4.61	2.13	7.0	6.47	2.69
0.3	4.55	2.07	8.0	6.57	2.79
0.4	4.57	2.05	9.0	6.64	2.84
0.5	4.60	2.06	10.0	6.68	2.86
0.6	4.65	2.06	15.0	6.28	2.63
0.7	4.71	2.07	20.0	5.18	2.21
0.8	4.77	2.07	25.0	3.87	1.76
0.9	4.84	2.08	30.0	2.82	1.27
1.0	4.91	2.10	35.0	2.02	0.84
2.0	5.37	2.18	40.0	1.52	.53
3.0	5.70	2.27	45.0	1.23	-
4.0	5.95	2.36	50.0	1.08	-
5.0	6.15	2.46			

Additional Data at 25°

Kryukova, 1939\*

Kolthoff, Perlich and Weiblen, 1942

Gms. per Liter		Moles per liter	
H <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>
0.049	0.0155	0.001	3.6 x 10 <sup>-5</sup>
0.245	.0089	0.005	2.2
4.90	.0042	0.0075	2.2
49.0	.0045	0.010	1.8
		0.025	1.8
		0.050	1.7
		0.100	1.6
		0.250	1.8
		0.500	2.1

\*determined polarographically

Additional Results at Higher Concentrations

At about 18° (Ditz and Kanhauser, 1916)

The solutions were analyzed after being shaken from time to time during three days, and the analyses repeated after an additional two days.

% conc. H <sub>2</sub> SO <sub>4</sub>		Gms. PbSO <sub>4</sub> per 100 gms. sat. sol.	% conc. H <sub>2</sub> SO <sub>4</sub>		Gms. PbSO <sub>4</sub> per 100 gms. sat. sol.
H <sub>2</sub> SO <sub>4</sub>	free SO <sub>3</sub>		H <sub>2</sub> SO <sub>4</sub>	free SO <sub>3</sub>	
91.27	-	0.047	98.11	-	0.54
93.78	-	0.063	98.37	-	0.70
96.04	-	0.147	98.63	-	1.29
97.01	-	0.210	98.94	-	1.34

(Cont.)

## SOLUBILITY OF LEAD SULFATE IN SULFURIC ACID SOLUTIONS

## Additional Results at Higher Concentrations

At about 18° (Ditz and Kanhauser, 1916)--Cont.

% conc. $H_2SO_4$		Gms. $PbSO_4$ per 100 gms. sat. sol.	% conc. $H_2SO_4$		Gms. $PbSO_4$ per 100 gms. sat. sol.
$H_2SO_4$	free $SO_3$		$H_2SO_4$	free $SO_3$	
99.52	-	2.51	101.45	6.4	3.78
100.01	0.044	4.21	102.5	11.1	6.00
100.2	0.89	3.97	103.4	15.1	7.22
100.5	2.22	3.62	105.05	22.4	8.23
101.13	5.02	3.54			

30

## Results of Donk, 1916

t°	Gms. per 100 Gms. Sat. Sol.		Solid Phase	t°	Gms. per 100 Gms. Sat. Sol.		Solid Phase
	$H_2SO_4$	$PbSO_4$			$H_2SO_4$	$PbSO_4$	
0	51.2	0	$PbSO_4$	100	61.2	0	$PbSO_4$
0	89.4	0	" + $H_2SO_4 \cdot H_2O$	100	72.5	0.1	"
0	97	0	$H_2SO_4$	100	96.3	0.2	"
0	97.2	0.3	" + $PbSO_4$	100	99.1	0.9	"
50	50.4	0	$PbSO_4$	200	79	0	"
50	86.7	0.1	"	200	88.8	0.1	"
50	95.1	0.2	"	200	95.5	0.3	"
50	99.3	0.6	"	200	98.9	1.1	"

## Results of Frisak, 1922

Aqueous lead nitrate solution was added, by means of a buret, to aqueous sulfuric acid solutions at definite temperature until a permanent cloud remained. The results were plotted and the following values read from the curve.

t°	Gms. Pb dissolved per 100 gms. sat. solution in Aqueous $H_2SO_4$ containing							
	60 % $H_2SO_4$	65 % $H_2SO_4$	70 % $H_2SO_4$	75 % $H_2SO_4$	80 % $H_2SO_4$	85 % $H_2SO_4$	90 % $H_2SO_4$	95 % $H_2SO_4$
16	0.002	0.002	0.002	0.0021	0.0025	0.004	0.008	0.024
127	0.0035	0.0042	0.005	0.007	0.009	0.014	0.024	0.060
149	0.006	0.0075	0.009	0.013	0.018	0.030	0.055	-
166	-	0.010	0.014	0.021	0.032	0.048	-	-

Additional data in the system  $PbSO_4 - H_2SO_4 - H_2O$  are given by Tananaev and Mizetskaya, 1948.

## SOLUBILITY OF LEAD SULFATE IN HYDROCHLORIC ACID SOLUTIONS

Normality of HCl	Results of Beck and Stegmüller, 1910			Results of Huybrechts and Ramelot, 1928			
	Milligrams Pb per 100 cc. Solution			At 18°		At 30°	
	At 18° At 25° At 37°			Gms. per liter		Gms. per liter	
				HCl	PbSO <sub>4</sub>	HCl	PbSO <sub>4</sub>
0 (pure H <sub>2</sub> O)	2.60	3	3.80				
0.1	19	22.18	28.04	0.1	0.0516	9.75	0.984
0.2	35.70	42.88	54.50	0.5	0.0566	24.40	1.767
0.3	55.37	65.16	84.04	11.0	0.133	48.80	1.583
0.4	75.27	88.80	111.90	2.5	0.244		
				4.88	0.384		
				7.5	0.573		
				9.75	0.748		
				25.0	1.020		
				50.0	0.983		

50

SOLUBILITY OF PbSO<sub>4</sub> IN HCl + H<sub>2</sub>SO<sub>4</sub> SOLUTIONS AT 18°  
(Huybrechts and Ramelot, 1928)Varying amounts of H<sub>2</sub>SO<sub>4</sub> were added to dilute HCl solutions.

Aqueous 0.134 normal HCl		Aqueous 0.275 normal HCl		Aqueous 0.687 normal HCl		Aqueous 1.372 normal HCl	
Gms. per liter		Gms. per liter		Gms. per liter		Gms. per liter	
H <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>
0.0	0.384	0.0	0.730	0.0	1.020	0.0	0.983
0.16	0.179	0.16	0.522	0.16	1.030	0.18	0.974
0.48	0.124	0.48	0.292	0.48	1.026	1.0	0.950
0.96	0.055	0.96	0.1655	0.96	1.024	5.0	0.922
4.8	0.0157	4.8	0.0505	2.5	0.711	10.0	0.924
9.6	0.0101	9.6	0.0314	4.8	0.382	23.6	0.911
24.0	0.0109	24.0	0.0202	9.6	0.187	47.2	0.818
49.0	0.0101	48.0	0.0168	48.0	0.066		

SOLUBILITY OF PbSO<sub>4</sub> IN HCl + (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> SOLUTIONS AT 18°  
(Huybrechts and Ramelot, 1926)

Aqueous 0.134 normal HCl		Aqueous 0.287 normal HCl		Aqueous 0.687 normal HCl		Aqueous 1.372 normal HCl	
Gms. per liter		Gms. per liter		Gms. per liter		Gms. per liter	
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>
0.0	0.384	0.0	0.748	0.0	1.020	0.0	0.982
0.2	0.213	0.12	0.616	0.5	1.033	1.0	0.925
1.0	0.069	1.0	0.217	1.0	1.059	2.5	0.882
2.0	0.038	2.0	0.145	2.5	1.071	5.0	0.870
2.5	0.027	5.0	0.047	5.0	0.435	7.5	0.905
5.0	0.015	10.0	0.027	7.5	0.265	10.0	0.748
10.0	0.010	100.0	0.015	10.0	0.206	50.0	0.591
		300.0	0.007	50.0	0.049	100	0.425
				100.0	0.028	200	0.282
				300.0	0.014		

SOLUBILITY OF LEAD SULFATE IN AQUEOUS SOLUTIONS OF PERCHLORIC ACID  
AND OF MIXTURES OF PERCHLORIC ACID AND SULFURIC ACID AT 25°  
(Willard and Kassner, 1930)

Composition of solvent in mols. per liter			Dissolved PbSO <sub>4</sub>	
			Gms. per 100 cc.	Millimols. per 100 cc.
0.1 Mol. HClO <sub>4</sub>			0.0278	0.0917
0.5 "			0.0528	0.1742
1.0 "			0.0714	0.2301
2.0 "			0.0787	0.2596
3.0 "			0.0687	0.2266
4.2 "			0.0490	0.1616
0.1 "	+ 0.005 Mol. H <sub>2</sub> SO <sub>4</sub>		0.0070	0.0230
0.5 "	+	"	0.0206	0.0679
1.0 "	+	"	0.0367	0.1211
0.5 "	+ 0.01	"	0.0137	0.0451
0.1 "	+ 0.02	"	0.0024	0.0079
0.5 "	+ 0.02	"	0.0067	0.0220
0.1 "	+ 0.05	"	0.0013	0.0043
0.5 "	+ 0.05	"	0.0030	0.0099
0.1 "	+ 0.10	"	0.0010*	0.0033*
0.1 "	+ 0.25	"	0.0008*	0.0026*
0.1 "	+ 0.50	"	0.0003*	0.0010*
0.1 "	+ 0.50 Mol. Pb(ClO <sub>4</sub> ) <sub>2</sub>		0.0002	0.0007

SO

\*Lead determined colorimetrically.

SOLUBILITY OF LEAD SULFATE IN NITRIC ACID

At 18°

(Beck and Stegmüller, 1910)

(Huybrechts and Ramelot, 1926)

Normality of HNO <sub>3</sub>	Mgm. Pb per 100 cc. Sol.	Gms. per liter	
		HNO <sub>3</sub>	PbSO <sub>4</sub>
0.1	10.48		
0.2	17.48	5.65	0.2195
0.3	23.41	11.32	0.348
0.4	29.84	28.30	0.784
		56.60	1.437

At 25° (Willard and Kassner, 1930)

Composition of solvent in mols. per liter			Dissolved PbSO <sub>4</sub>	
			Gms. per 100 cc.	Millimols. per 100 cc.
0.1 Mol. HNO <sub>3</sub>			0.0426	0.1405
0.5 "			0.0992	0.3272
1.0 "			0.2021	0.6667
2.0 "			0.3605	1.1890
3.0 "			0.5389	1.7770
4.2 "			0.7263	2.3960
0.1 "	+ 0.005 Mol. H <sub>2</sub> SO <sub>4</sub>		0.0078	0.0257
0.5 "	+ 0.005	"	0.0398	0.1313

**Pb LEAD**

**SOLUBILITY OF  $\text{PbSO}_4$  IN  $\text{HNO}_3$  +  $\text{H}_2\text{SO}_4$  MIXTURES**

Results at 18°

(Huybrechts and Ramelot, 1926)

	Aqueous 0.18 normal $\text{HNO}_3$		Aqueous 0.89 normal $\text{HNO}_3$	
	Gms. per liter		Gms. per liter	
	$\text{H}_2\text{SO}_4$	$\text{PbSO}_4$	$\text{H}_2\text{SO}_4$	$\text{PbSO}_4$
50	0.0	0.348	0.0	1.437
	0.5	0.0819	0.5	0.777
	1.0	0.0483	1.0	0.537
	2.5	0.0202	5.0	0.146
	5.0	0.0183	10.0	0.084
	10.0	0.0082	20.0	0.045
	20.0	0.0078	25.0	0.047
	50.0	0.0065	50.0	0.020

Results at 25°

(Willard and Kasaner, 1930)

Composition of solvent in mols. per liter		Dissolved $\text{PbSO}_4$	
		Gms. per 100 cc.	Millimols. per 100 cc.
1.0 Mol. $\text{HNO}_3$	+ 0.005 Mol. $\text{H}_2\text{SO}_4$	0.1007	0.3322
0.5 "	+ 0.01 "	0.0328	0.1082
0.5 "	+ 0.02 "	0.0159	0.0524
0.1 "	+ 0.05 "	0.0015	0.0049
0.5 "	+ 0.05 "	0.0089	0.0293
0.1 "	+ 0.25 "	0.0011	0.0036
0.1 "	+ 0.5 "	0.0009	0.0030
0.1 "	+ 0.5 Mol. $\text{Pb}(\text{NO}_3)_2$	0.0008	0.0026

**SOLUBILITY OF  $\text{PbSO}_4$  IN  $\text{HNO}_3$  +  $(\text{NH}_4)_2\text{SO}_4$  SOLUTIONS AT 18°**

(Huybrechts and Ramelot, 1926)

Aqueous 0.18 normal $\text{HNO}_3$				Aqueous 0.89 normal $\text{HNO}_3$			
Gms. per liter		Gms. per liter		Gms. per liter		Gms. per liter	
$(\text{NH}_4)_2\text{SO}_4$	$\text{PbSO}_4$	$(\text{NH}_4)_2\text{SO}_4$	$\text{PbSO}_4$	$(\text{NH}_4)_2\text{SO}_4$	$\text{PbSO}_4$	$(\text{NH}_4)_2\text{SO}_4$	$\text{PbSO}_4$
0.0	0.348	5.0	0.0146	0.0	1.437	5.0	0.196
0.5	0.097	10.0	0.0090	0.5	0.926	10.0	0.091
1.0	0.0512	25.0	0.0052	1.0	0.722	25.0	0.036
2.5	0.0249	50.0	0.0079	2.5	0.405	50.0	0.020

## SOLUBILITY OF LEAD SULFATE IN LEAD NITRATE SOLUTIONS

At 25°

(Tananaev and Mizetskaya, 1948)

Moles $\text{Pb}(\text{NO}_3)_2$ per liter solvent	Moles $\text{PbSO}_4$ per liter sat. sol.
0.00033	0.000135
0.00066	0.000120
0.001	0.000116
0.01	0.000154
1.0	0.000677

At 29°

(Kolthoff and Rosenblum, 1933)

Normality of	
aq. $\text{Pb}(\text{NO}_3)_2$	dissolved $\text{PbSO}_4$
0.000501	0.000148
0.000750	0.000119
0.0010	0.000088
0.0015	0.000076
0.0025	0.000047

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SOLUBILITY OF LEAD SULFATE IN AQUEOUS SOLUTIONS OF POTASSIUM SULFATE  
(Huybrechts and Ramelot, 1928)

Results at 18°

Results at 30°

Gms. per liter		Gms. per liter		Gms. per liter		Gms. per liter	
$\text{K}_2\text{SO}_4$	$\text{PbSO}_4$	$\text{K}_2\text{SO}_4$	$\text{PbSO}_4$	$\text{K}_2\text{SO}_4$	$\text{PbSO}_4$	$\text{K}_2\text{SO}_4$	$\text{PbSO}_4$
0.1	0.0125	5.0	0.0037	0.1	0.0128	5.0	0.0036
0.5	0.0047	10.0	0.0007	0.5	0.0064	7.5	0.0047
1.0	0.0053	30.0	0.0002	0.75	0.0060	10.0	0.0007
2.5	0.0042	100.0	0.0002	1.5	0.0055	20.0	0.0011

SOLUBILITY OF LEAD SULFATE IN SOLUTIONS OF ELECTROLYTES AT 18° - 20°  
(Golovatyj, 1940)Results are in millimoles  $\text{PbSO}_4$  per liter

	Gm. eq. $\text{K}_2\text{SO}_4$ per liter						
	0.0	0.004	0.008	0.016	0.032	0.064	0.128
$\text{H}_2\text{O}$	0.139	0.0952	0.0784	0.0530	0.0544	0.108	0.114
0.01 N $\text{HNO}_3$	.386	.209	.184	.170	.227	.283	.504
.05 N $\text{HNO}_3$	.646	.382	.342	.284	.324	.417	.709
.1 N $\text{HNO}_3$	1.157	.957	.632	.514	.543	.687	.762
.5 N $\text{HNO}_3$	1.360	1.328	1.111	.923	.687	.634	.742
.01 N $\text{KOH}$	0.231	0.207	0.189	.217	.286	.344	.481
.05 N $\text{KOH}$	1.407	1.233	1.1331	1.2342	1.534	1.5734	1.604
.1 N $\text{KNO}_3$	0.407	-	0.146	0.135	0.124	0.204	0.214
.2 N $\text{KNO}_3$	.461	-	0.284	.207	.179	.184	.234
1.0 N $\text{KNO}_3$	2.289	-	1.365	.822	.544	.6198	.734

Pb LEAD

SOLUBILITY OF LEAD SULFATE IN AQUEOUS SOLUTIONS OF AMMONIUM SULFATE  
(Huybrechts and Ramelot, 1928)

Results at 18°				Results at 30°	
Gms. per liter		Gms. per liter		Gms. per liter	
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>
0.1	0.0107	30.0	0.0049	0.1	0.0105
0.5	0.0056	50.0	0.0079	1.0	0.0046
0.75	0.0042	70.0	0.0093	2.5	0.0042
1.00	0.0034	100.	0.0123	5.0	0.0044
5.00	0.0040	150	0.0157	7.5	0.0048
10.0	0.0047	200	0.0107	25.0	0.0060

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SOLUBILITY OF LEAD SULFATE IN AQUEOUS SOLUTIONS OF SODIUM SULFATE  
(Huybrechts and de Langeron, 1930)

Gms. H <sub>2</sub> SO <sub>4</sub> per liter aq. solvent	Gms. PbSO <sub>4</sub> per liter sat. sol.		Gms. H <sub>2</sub> SO <sub>4</sub> per liter aq. solvent	Gms. PbSO <sub>4</sub> per liter sat. sol.	
	at 15°	at 30°		at 15°	at 30°
0.1	0.0079	0.0117	7.5	0.0023	0.0044
0.25	0.0057	0.0083	10.0	0.0027	0.0049
0.50	0.0049	0.0060	25.0	0.0038	0.0057
0.75	0.0045	0.0057	50.0	0.0060	0.0079
1.00	0.0045	0.0057	75.0	0.0083	0.0102
2.50	0.0034	0.0049	100.0	0.0105	0.0124
5.00	0.0023	0.0044	132.0	0.0123	0.0147
			400.0		0.0284

SOLUBILITY OF LEAD SULFATE IN AQUEOUS SOLUTIONS OF  
SODIUM SULFATE AT 25.5°  
(Kolthoff and Rosenblum, 1933)

Normality of aq. Na <sub>2</sub> SO <sub>4</sub>	Normality of dissolved PbSO <sub>4</sub>
0.000505	0.000145
0.000745	0.000115
0.001011	0.00010
0.001505	0.0008

SOLUBILITY OF LEAD SULFATE IN SOLUTIONS OF ELECTROLYTES AT 25°  
(Kolthoff, Perlich, and Weiblen, 1942)

In Sodium Sulfate Solutions

Moles per liter		Moles per liter	
Na <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>	PbSO <sub>4</sub>
0.0	15.2 x 10 <sup>-5</sup>	0.08	1.3 x 10 <sup>-5</sup>
0.001	2.4 x 10 <sup>-5</sup>	0.100	1.6 x 10 <sup>-5</sup>
0.01	1.6 x 10 <sup>-5</sup>	0.200	1.9 x 10 <sup>-5</sup>
0.02	1.4 x 10 <sup>-5</sup>	0.350	2.3 x 10 <sup>-5</sup>
0.04	1.3 x 10 <sup>-5</sup>	0.500	2.3 x 10 <sup>-5</sup>

## SOLUBILITY OF LEAD SULFATE IN SOLUTIONS OF ELECTROLYTES AT 25°--Cont.

In 0.01 M  $\text{Na}_2\text{SO}_4$  Solutions with added  $\text{NaNO}_3$ 

Moles per liter	
$\text{NaNO}_3$	$\text{PbSO}_4$
0.0	$1.5 \times 10^{-5}$
0.0500	$2.6 \times 10^{-5}$
0.100	$3.9 \times 10^{-5}$
0.500	$17 \times 10^{-5}$
1.00	$47 \times 10^{-5}$

SOLUBILITY OF LEAD SULFATE IN AQUEOUS SOLUTIONS OF POTASSIUM ACETATE AND OF SODIUM ACETATE AT 25°  
(Fox, 1909) 30

In Aqueous Potassium Acetate

Gms. per 100 Gms. Sat. Sol.		Solid Phase
$\text{CH}_3\text{COOK}$	$(\text{CH}_3\text{COO})_2\text{Pb}$	
4.33	2.54	$\text{PbSO}_4 + \text{PbK}_2(\text{SO}_4)_2$
9.03	3.55	"
17.81	5.43	"
26.58	9.83	"
28.82	11.40	"
28.93	19.41	"

In Aqueous Sodium Acetate

Gms. per 100 Gms. Sat. Sol.			Solid Phase
$\text{CH}_3\text{COONa}$	$(\text{CH}_3\text{COO})_2\text{Pb}$	$\text{Na}_2\text{SO}_4$	
6.69	0.78	0.34	$\text{PbSO}_4$
6.95	0.81	0.35	"
11.76	2.73	1.26	"
16.90	5.70	2.49	"
19.92	8.24	3.60	"
21.51	10.75	4.68	"

In the case of the  $\text{CH}_3\text{COOK}$  solutions, the double salt  $\text{PbK}_2(\text{SO}_4)_2$  is formed and no  $\text{SO}_4$  ions enter the solution.

SOLUBILITY OF LEAD SULFATE IN AQUEOUS SOLUTIONS OF AMMONIUM ACETATE AT 25°  
(Marden, 1916)

Gms. per 1000 Gms. Sat. Sol.		Gms. per 1000 Gms. Sat. Sol.		$d_{26}$ of Sat. Sol.
$\text{NH}_4\text{C}_2\text{H}_3\text{O}_2$	$\text{PbSO}_4$	$\text{NH}_4\text{C}_2\text{H}_3\text{O}_2$	$\text{PbSO}_4$	
7.96	0.636	53.4	5.60	1.012
15.91	1.370	106.8	16.8	1.024
31.70	3.04	213.7	38.9	1.045



Pb LEAD

SOLUBILITY OF LEAD SULFATE IN AQUEOUS SOLUTIONS OF AMMONIUM ACETATE AND OF SODIUM ACETATE  
(Noyes and Whitcomb, 1905; Dunnington and Long, 1899; Dibbitts, 1874)

In Ammonium Acetate at 25° (N. and W.)

Millimols per Liter		Gms. per Liter	
NH <sub>4</sub> C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>	PbSO <sub>4</sub>	NH <sub>4</sub> C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>	PbSO <sub>4</sub>
0	0.134	0	0.041
103.5	2.10	7.98	0.636
207.1	4.55	15.96	1.38
414.1	10.10	31.92	3.02

SO

In Sodium Acetate

At 100° (D. and L.)		(D.)	
Gms. NH <sub>4</sub> C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> per 100 cc. Solution	Gms. PbSO <sub>4</sub> per 100 gms. Solution	Gms. per 100 Gms. H <sub>2</sub> O	
		NaC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>	PbSO <sub>4</sub>
23	7.12	2.05	0.054
32	9.88	8.2	0.853
37	10.58	41	11.23
45	11.10		

SOLUBILITY OF LEAD SULFATE IN ZINC SULFATE SOLUTIONS  
(Barker, Powell and Young, 1950)

Solvent gms./liter		Mg. Pb per liter at:	
Zn	H <sub>2</sub> SO <sub>4</sub>	20°	30°
75	0.1	4.78	6.83
75	75	4.30	4.65
125	0.1	5.46	6.83
125	75	4.30	4.37

SOLUBILITY OF PbSO<sub>4</sub> IN AQUEOUS SOLUTIONS OF NaCl AT 18°  
(Beck and Stegmuller, 1910)

Normality of NaCl	Mgm. Pb per 100 cc. Sol.
0.1	11.19
0.2	18.73
0.3	26.51
0.4	33.76

Data for the solubility of PbSO<sub>4</sub> in aqueous KCl + 0.001 N HCl solutions are given by Cavigli, 1950.

Solubilities of PbSO<sub>4</sub> in 0.1 M Li<sup>+</sup>, Na<sup>+</sup>, K<sup>+</sup>, Mg<sup>++</sup> and Al<sup>+++</sup>, NO<sub>3</sub><sup>-</sup> and SO<sub>4</sub><sup>=</sup> solutions at 25° are reported by Tananaev and Mizetskaya, 1951.

Data for the solubility of lead sulfate in various salt solutions of very low concentration are given by Ruchhoff and Kachmar, 1942.

$\text{PbSO}_4$  is 733 times as soluble in  $3N \text{ NaNO}_3$  solution as is water. (Belfiori, 1940.)

SOLUBILITY OF LEAD SULFATE IN AQUEOUS SOLUTIONS OF THORIUM CHLORIDE  
(Balcar and Stegmann, 1928)

To solutions of varying concentrations of thorium chloride, illuminated by a converging beam of light, equivalent solutions of lead chloride and sulfuric acid were added dropwise and the point determined at which the Tyndall cone became permanent. This was taken as the point representing saturation of the solution at  $25^\circ$ . (?)

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Gram mols. per liter

ThCl <sub>4</sub>	PbSO <sub>4</sub>
0.0044	0.00323
0.0105	0.00574
0.0233	0.00959
0.0495	0.01760
0.0817	0.01970

Data for the solubility of lead sulfate in solutions containing both lithium sulfate and thorium nitrate at  $25^\circ$  are given by Tananaev, Mizetskaya and Vinogradova, 1952.

SOLUBILITY OF LEAD SULFATE IN AQUEOUS ETHANOL SOLUTIONS AT  $25^\circ$   
(Kolthoff, Perlich, and Weiblen, 1942)

Volume % $\text{C}_2\text{H}_5\text{OH}$	Mg. Pb per liter	Moles PbSO <sub>4</sub> per liter	Volume % $\text{C}_2\text{H}_5\text{OH}$	Mg. Pb per liter	Moles PbSO <sub>4</sub> per liter
0	30	$15 \times 10^{-5}$	40	0.51	$0.25 \times 10^{-5}$
10	11.0	$5.4 \times 10^{-5}$	50	0.32	$0.16 \times 10^{-5}$
20	4.2	$2.1 \times 10^{-5}$	60	0.20	$0.10 \times 10^{-5}$
30	1.5	$0.76 \times 10^{-5}$	70	0.06	$0.03 \times 10^{-5}$

Results at other temperatures  
(Koizumi, 1948)

% $\text{C}_2\text{H}_5\text{OH}$	Density at $20^\circ$	Moles PbSO <sub>4</sub> per Liter		
		$20^\circ$	$25^\circ$	$30^\circ$
0.0	0.99823	$14.21 \times 10^{-5}$	$14.81 \times 10^{-5}$	$15.44 \times 10^{-5}$
3.698	.99156	$8.95 \times 10^{-5}$	$10.12 \times 10^{-5}$	$10.76 \times 10^{-5}$
7.804	.98508	$5.72 \times 10^{-5}$	$6.09 \times 10^{-5}$	$6.26 \times 10^{-5}$

# Pb LEAD

## SOLUBILITY OF LEAD SULFATE IN ETHANOLIC SODIUM SULFATE SOLUTIONS AT 25° (Kolthoff, Perlman, and Weiblen, 1942)

Moles  $\text{Na}_2\text{SO}_4$  per liter 50%  
 $\text{C}_2\text{H}_5\text{OH}$  by Volume:

0.0	0.001	0.005	0.010	0.100
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Mg. Pb per liter:

0.32	0.26	0.24	0.17	0.25
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Moles  $\text{PbSO}_4$  per liter:

$1.6 \times 10^{-6}$	$1.3 \times 10^{-6}$	$1.2 \times 10^{-6}$	$0.82 \times 10^{-6}$	$1.22 \times 10^{-6}$
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SO Results for the solubility of  $\text{PbSO}_4$  up to 58% tertiary butyl alcohol  
(+  $\text{H}_2\text{O}$ ) at 20, 25, 30° are given by Koizumi, Miyamoto and Watanabe, 1957.

## SOLUBILITY OF $\text{PbSO}_4$ IN AQUEOUS ETHYLENE GLYCOL SOLUTIONS (Koizumi and Ukaji, 1953)

Wt. % Glycol in Solvent	Results in moles $\text{PbSO}_4$ per liter at:		
	20°	25°	30°
0	$14.21 \times 10^{-5}$	$14.81 \times 10^{-5}$	$15.44 \times 10^{-5}$
7.431	$12.75 \times 10^{-5}$	$12.82 \times 10^{-5}$	$12.90 \times 10^{-5}$
14.679	$9.90 \times 10^{-5}$	$10.28 \times 10^{-5}$	$10.64 \times 10^{-5}$
21.048	$8.51 \times 10^{-5}$	$8.83 \times 10^{-5}$	$9.40 \times 10^{-5}$
28.770	$7.06 \times 10^{-5}$	$7.41 \times 10^{-5}$	$7.81 \times 10^{-5}$

## SOLUBILITY OF $\text{PbSO}_4$ IN AQUEOUS GLYCEROL SOLUTIONS (Koizumi, 1949a)

Wt. % Glycerol in Solvent	Results in moles $\text{PbSO}_4$ per liter at:		
	20°	25°	30°
0	$14.21 \times 10^{-5}$	$14.81 \times 10^{-5}$	$15.44 \times 10^{-5}$
7.712	$10.31 \times 10^{-5}$	$11.02 \times 10^{-5}$	$11.70 \times 10^{-5}$
15.698	$6.00 \times 10^{-5}$	$6.92 \times 10^{-5}$	$7.80 \times 10^{-5}$

SOLUBILITY OF  $\text{PbSO}_4$  IN AQUEOUS ACETONE SOLUTIONS  
(Koizumi, 1949)

Data at 20, 25, 30° from 16 to 80% acetone are given by Koizumi, Miyamoto and Koakutsu, 1957.

Results in moles  $\text{PbSO}_4$  per liter at:

Wt. % Acetone in Solvent	20°	25°	30°
0	$14.21 \times 10^{-5}$	$14.81 \times 10^{-5}$	$15.44 \times 10^{-5}$
4.021	$8.65 \times 10^{-5}$	$9.20 \times 10^{-5}$	$9.70 \times 10^{-5}$
8.068	$4.59 \times 10^{-5}$	$5.02 \times 10^{-5}$	$5.50 \times 10^{-5}$

SOLUBILITY OF LEAD SULFATE IN AQUEOUS DIOXANE SOLUTIONS  
(Koizumi, 1947)

Results in moles  $\text{PbSO}_4$  per liter at:

Wt. % Dioxane in Solvent	20°	25°	30°
0.0	$14.21 \times 10^{-5}$	$14.81 \times 10^{-5}$	$15.44 \times 10^{-5}$
2.649	$11.66 \times 10^{-5}$	$12.10 \times 10^{-5}$	$12.74 \times 10^{-5}$
5.178	$10.34 \times 10^{-5}$	$10.96 \times 10^{-5}$	$11.52 \times 10^{-5}$

SOLUBILITY OF LEAD SULFATE IN ISODIELECTRIC SOLVENTS  
(Koizumi, 1950)

Water was added separately to each solvent to produce the same dielectric constant in each case.

t°	Dielectric constant	Moles $\text{PbSO}_4$ per liter $\times 10^6$				
		Dioxane	Acetone	Glycerine	Ethanol	Methanol
20	80.37	142.1	142.1	142.1	142.1	142.1
	78.10	117.4	85.0	100.8	95.0	91.6
	75.90	103.8	45.0	61.0	57.0	61.0
25	78.54	148.1	148.1	148.1	148.1	148.1
	76.35	121.0	92.0	109.5	100.2	96.0
	74.10	109.2	50.8	69.2	60.2	61.8
30	76.73	154.4	154.4	154.4	154.4	154.4
	74.50	129.8	95.2	115.3	102.8	96.8
	72.35	116.2	54.4	77.4	61.7	63.8

## Pb LEAD

Fusion-point data are given for:

$\text{PbSO}_4 + \text{K}_2\text{SO}_4$	(Calcagni and Mariotta, 1912; Grahmann, 1913)
$\text{PbSO}_4 + \text{Na}_2\text{SO}_4$	(Calcagni and Mariotta, 1912)
$\text{PbSO}_4 + \text{PbWO}_4$	(Jaeger and Germs, 1921; Belyaev, 1952, 1955 Belyaev and Nesterova, 1952)

## BASIC LEAD SULFATES

SOLUBILITY OF BASIC LEAD SULFATES IN WATER AT 18°  
(Pleissner, 1907)

\$0

Compound and Formula	One Liter Sat. Solution Contains:		
	Mg. Lead Salt =	Mg. Pb =	Millimols Pb
$1/2$ Basic Lead Sulfate $\text{PbSO}_4 \cdot \text{PbO}$	13.4	10.6	0.050
$3/4$ Basic Lead Sulfate $\text{PbSO}_4 \cdot 3\text{PbO} \cdot \text{H}_2\text{O}$	26.2	22	0.106

## LEAD THIOSULFATE $\text{PbS}_2\text{O}_3$

SOLUBILITY IN AMMONIUM ACETATE SOLUTIONS AT 20°  
(Mangan, 1949)

$\text{NH}_4\text{OAc}$ moles per liter	$\text{PbS}_2\text{O}_3$ mmol. per liter	$\text{NH}_4\text{OAc}$ moles per liter	$\text{PbS}_2\text{O}_3$ mmol. per liter
0.5	3.86	3.0	34.12
1.0	8.00	4.0	54.00
1.5	13.24	5.0	80.24
2.0	19.98		

In 1.0 M  $\text{NH}_4\text{OAc}$ :

6°	5.60	42°	13.80
19°	8.40	56°	18.20

From data in  $\text{Na}_2\text{S}_2\text{O}_3$  solutions, Yatsimirskii (1951) found the  $K_{sp}$  of  $\text{PbS}_2\text{O}_3$  to be  $3.99 \times 10^{-7}$ .

## LEAD HYPOSULFATE

SOLUBILITY OF MIXTURES OF LEAD HYPOSULPHATE, AND STRONTIUM  
HYPOSULPHATE AT 25°  
(Fock, 1897)

Mol. % in Solution		Gms. per Liter		Sp. Gr. of Solutions	Mol. % in Solid Phase	
PbS <sub>2</sub> O <sub>6</sub> ·4H <sub>2</sub> O	SrS <sub>2</sub> O <sub>6</sub> ·4H <sub>2</sub> O	PbS <sub>2</sub> O <sub>6</sub>	SrS <sub>2</sub> O <sub>6</sub>		PbS <sub>2</sub> O <sub>6</sub> ·4H <sub>2</sub> O	SrS <sub>2</sub> O <sub>6</sub> ·4H <sub>2</sub> O
0.0	100.0	0.0	145.6	1.1126	0.0	100.0
1.05	98.95	2.97	151.2	1.1184	0.30	99.7
15.31	84.69	40.82	152.5	1.1503	3.87	96.13
46.80	53.20	149.2	114.5	1.2147	9.84	90.16
62.30	37.70	256.1	85.0	1.2889	19.26	80.74
75.75	24.25	310.3	67.0	1.3252	23.73	76.27
78.09	21.91	373.7	70.8	1.3726	32.24	67.76
88.29	11.71	509.5	45.6	1.4671	49.97	50.13
100.0	0.00	374.3	0.0	1.6817	0.00	0.00

LEAD PERSULFATE PbS<sub>2</sub>O<sub>8</sub>

80

SOLUBILITY IN AQUEOUS SULFURIC ACID AT 22°  
(Dolezalek and Finckli, 1906)

The solid phase at concentrations of acid up to 1352 gms. per liter is the white basic salt of the composition PbOSO<sub>4</sub>·H<sub>2</sub>O. In the concentration limits of about 1470-1703 gms. H<sub>2</sub>SO<sub>4</sub> per liter the original yellow color of the solid phase remains unchanged.

Gms. per Liter		Solid Phase	Gms. per Liter		Solid Phase
H <sub>2</sub> SO <sub>4</sub>	PbS <sub>2</sub> O <sub>8</sub>		H <sub>2</sub> SO <sub>4</sub>	PbS <sub>2</sub> O <sub>8</sub>	
948	0	PbOSO <sub>4</sub> ·H <sub>2</sub> O	1253	14.85	PbOSO <sub>4</sub> ·H <sub>2</sub> O
1014	0.719	"	1352	16.17	"
1081	1.198	"	1470	9.30	PbS <sub>2</sub> O <sub>8</sub>
1098	1.557	"	1532	9.46	"
1130	2.115	"	1631	19.80	"
1180	5.749	"	1698	33.34	"
1217	9.303	"	1703	35.22	"

**Pb LEAD**

**LEAD SULFAMATE  $\text{Pb}(\text{SO}_3\text{NH}_2)_2$**

**SOLUBILITY IN WATER**  
(Odehnal, 1955)

Analysis of solutions was by vacuum evaporation at 45 - 50°.

	Gms. $\text{Pb}(\text{SO}_3\text{NH}_2)_2$		Gms. $\text{Pb}(\text{SO}_3\text{NH}_2)_2$	
	t°	per 100 ml. sat. sol.	t°	per 100 ml. sat. sol.
SO	0	65.31	45	75.81
	25	70.97	50	77.08
		(68.5) <sup>a</sup>	55	78.08
	30	72.15	60	79.07
	35	73.35	65	80.46
	40	74.37		

<sup>a</sup>gms. per 100 gms. sat. sol. Cupery, 1938

**SeO LEAD SELENITE  $\text{PbSeO}_3$**

After seven days agitation at 10°, 11 mg. of  $\text{PbSeO}_3$  were found to be dissolved in 100 cc. of water. (Dolique, 1943.)

The Ksp at 20°, as determined from the solubility in dilute  $\text{HNO}_3$  and  $\text{H}_2\text{SO}_4$  solutions is  $3.4 (\pm 1.3) \times 10^{-12}$ . (Chukhlantsev and Tomashevskii, 1957.)

**LEAD SELENATE  $\text{PbSeO}_4$**

The Ksp at 25° is  $1.56 \times 10^{-6}$ . (Kapustinskii and Selivanova, 1949.)

Data for the solubility of  $\text{PbSeO}_4$  in aqueous solutions of  $\text{Li}_2\text{SeO}_4$ ,  $\text{K}_2\text{SeO}_4$  and  $\text{Na}_2\text{SeO}_4$  at 25° are given by Selivanova and Boguslavskii, 1955.

**LEAD TANTALATE  $\text{Pb}_8\text{Ta}_{12}\text{O}_{38} \cdot 33\text{H}_2\text{O}$**

The solubility is 5.17 mg./liter. (Efimov, Pchelkin and Lapitskii, 1954.)

LEAD TITANATE  $\text{PbTiO}_3$ 

Melting point data are given for:

$\text{PbTiO}_3 + \text{BaTiO}_3 + \text{CaTiO}_3$  (Ikeda, 1958)  
 $\text{PbTiO}_3 + \text{BaTiO}_3 + \text{K}_2\text{F}_2$  (Sholokhovitch, Fesenko, Kramarov and Khodakov, 1956)  
 $\text{PbTiO}_3 + \text{BaTi}$   
 $\text{PbTiO}_3 + \text{Na}_2\text{CO}_3, + \text{K}_2\text{CO}_3, + \text{KF}, + \text{Na}_2\text{MoO}_4,$  (Belyaev, Sholokhovitch and Barkova, 1954)  
 $+ \text{K}_2\text{MoO}_4, + \text{NaSiO}_3, + \text{K}_2\text{SiO}_3, + \text{NaVO}_3,$   
 $+ \text{KVO}_3, + \text{Na}_2\text{WO}_4$  (binary systems)

LEAD VANADATE  $\text{Pb}(\text{VO}_3)_2$ 

The Ksp at  $18^\circ$  is  $6.8 \times 10^{-12}$ . (Zolotavir, 1947.)

LEAD TUNGSTATE  $\text{PbWO}_4$ 

WO

The solubility in water at  $25^\circ$  is 0.0159 gms. per liter of saturated solution. (Berkem, 1943.)

## PALLADIUM Pd

Pd

The distribution of metallic palladium in the system Fe + FeS at the eutectic temperature was studied by Noddack, Noddack, and Bohnstedt (1940).

Data for the system Pd - H up to  $313^\circ$ , 35 atmospheres are given by Gillespie and Galstaun, 1936.

## PALLADIUM-DIMETHYLGLYOXIME

SOLUBILITY IN HYDROCHLORIC ACID SOLUTIONS AT  $25^\circ$   
 (Murontsev, 1955)

Solvent: Wt. % HCl	Gms. Pd - DMG per liter
0.5	0.0022
1.0	0.0044
3.0	0.0120
3.0 + 5% NaCl	0.0152
3.0 + 10% NaCl	0.0230
5.0	0.0192
10.0	0.0369



## Pd PALLADIUM

### Cl PALLADIUM CHLORIDE $\text{PdCl}_2$

When 1 gm. of palladium, as chloride, is dissolved in 100 cc. of  $\text{H}_2\text{O}$  and shaken with 100 cc. of ether, 0.02% of the metal enters the ethereal layer at ordinary temperature. When aqueous 10%  $\text{HCl}$  is used, 0.01% of the metal enters the ethereal layer. (Mylius, 1911.)

Data for the extraction of palladium from aqueous  $\text{HCl}$  solutions by ether are also given by Bock, 1951.

100 cc. anhydrous hydrazine dissolve 1 gm.  $\text{PdCl}_2$ , with evolution of gas and formation of a black precipitate, at room temperature. (Welsh and Broderson, 1915.)

### PALLADIUM (OUS) AMMINO CHLORIDE

#### SOLUBILITY IN HYDROCHLORIC ACID SOLUTIONS AT 10° (Murontsev, 1955)

Wt. % $\text{HCl}$	Gms. salt per liter
1.0	0.0440
3.0	0.0452
5.0	0.0456

### PALLADIUM ACETOXIME SALTS

#### SOLUBILITIES IN ACETONE AT 25° (Babaeva and Lyuboshits, 1953)

Salt	Gms. per 100 gms. Sat. Sol. in acetone
$\text{Pb}(\text{acetoxime})_2 \text{Cl}_2$	0.67
$\text{Pb}(\text{acetoxime})_2 \text{ClNO}_2$	1.05
$\text{Pb}(\text{acetoxime})_2 (\text{NO}_2)_2$	0.22

### I PALLADIUM IODIDE $\text{PdI}_2$

#### SOLUBILITY OF PALLADIUM IODIDE IN POTASSIUM IODIDE SOLUTIONS AT 18° (Tananaev, 1948)

The solid phase is anhydrous  $\text{PdI}_2$

Moles per liter		Moles per liter		Moles per liter	
KI	$\text{PdI}_2$	KI	$\text{PdI}_2$	KI	$\text{PdI}_2$
0.10	$1.4 \times 10^{-5}$	0.21	$6.4 \times 10^{-5}$	0.28	$1.1 \times 10^{-4}$
.12	$2.5 \times 10^{-5}$	.224	$7.6 \times 10^{-5}$	.36	$2.14 \times 10^{-4}$
.16	$4.6 \times 10^{-5}$	.228	$8 \times 10^{-5}$	.44	$2.5 \times 10^{-4}$
.18	$5.2 \times 10^{-5}$	.232	$8.8 \times 10^{-5}$	.60	$4.7 \times 10^{-4}$
.20	$5.6 \times 10^{-5}$	.236	$9.4 \times 10^{-5}$	1.00	$1.3 \times 10^{-3}$

POLONIUM COMPOUNDS

Data for the solubility of polonium hydroxide in KOH solutions and for Po acetate, cyanide and oxalate are reported by Bagnall and Freeman, 1957. The results are expressed in radiation units.

PRAESEODYMIUM, also see DIDYMIUM

PRAESEODYMIUM BROMATE  $\text{Pr}(\text{BrO}_3)_3 \cdot 9\text{H}_2\text{O}$

BrO

SOLUBILITY OF PRAESEODYMIUM BROMATE IN WATER  
(James, Fogg, McIntire, Evans and Donovan, 1927)

t°	Gms. per 100 gms. sat. sol.		t°	Gms. per 100 gms. sat. sol.	
	$\text{Pr}(\text{BrO}_3)_3 \cdot 9\text{H}_2\text{O}$	$\text{Pr}(\text{BrO}_3)_3$		$\text{Pr}(\text{BrO}_3)_3 \cdot 9\text{H}_2\text{O}$	$\text{Pr}(\text{BrO}_3)_3$
0	46.96	35.87	25	66.23	50.59
5	51.42	39.28	30	69.83	53.34
10	55.25	42.20	35	73.58	56.21
15	59.03	45.09	40	77.23	59.00
20	62.66	47.87	45	81.29	62.10

PRAESEODYMIUM ACETATE  $\text{Pr}(\text{CH}_3\text{COO})_2 \cdot \text{H}_2\text{O}$

CH

100 gms. sat. solution of praseodymium acetate in water contain 21.48 gms.  $\text{Pr}(\text{CH}_3\text{COO})_2$  at 25°. Saturation was obtained by constant shaking. (Meyer and Muller, 1920.)

PRAESEODYMIUM GLYCOLATE  $\text{Pr}_2(\text{C}_2\text{H}_3\text{O}_3)_3$

One liter water dissolves 3.578 gms.  $\text{Pr}_2(\text{C}_2\text{H}_3\text{O}_3)_3$  at 20°. (Jantsch and Grünkraut, 1912-1913.)

PRAESEODYMIUM LACTATE  $\text{Pr}(\text{C}_3\text{H}_5\text{O}_3)_3 \cdot 2\frac{1}{2}\text{H}_2\text{O}$

1000 cc. sat. solution of praseodymium lactate in water contain 24.84 gms.  $\text{Pr}(\text{C}_3\text{H}_5\text{O}_3)_3 \cdot 2\frac{1}{2}\text{H}_2\text{O}$  at 20°. Saturation was obtained by constant shaking.

PRAESEODYMIUM SORBATE  $\text{Pr}(\text{C}_5\text{H}_7\text{COO})_3$

The solubility in water is 0.001891 moles per liter at 20° (Bergamini, 1949.)

# Pr PRASEODYMIUM

## PRASEODYMIUM SODIUM ETHYLENEDIAMINE TETRA ACETATE $\text{Na}[\text{Pr}(\text{C}_6\text{H}_4\text{N}_2\text{O}_8)]$

The solubility in water at 25° is 0.078 moles per 1000 gms. sat. solution. (Moeller, Moss and Marshall, 1955.)

# CH PRASEODYMIUM SULFONATES

## SOLUBILITY IN WATER

Name Formula of Praseodymium Salt	Gms. Anhydrous Salt per 100 Gms. H <sub>2</sub> O	Ref.
Bromonitrobenzene Sulfonic Acid $\text{Pr}[\text{C}_6\text{H}_3\cdot\text{Br}\cdot\text{NO}_2\cdot\text{SO}_3, 1, 4, 2]_3\cdot 8\text{H}_2\text{O}$	6.08	A
Benzene Sulfonic Acid $\text{Pr}[\text{C}_6\text{H}_5\text{SO}_3]_3\cdot 9\text{H}_2\text{O}$	55.6	B
m Nitrobenzene Sulfonic Acid $\text{Pr}[\text{C}_6\text{H}_4(\text{NO}_2)\text{SO}_3]_3\cdot 6\text{H}_2\text{O}$	33.9	B
m Chlorobenzene Sulfonic Acid $\text{Pr}[\text{C}_6\text{H}_4\text{Cl}\cdot\text{SO}_3]_3\cdot 9\text{H}_2\text{O}$	12.6	B
Chloronitrobenzene Sulfonic Acid $\text{Pr}[\text{C}_6\text{H}_3\cdot\text{SO}_3\cdot\text{NO}_2\cdot\text{Cl}, 1, 3, 6]_3\cdot 14\text{H}_2\text{O}$	25.9	B
α Naphthalene Sulfonic Acid $\text{Pr}[\text{C}_{10}\text{H}_7\text{SO}_3]_3\cdot 6\text{H}_2\text{O}$	6.1	B
1,5 Nitronaphthalene Sulfonic Acid $\text{Pr}[\text{C}_{10}\text{H}_6(\text{NO}_2)\text{SO}_3]_3\cdot 6\text{H}_2\text{O}$	0.47	B
1,6 Nitronaphthalene Sulfonic Acid $\text{Pr}[\text{C}_{10}\text{H}_6(\text{NO}_2)\text{SO}_3]_3\cdot 9\text{H}_2\text{O}$	0.18	B
1,7 Nitronaphthalene Sulfonic Acid $\text{Pr}[\text{C}_{10}\text{H}_6(\text{NO}_2)\text{SO}_3]_3\cdot 11\text{H}_2\text{O}$	1.3	B

A = Katz and James, 1913

B = Holmberg, 1907

# CO PRASEODYMIUM OXALATE $\text{Pr}_2(\text{C}_2\text{O}_4)_3\cdot 10\text{H}_2\text{O}$

One liter H<sub>2</sub>O dissolves 0.00074 gm.  $\text{Pr}_2(\text{C}_2\text{O}_4)_3$  at 25°. (Rimbach and Schubert, 1909.)

One liter sat. solution of praseodymium oxalate in water contains 0.00149 gm.  $\text{Pr}_2(\text{C}_2\text{O}_4)_3$  at 25°, determined by the gravimetric method and 0.00215 determined by conductivity. (Sarver and Brinton, 1927.)

SOLUBILITY OF PRASEODYMIUM OXALATE IN AQUEOUS SOLUTIONS OF ACIDS AT 25°  
 (Sarver and Brinton, 1927)

Gms. Pr <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> per 100			Gms. Pr <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> per 100		
Composition of Aq. Solvent in Normality	gms. sat. sol.	Composition of Aq. Solvent in Normality	gms. sat. sol.		
0.1008 HCl	0.0098	6.0 HCl + sat. (COOH) <sub>2</sub>	0.1492		
0.2576 HCl	0.0279	6.2 HCl + sat. (COOH) <sub>2</sub>	0.1338		
0.5004 HCl	0.0625	0.2482 HNO <sub>3</sub>	0.0238		
1.018 HCl	0.1603	1.992 HNO <sub>3</sub>	0.5101		
1.484 HCl	0.2658	4.054 HNO <sub>3</sub>	1.656		
2.000 HCl	0.4108	2.000 " + 0.1 (COOH) <sub>2</sub>	0.1295		
2.865 HCl	0.6799	3.03 " + 0.1 (COOH) <sub>2</sub>	0.5712		
0.978 HCl + 0.1 (COOH) <sub>2</sub>	0.0128	4.00 " + 0.1 (COOH) <sub>2</sub>	1.057		
2.000 HCl + 0.1 (COOH) <sub>2</sub>	0.1163	2.00 " + 0.5 (COOH) <sub>2</sub>	0.0292		
2.865 HCl + 0.1 (COOH) <sub>2</sub>	0.3255	3.03 " + 0.5 (COOH) <sub>2</sub>	0.1323		
3.965 HCl + 0.1 (COOH) <sub>2</sub>	0.7021	4.00 " + 0.5 (COOH) <sub>2</sub>	0.3987		
0.978 HCl + 0.5 (COOH) <sub>2</sub>	0.0026	4.00 " + sat. (COOH) <sub>2</sub>	0.0663		
2.000 HCl + 0.5 (COOH) <sub>2</sub>	0.0173	6.00 " + sat. (COOH) <sub>2</sub>	0.912		
2.865 HCl + 0.5 (COOH) <sub>2</sub>	0.0548	0.086 H <sub>2</sub> SO <sub>4</sub>	0.0103		
3.965 HCl + 0.5 (COOH) <sub>2</sub>	0.1833	0.419 H <sub>2</sub> SO <sub>4</sub>	0.0512		
1.484 HCl + sat. (COOH) <sub>2</sub>	0.0046	0.958 H <sub>2</sub> SO <sub>4</sub>	0.1294		
4.0 HCl + sat. (COOH) <sub>2</sub>	0.0986	1.846 H <sub>2</sub> SO <sub>4</sub>	0.2808		
		2.612 H <sub>2</sub> SO <sub>4</sub>	0.4213		

100 gms. aqueous 19.4% HNO<sub>3</sub> (d = 1.116) dissolve 1.16 gms.  
 Pr<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub> at 15°. (v. Scheele, 1899.)

100 gms. aqueous 10.2% HNO<sub>3</sub> (d = 1.063) dissolve 0.50 gm.  
 Pr<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub> at 15°. (v. Scheele, 1899.)

The K<sub>sp</sub> of Pr<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub> in 0.02 N HCl at 20° is 1.3 x 10<sup>-38</sup>.  
 (Korenman, 1954.)

 SOLUBILITY OF PRASEODYMIUM OXALATE IN AQUEOUS SOLUTIONS OF NITRIC ACID  
 ALONE AND CONTAINING OXALIC ACID AT 90°  
 (Neckers and Kramers, 1928)

Normality of aq. HNO <sub>3</sub>	Gms. Pr <sub>2</sub> O <sub>3</sub> per 100 cc sat. sol.	Normality of aq. HNO <sub>3</sub>	Gms. (COOH) <sub>2</sub> per 100 gms. solvent	Gms. Pr <sub>2</sub> O <sub>3</sub> per 100 cc sat. sol.
0.779	0.3871	0.779	5.0	0.0275
1.558	1.0764	1.558	5.0	0.1639
2.337	1.8467	2.337	5.0	0.6932
5.000	0.8825	5.000	5.0	5.2339

The extraction of Pr<sup>+++</sup> from acid solutions by acetylacetone is  
 reported by Krishen, 1957.

**Pr PRASEODYMIUM**

**Cl PRASEODYMIUM CHLORIDE  $\text{PrCl}_3$**

SOLUBILITY OF PRASEODYMIUM CHLORIDE IN WATER  
(Friend and Hale, 1940)

t°	Gms. $\text{PrCl}_3$ per 100 gms. Sat. Sol.	Solid Phase	t°	Gms. $\text{PrCl}_3$ per 100 gms. Sat. Sol.	Solid Phase
0	47.75	$\text{PrCl}_3 \cdot 7\text{H}_2\text{O}$	45.8	51.47	$\text{PrCl}_3 \cdot 7\text{H}_2\text{O}$
11.4	48.39	"	55.4	53.04	"
13.0	50.96 <sup>a</sup>	"	59.0	53.60	"
26.2	49.65	"	63.6	54.51	"
35.0	50.15	"	71.5	56.62	"
44.6	51.46	"	80.2	58.62	"

<sup>a</sup>Matignon, 1906

SOLUBILITY OF PRASEODYMIUM CHLORIDE IN WATER, AQUEOUS HYDROCHLORIC  
ACID AND IN PYRIDINE  
(Matignon, 1906, 1909)

Solvent	t°	Sp. Gr. Sat. Sol.	Gms. per 100 Gms. Sat. Sol.
Water	13	1.687	50.96 $\text{PrCl}_3$
Aqueous HCl	13	1.574	41.05 $\text{PrCl}_3$ + 7.25 HCl
Pyridine	room temp.	-	2.1 $\text{PrCl}_3$

**PRASEODYMIUM BASIC CHLORIDES**

SOLUBILITY OF PRASEODYMIUM TRICHLORIDE AND OF PRASEODYMIUM OXIDE  
IN AQUEOUS SOLUTIONS OF AMMONIUM CHLORIDE AT SEVERAL TEMPERATURES  
(Prandtl and Rauchenberger, 1920)

The basic chlorides which were obtained were as follows. At 15°,  $\text{Pr}_4\text{Cl}_2\text{O}_5 \cdot 9\text{H}_2\text{O}$ ; at 30°,  $\text{Pr}_3\text{ClO}_4 \cdot 6\text{H}_2\text{O}$ ; at 50°,  $\text{Pr}_3\text{Cl}_2\text{O}_5 \cdot 20\text{H}_2\text{O}$ .

**CrO PRASEODYMIUM CHROMATE  $\text{Pr}_2(\text{CrO}_4)_3 \cdot 8\text{H}_2\text{O}$**

100 gms. sat. solution of praseodymium chromate in water contain 0.021 gm.  $\text{Pr}_2(\text{CrO}_4)_3$  at 25°. (Britton, 1924.)

**MoO PRASEODYMIUM MOLYBDATE  $\text{Pr}_2(\text{MoO}_4)_3$**

One liter water dissolves 0.0152 gm.  $\text{Pr}_2(\text{MoO}_4)_3$  at 23° and 0.0143 gms. at 75°. (Hitchcock, 1895.)

PRASEODYMIUM NITRATE  $\text{Pr}(\text{NO}_3)_3$ 

 SOLUBILITY OF PRASEODYMIUM NITRATE IN WATER  
(Friend, 1935)

t°	Gms. $\text{Pr}(\text{NO}_3)_3$ per 100 gms. sat. sol.	Solid Phase
15.8	59.32	$\text{Pr}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$
22.0	60.18	"
30.4	61.94	"
43.0	65.00	"
56.0 (m. pt.)	75.15	"

 PRASEODYMIUM MAGNESIUM NITRATE  $2\text{Pr}(\text{NO}_3)_3 \cdot 3\text{Mg}(\text{NO}_3)_2 \cdot 24\text{H}_2\text{O}$ 

 SOLUBILITY OF PRASEODYMIUM MAGNESIUM NITRATE IN WATER  
(Friend and Wheat, 1935)

t°	Gms. $2\text{Pr}(\text{NO}_3)_3 \cdot 3\text{Mg}(\text{NO}_3)_2 \cdot 24\text{H}_2\text{O}$ per 100 gms. sat. sol.	t°	Gms. $2\text{Pr}(\text{NO}_3)_3 \cdot 3\text{Mg}(\text{NO}_3)_2 \cdot 24\text{H}_2\text{O}$ per 100 gms. sat. sol.
15	63.0 (1) (d. = 1.49)	61.8	74.25
17.8	63.1	70.0	77.5 (1) (d. = 1.61)
30.0	66.4 (1) (d. = 1.52)	74.6	78.39
37.4	67.74	111.2 <sup>m</sup>	100.0
50.0	71.4 (1) (d. = 1.55)		

 (1) Prandtl and Ducrue, 1926 <sup>m</sup>melting point

 7.70 gms. of the hydrated double salt  $2\text{Pr}(\text{NO}_3)_3 \cdot 3\text{Mg}(\text{NO}_3)_2 \cdot 24\text{H}_2\text{O}$  dissolve in concentrated  $\text{HNO}_3$  (d. <sup>16</sup><sub>4</sub> = 1.325) at 16°. (Jantsch, 1912.)

## OTHER PRASEODYMIUM DOUBLE NITRATES

 SOLUBILITY OF EACH SEPARATELY IN WATER  
(Prandtl and Ducrue, 1926)

Composition	t°	d of sat. sol.	Gms. per 100 gms. sat. sol.			
			$\text{P}_2\text{O}_5$		Double salt	
$2\text{Pr}(\text{NO}_3)_2 \cdot 3\text{Co}(\text{NO}_3)_2 \cdot 24\text{H}_2\text{O}$	15	1.62	13.64	9.30	CoO	67.6
"	30	1.65	14.28	9.75	"	70.8
"	45	1.69	14.98	10.13	"	74.3
"	60	1.72	15.89	10.79	"	78.8
$2\text{Pr}(\text{NO}_3)_2 \cdot 3\text{Mn}(\text{NO}_3)_2 \cdot 24\text{H}_2\text{O}$	15	1.63	14.60	9.44	MnO	71.8
"	30	1.68	15.42	9.75	"	75.9
"	45	1.72	16.24	10.40	"	79.9
"	60	1.79	17.43	11.15	"	85.8

(Cont.)

## Pr PRASEODYMIUM

## SOLUBILITY OF EACH SEPARATELY IN WATER--Cont.

Composition	t°	d of sat. sol.	Gms. per 100 gms. sat. sol.		
			P <sub>2</sub> O <sub>3</sub>		Double salt
2Pr(NO <sub>3</sub> ) <sub>2</sub> ·3Ni(NO <sub>3</sub> ) <sub>2</sub> ·24H <sub>2</sub> O	15	1.60	12.99	8.83	NiO 64.4
"	30	1.63	13.83	9.41	" 68.5
"	45	1.66	14.50	9.87	" 71.8
"	60	1.70	15.27	10.47	" 75.7
2Pr(NO <sub>3</sub> ) <sub>2</sub> ·3Zn(NO <sub>3</sub> ) <sub>2</sub> ·24H <sub>2</sub> O	15	1.63	13.22	9.87	ZnO 66.3
"	30	1.67	14.08	10.45	" 70.6
"	45	1.71	15.02	11.01	" 75.4
"	60	1.76	15.97	11.98	" 80.1

NO

 SOLUBILITIES IN CONCENTRATED HNO<sub>3</sub> (d.<sub>4</sub><sup>16</sup> = 1.325) AT 16°  
 (Jantsch, 1912)

Salt and Formula	Gms. Hydrated Salt per 100 cc. Sat. Solution
Praseodymium Nickel Nitrate [Pr(NO <sub>3</sub> ) <sub>6</sub> ] <sub>2</sub> Ni <sub>3</sub> ·24H <sub>2</sub> O	9.28
Praseodymium Cobalt Nitrate [Pr(NO <sub>3</sub> ) <sub>6</sub> ] <sub>2</sub> Ni <sub>3</sub> ·24H <sub>2</sub> O	12.99
Praseodymium Zinc Nitrate [Pr(NO <sub>3</sub> ) <sub>6</sub> ] <sub>2</sub> Co <sub>3</sub> ·24H <sub>2</sub> O	14.69
Praseodymium Manganese Nitrate [Pr(NO <sub>3</sub> ) <sub>6</sub> ] <sub>2</sub> Mn <sub>3</sub> ·24H <sub>2</sub> O	23.40

 DISTRIBUTION OF PRASEODYMIUM NITRATE BETWEEN WATER AND  
 n-HEXYL ALCOHOL AT 25°  
 (Templeton, 1949)

Wt. % Pr <sub>6</sub> O <sub>11</sub> in		Wt. % Pr <sub>6</sub> O <sub>11</sub> in	
Aqueous Phase	Alcohol Phase	Aqueous Phase	Alcohol Phase
28.75	2.71	25.35	0.93
28.7	2.68	23.9	.74
28.4	2.35	22.6	.51
26.05	1.43	21.3	.38
25.4	1.09	20.25	.25

A sat. solution of Pr(NO<sub>3</sub>)<sub>3</sub>·6H<sub>2</sub>O in ethyl ether, prepared by frequent agitation and allowing to stand over night at about 20°, contained 0.004 gm. Pr<sub>2</sub>O<sub>3</sub> per 100 cc. (Wells, 1930.)

Data for the distribution of Pr(NO<sub>3</sub>)<sub>2</sub> between aqueous acids and salts and tributyl phosphate are reported by Knapp, Smutz and Spedding, 1956.

PRASEODYMIUM OXIDE, HYDROXIDE  $\text{Pr}_2\text{O}_3$ ,  $\text{Pr}(\text{OH})_3$ 

OH

One liter sat. solution of praseodymium oxide in water contains 0.0000061 gm. mol.  $\text{Pr}_2\text{O}_3$  at  $29^\circ$ , as determined by electrometric titration. The corresponding value for  $\text{Pr}_6\text{O}_{11}$  is 0.0000039 at  $29^\circ$ . (Busch, 1927.)

Korenman, 1955 reports the  $K_{sp}$  of  $\text{Pr}(\text{OH})_3$  to be  $7 \times 10^{-24}$  from data on the pH at precipitation.

Data for the precipitation of  $\text{Pr}(\text{OH})_3$  from ammonium acetate solutions is given by Perey, 1949.

 PRASEODYMIUM DIMETHYL PHOSPHATE  $\text{Pr}_2[(\text{CH}_3)_2\text{PO}_4]_6$ 

100 gms.  $\text{H}_2\text{O}$  dissolve 64.1 gm.  $\text{Pr}[(\text{CH}_3)_2\text{PO}_4]_6$  at  $25^\circ$ . (Morgan and James, 1914.)

 PRASEODYMIUM SULFATE  $\text{Pr}_2(\text{SO}_4)_3$ 

SO

## SOLUBILITY OF PRASEODYMIUM SULFATE IN WATER

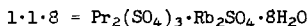
The somewhat irregular results of Muthmann and Rolig, 1898; Meyer, and Jackson and Rienacker, 1930, were plotted and the following values taken from the average curve drawn through them.

Gms. $\text{Pr}_2(\text{SO}_4)_3$ per t° 100 gms. sat. sol. Solid Phase			Gms. $\text{Pr}_2(\text{SO}_4)_3$ per t° 100 gms. sat. sol. Solid Phase		
0	16.5	$\text{Pr}_2(\text{SO}_4)_3 \cdot 8\text{H}_2\text{O}$	50	6.0	$\text{Pr}_2(\text{SO}_4)_3 \cdot 8\text{H}_2\text{O}$
10	13.5	"	60	4.8	"
20	11.2	"	70	4.0	"
25	10.0	"	80	3.4	"
30	9.0	"	90	1.1(?)	$\text{Pr}_2(\text{SO}_4)_3 \cdot 5\text{H}_2\text{O}$
40	7.2	"	100	0.9(?)	"

Spedding and Jaffe, 1954 report the solubility of "hydrated  $\text{Pr}_2(\text{SO}_4)_3$ " to be 10.88 gms. per 100 gms.  $\text{H}_2\text{O}$  at  $25^\circ$ .

 THE SYSTEM PRASEODYMIUM SULFATE - RUBIDIUM SULFATE - WATER AT  $25^\circ$   
(Restanio, 1934)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Pr}_2(\text{SO}_4)_3$	$\text{Rb}_2\text{SO}_4$		$\text{Pr}_2(\text{SO}_4)_3$	$\text{Rb}_2\text{SO}_4$	
4.82	0.30	$\text{Pr}_2(\text{SO}_4)_3 \cdot 8\text{H}_2\text{O}$	0.06	6.72	1.1.8
3.67	0.33	"	0.0	15.22	"
1.98	0.38	---	0.0	17.59	"
1.28	0.41	---	0.0	19.43	"
1.08	0.38	---	0.0	20.84	---

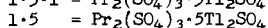
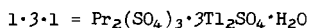
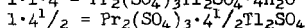
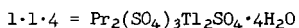




## Pr PRASEODYMIUM

### THE SYSTEM PRASEODYMIUM SULFATE - THALLIUM SULFATE - WATER AT 25° (Zambonini and Pestanico, 1931)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{Pr}_2(\text{SO}_4)_3$	$\text{Tl}_2\text{SO}_4$	Solid Phase	$\text{Pr}_2(\text{SO}_4)_3$	$\text{Tl}_2\text{SO}_4$	Solid Phase
8.43	0.03	$\text{Pr}_2(\text{SO}_4)_3 \cdot 8\text{H}_2\text{O} + 1 \cdot 1 \cdot 4$	0.10	3.42	$1 \cdot 3 \cdot 1 + 1 \cdot 4^{1/2}$
6.18	0.13	$1 \cdot 1 \cdot 4$	0.0	4.98	$1 \cdot 4^{1/2}$
0.52	0.73	"	0.0	5.27	1.5
0.18	2.80	"	0.0	5.83	"
0.15	2.98	"	0.0	5.91	" + $\text{TlSO}_4$



## SeO PRASEODYMIUM SELENATE $\text{Pr}_2(\text{SeO}_4)_3$

### SOLUBILITY OF PRASEODYMIUM SELENATE IN WATER (Friend, 1932)

Gms. $\text{Pr}_2(\text{SeO}_4)_3$ per 100			Gms. $\text{Pr}_2(\text{SeO}_4)_3$ per 100		
t°	gms. sat. sol.	Solid Phase	t°	gms. sat. sol.	Solid Phase
0.5	26.59	$\text{Pr}_2(\text{SeO}_4)_3 \cdot ?\text{H}_2\text{O}$	55.5	23.99	$\text{Pr}_2(\text{SeO}_4)_3 \cdot ?\text{H}_2\text{O}$
17.4	23.88	"	59.5	23.33	$\text{Pr}_2(\text{SeO}_4)_3 \cdot 12\text{H}_2\text{O}$
24.6	24.29	"	63.6	14.00	"
30.0	24.50	"	67.0	9.96	"
40.2	23.67	"	75.0	6.89	"
48.6	24.00	"	81.0	5.64	"
52.0	23.89	"	92.0	2.99	"

Owing to hydrolysis, especially at the higher temperatures, the saturated solutions were usually slightly acid. Difficulties were experienced in obtaining concordant results. Determinations were also made of the influence of small amounts of free selenic acid upon the solubility of the salt.

## WO PRASEODYMIUM TUNGSTATE $\text{Pr}_2(\text{WO}_4)_3$

### SOLUBILITY OF PRASEODYMIUM TUNGSTATE IN WATER (Vickerey, 1949)

t°	Gms. $\text{Pr}_2(\text{WO}_4)_3$ per 100 ml.	
	Unignited	Ignited
20	0.020	0.002
75	0.00438 <sup>a</sup>	-
100	0.025	0.002 <sup>a</sup> Hitchcock, 1895

## Pt PLATINUM

### SOLUBILITY OF PLATINUM IN MERCURY (Plaksin and Suvorovskaya, 1940, 1941, 1945)

The system platinum - mercury was studied by thermal, X-ray, and microscopic methods and the phase diagrams drawn. Mercury dissolves in

platinum up to 23 atomic %, and forms 3 compounds. The solubility of platinum in mercury is as follows:

Temperature:	16.5°	144°	200°
Atomic % Pt	0.0205	1.08	1.77

The distribution of metallic platinum between Fe and FeS at the eutectic temperature of the system was studied by Noddack, Noddack, and Bohnstedt, 1940.

## PLATINUM ALLOYS

### SOLUBILITY OF PLATINUM ALLOYS IN NITRIC ACID (Winkler--Z. anal. Ch. 13, 369, '74)

Alloy	Approx. % Pt in Alloy	Grams Alloy Dissolved per 100 Grams HNO <sub>3</sub> Solution of				WO
		1.398 Sp. Gr.	1.298 Sp. Gr.	1.190 Sp. Gr.	1.298 Sp. Gr.	
Pt and Silver	10	57	44	69	37	
"	5	69	57	51	35	
"	2.5	62	61	69	--	
"	1	75	70	76	--	
Pt and Copper	10	46	27	11	51	
"	5	36	34	14	41	
"	2.5	51	40	30	--	
"	1	52	41	37	--	
Pt and Lead	10	7	9	8	--	
"	5	8	9	10	--	
"	2.5	22	17	11	--	
"	1+	21	18	23	--	
Pt and Bismuth	10	14	19	4	3	
"	5	21	20	6	18	
"	2.5	25	42	8	--	
"	1	49	64	10	--	
Pt and Zinc	10	10	11	19	5	
"	5	16	12	6	11	
"	2.5	16	24	19	--	
"	1	20	32	37	--	

## PLATINUM BROMIDE PtBr<sub>4</sub>

Br

100 grams sat. aqueous solution contain 0.41 gram PbBr<sub>4</sub> at 20°.  
(Halberstadt, 1884.)

## PLATINUM POTASSIUM BROMIDE PtK<sub>2</sub>Br<sub>6</sub>

100 gms. sat. solution in water contain 2.02 gms. PtK<sub>2</sub>Br<sub>6</sub> at 20°.  
(Halberstadt, 1884.)

# Pt PLATINUM

## Cl PLATINUM CHLORIDE $\text{PtCl}_4$

### SOLUBILITY OF PLATINUM CHLORIDE IN WATER (Kurnakov and Nikitina, 1940)

t°	Gms. $\text{PtCl}_4$ per 100 gms. Sat. Sol.	Solid Phase	t°	Gms. $\text{PtCl}_4$ per 100 gms. Sat. Sol.	Solid Phase
0	39.99	$\text{PtCl}_4 \cdot 8\text{H}_2\text{O}$	70	74.66	$\text{PtCl}_4 \cdot 4\text{H}_2\text{O}$
25	58.70 <sup>a</sup>	(?)	80	78.60	$\text{PtCl}_4 \cdot 3\text{H}_2\text{O}$
40	62.38	$\text{PtCl}_4 \cdot 5\text{H}_2\text{O}$	90	82.5	"
50	69.03	"	98	85.11	"
60	74.00	$\text{PtCl}_4 \cdot 4\text{H}_2\text{O}$			

<sup>a</sup>agrees with Genke, 1926

### DISTRIBUTION OF PLATINUM CHLORIDE BETWEEN WATER AND ETHER AT ORDINARY TEMPERATURE (Mylus, 1911)

When 1 gm. of platinum as chloride is dissolved in 100 cc. of aqueous 10% HCl and shaken with 100 cc. of ether, 0.01 per cent of the platinum enters the ethereal layer. If water is used instead of 10% HCl, approximately the same per cent of Pt enters the ether layer.

100 cc. anhydrous hydrazine dissolve 1 gm. platinic chloride, with formation of a black precipitate at room temperature. (Welsh and Broderson, 1915.)

## PLATINIC DOUBLE CHLORIDES

### SOLUBILITY OF EACH SEPARATELY IN WATER (Crookes, 1864; Bunsen, 1861; Archibald, Wilcox and Buckley, 1908)

t°	Grams per 100 Grams Water					
	$(\text{NH}_4)_2\text{PtCl}_6$	$\text{Cs}_2\text{PtCl}_6$	$\text{K}_2\text{PtCl}_6$	$\text{K}_2\text{PtCl}_6(\text{a})$	$\text{Rb}_2\text{PtCl}_6$	$\text{Tl}_2\text{PtCl}_6$
0	-	0.024	0.74	0.478	0.184	-
10	-	0.050	0.90	0.599	0.154	-
15	0.666	-	-	-	-	0.0064
20	-	0.079	1.12	0.774	0.141	-
25	-	0.095	1.26	-	0.143	-
30	-	0.110	1.41	1.000	0.145	-
40	-	0.142	1.76	1.355	0.166	-
50	-	0.177	2.17	-	0.203	-
60	-	0.213	2.64	2.444	0.253	-
70	-	0.251	3.19	-	0.329	-
80	-	0.291	3.79	3.711	0.417	-
90	-	0.332	4.45	-	0.521	-
100	1.25	0.377	5.18	5.030	0.634	0.050

<sup>a</sup>Archibald, Wilcox and Buckley, 1908

SOLUBILITY OF POTASSIUM CHLOROPLATINATE IN AQUEOUS SOLUTIONS  
OF POTASSIUM CHLORIDE AND OF SODIUM CHLORIDE  
(Archibald, Wilcox and Buckley, 1908)

K

In Aqueous KCl at 20°		In Aqueous NaCl at 16°	
Gm. Mols. KCl per Liter	Gms. $K_2PtCl_6$ per 100 gms. solvent	Gm. Mols. NaCl per Liter	Gms. $K_2PtCl_6$ per 100 gms. solvent
0.20	0.0236	0	0.672
0.25	0.0207	0.05	0.700
0.50	0.0109	0.10	0.729
1	0.0046	0.25	0.758
2	0.0045	0.50	0.775
3	0.0043	0.75	0.791
4	0.0042	1	0.805
sat.	0.0034	2	0.834

Cl

At 100°  
(Archibald and Kern, 1917)

2	5.03
---	------

SOLUBILITY OF  $K_2PtCl_6$  IN AQUEOUS METHANOL SOLUTIONS AT 20°  
(Archibald, Wilcox and Buckley, 1908)

Wt. % Alcohol in solvent	Gms. $K_2PtCl_6$ per 100 Gms.	
	Aq. $CH_3OH$	Aq. $C_2H_5OH$
0	0.7742	0.7742
5	0.535	0.491
10	0.412	0.372
20	0.264	0.218
30	0.1831	0.134
40	0.1165	0.076

SOLUBILITY OF  $K_2PtCl_6$  IN AQUEOUS ETHANOL SOLUTIONS

At 14°			At 20°		
(Pierrat, 1921)			(Archibald, Wilcox and Buckley, 1908)		
Wt. % $C_2H_5OH$ in solvent	Gms. $K_2PtCl_6$ per liter sat. sol.		Wt. % Alcohol in Solvent	Gms. $K_2PtCl_6$ per 100 Gms.	
				Aq. $CH_3OH$	Aq. $C_2H_5OH$
0.0	9.3		50	0.0625	0.0491
8.7	4.2		60	0.0325	0.0265
15.9	2.6		70	0.0182	0.0128
27.3	1.4		80	0.0124	0.0085
42.4	0.5		90	0.0038	0.0025
58.5	0.2		100	0.0027	0.0009
94.7	0.02				

# Pt PLATINUM

100 gms. aqueous 8.2% isobutyl alcohol dissolve 0.625 gm.  $K_2PtCl_6$  at 20°.

100 gms. aqueous sat. isobutyl alcohol dissolve 0.318 gm.  $K_2PtCl_6$  at 20°. (Archibald, Wilcox and Buckley, 1908.)

## PLATINUM AMMINES

### REFERENCES

- |                                      |                                     |
|--------------------------------------|-------------------------------------|
| (1) Tschugajew, 1926                 | (8) Volshtein and Velikanova, 1957  |
| (2) Cleve, 1866                      | (9) Chernyaev and Mashentsev, 1949  |
| (3) Rubinshtein and Derbisher, 1950  | (10) Gel'man and Karandashova, 1951 |
| (4) Gel'man and Essen, 1950          | (11) Stromholm, 1900                |
| (5) Zvyagintsev and Filimonova, 1951 | (12) Grinberg and Zemlyakova, 1948  |
| (6) Chernyaev and Krasovskaya, 1957  | (13) Brubaker, 1957                 |
| (7) Tschugaev and Kiltinovie, 1916   |                                     |

Cl

Compound	t°	Solubility	Ref.
$[Pt(NH_3)_6]Cl_4$	0	14.79 wt. % in $H_2O$	(1)
$[Pt(NH_3)_5Cl]Cl_3$	0	2.83 wt. % in $H_2O$	(1)
$[Pt(NH_3)_5OH]Cl_3$	0	2.74 wt. % in $H_2O$	(1)
$[Pt(NH_3)_5Cl](NO_3)_3$	0	0.98 wt. % in $H_2O$	(1)
	21	" "	(1)
$[Pt(NH_3)_2Cl_2]$	0	0.26 g./100 g. $H_2O$	(2)
	100	3.4 "	(2)
$[Pt(NH_3)_2Cl_2]Cl_2$	0	0.14 g./100 g. $H_2O$	(2)
	100	3.0 "	(2)
$[Pt(NH_3)_3Cl]Cl_3$	0	0.33 g./100 g. $H_2O$	(2)
	100	1.54 "	(2)
$[Pt[(CH_2=CHCH_2)_2NH]_2][PtCl_4]$	25	0.040 wt. % in $H_2O$	(3)
$PtClNO_2NH_3BrNO_3Py$ (Py = pyridine)	100	0.033 wt. % in $H_2O$	(4)
$PtClNO_2NH_3INO_3Py$	20	0.004 wt. % in $H_2O$	(4)
$[Pt(NH_3)_5Cl]Cl[PtCl_6]$	25	1.124 g./100 g. $H_2O$	(5)
		0.01 g./100 g. 20% $NH_4Cl$ aqueous	(5)
$Pt(NH_3)_23,5(Cl)_21,6(NO_3)_2$	25	7.0 wt. % in $H_2O$	(6)
$Pt(NH_3)_25,6(Cl)_21,3(NO_3)_2$	25	3.8 wt. % in $H_2O$	(6)
$Pt(NH_3)_2(NO_2)_2(cis)$	25	0.083 gms./100 gms. $H_2O$	(7)
	63	0.66 "	(7)
	95	2.32 "	(7)
$Pt(NH_3)_2(NO_2)_2(trans)$	25	0.063 gms./100 gms. $H_2O$	(7)
	63	0.49 "	(7)
	74.4	0.81 "	(7)
	95	1.85 "	(7)

(Cont.)

## PLATINUM AMINES--Cont.

Compound	t°	Solubility	Ref.
$[\text{Pt}(\text{NH}_3)_4][\text{Pt}(\text{NO}_2)_4]$	25	0.011 gms./100 gms. $\text{H}_2\text{O}$	(7)
$\text{Pt}[\text{EtCH}(\text{NH}_2)\text{CO}_2]_2$ (cis)	20	1.15 wt. % in $\text{H}_2\text{O}$	(8)
$\text{Pt}[\text{EtCH}(\text{NH}_2)\text{CO}_2]_2$ (trans)	20	0.02 wt. % in $\text{H}_2\text{O}$	(8)
$\text{Pt}[\text{EtCH}(\text{NH}_2)\text{CO}_2]_2[\text{thiourea}]_2\text{Cl}_2$	20	0.5 wt. % in $\text{H}_2\text{O}$	(8)
$\text{Pt}[\text{SC}(=\text{S})\text{NHNH}_2]_2$	25	0.00003 mole/l. $\text{H}_2\text{O}$	(9)
$\text{Pt}(\text{NH}_3)_2[\text{SC}(=\text{S})\text{NHNH}_2]_2$	25	0.00002 mole/l. $\text{H}_2\text{O}$	(9)
$\text{Pt}(\text{NH}_3)\text{ClPyI}$ (trans, Cl-I)	20	0.018 wt. % in $\text{H}_2\text{O}$	(10)
$\text{Pt}(\text{NH}_3)\text{IClPy}$ (cis, form 1)	20	0.024 wt. % in $\text{H}_2\text{O}$	(10) CI
$\text{Pt}(\text{NH}_3)\text{ClIPy}$ (cis, form 2)	20	0.022 wt. % in $\text{H}_2\text{O}$	(10)
$[(\text{CH}_3)_3\text{S}]_2\text{PtCl}_6$	16	0.47 wt. % in $\text{H}_2\text{O}$	(11)
$[(\text{CH}_3)_2(\text{C}_2\text{H}_5)\text{S}]_2\text{PtCl}_6$	16	3.43 wt. % in $\text{H}_2\text{O}$	(11)
$[\text{CH}_3(\text{C}_2\text{H}_5)_2\text{S}]_2\text{PtCl}_6$	16	2.42 wt. % in $\text{H}_2\text{O}$	(11)
$[(\text{C}_2\text{H}_5)_3\text{S}]_2\text{PtCl}_6$	16	1.98 wt. % in $\text{H}_2\text{O}$	(11)
$\text{Pt}(\text{NH}_3)_4[\text{Pt}(\text{SCN})_4]$	?	2 wt. % in 50% acetone	(12)
	?	1.5 wt. % in 50% acetone sat'd. w. benzene	(12)
$\text{Pt}(\text{en})_3(\text{ClO}_4)_4$	25	0.2229 moles per 1000 gms. $\text{H}_2\text{O}$	(13)

PLATINUM IODIDE  $\text{PtI}_4$ 

Data for the solubility of  $\text{PtI}_4$  in aqueous KI solutions are given by Tanannaev, 1948. The solid phase is  $\text{PtI}_4$  up to 0.6 mol. KI per liter; above it is  $\text{K}_2\text{PtI}_6$ . The solubility of the latter salt is approximately 0 when the solution is saturated with KI.

PLUTONIUM OXALATE  $\text{Pu}(\text{C}_2\text{O}_4)_2 \cdot 6\text{H}_2\text{O}$ 

CO

SOLUBILITY IN AQUEOUS SOLUTIONS AT 20°  
(Moskvin and Gel'man, 1958)

Water	$1.03 \times 10^{-4}$ moles $\text{Pu}(\text{C}_2\text{O}_4)_2$ per liter
In $\text{H}_2\text{SO}_4$	$8.0 \times 10^{-4}$ moles $\text{Pu}(\text{C}_2\text{O}_4)_2$ per liter
In $\text{HNO}_3$	$2.25 \times 10^{-4}$ moles $\text{Pu}(\text{C}_2\text{O}_4)_2$ per liter
In $\text{HClO}_4$	$1.57 \times 10^{-4}$ moles $\text{Pu}(\text{C}_2\text{O}_4)_2$ per liter

Solubilities in  $(\text{NH}_4)_2\text{C}_2\text{O}_4$  and in  $\text{HNO}_3$  and  $\text{HClO}_4$  are given by Gel'man and Moskvin, 1958. Minimum solubility in  $(\text{NH}_4)_2\text{C}_2\text{O}_4$  was  $3.55 \times 10^{-5}$  mol. Pu per liter.

## Pu PLUTONIUM

### PLUTONIUM ACETYLACETONATE

Data for the distribution of the acetylacetone complex between benzene and water, chloroform and water, and methyl isobutyl ketone and water at 25° are given by Rydberg, 1955.

### F PLUTONIUM FLUORIDE $\text{PuF}_3$

Data for the solubility of  $\text{PuF}_3$  in  $\text{NaF} - \text{BeF}_2$  and  $\text{LiF} - \text{BeF}_2$  mixtures is given by Barton, Grimes and Strehlow, 1958.

### PLUTONYL FLUORIDE $\text{PuO}_2\text{F}_2$

The solubility in water at 20° is 1.07 gms. per liter. (Alenchenkova, et al., 1958.)

Data for the preparation and relative solubilities of various double fluorides are reported by Anderson, 1949, 1949a.

### NO PLUTONIUM NITRATE $\text{Pu}(\text{NO}_3)_4$

Partition data for plutonium are given in the following systems:

$[\text{Pu IV, VI}]$  (20°) aqueous  $\text{HNO}_3 + \text{Ca}(\text{NO}_3)_2$  - methyl isobutyl ketone  
(Rydberg and Bernstrom, 1957)

$[\text{Pu}(\text{NO}_3)_4, \text{PuO}_2(\text{NO}_3)_2]$  aqueous  $\text{HNO}_3$  - tributyl phosphate  
(Alcock, Best, Hesford, McKay, 1958)

$[\text{Pu}(\text{NO}_3)_4, \text{PuO}_2(\text{NO}_3)_2]$  aqueous  $\text{HNO}_3$  - tributyl phosphate  
(Healy and McKay, 1956)

Solubilities of Pu IV and VI nitrates in "Butex" at 25° are reported by Dawson (1957). Data for solubilities of other Pu compounds are also given.

### OH PLUTONIUM HYDROXIDE $\text{Pu}(\text{OH})_4$

The  $K_{sp}$  is  $7.1 \times 10^{-56}$  at 25° (Kasha, 1949).

PLUTONIUM PHOSPHATE  $\text{Pu}_2\text{H}(\text{PO}_4)_3 \cdot x\text{H}_2\text{O}$ 

PO

SOLUBILITY IN DILUTE ACIDS AT 25°  
(King, 1949)

After equilibration,  $\text{Pu}_2\text{H}(\text{PO}_4)_3 \cdot x\text{H}_2\text{O}$  was converted to  $\text{Pu}(\text{HPO}_4)_2 \cdot y\text{H}_2\text{O}$ . The approach to saturation was slow in each case. Results in micrograms Pu IV per milliliter.

Solvent	time of equilibration, days		
	4	10	34
2.08 M $\text{HNO}_3$ + 1.20 M $\text{H}_3\text{PO}_4$	38	46	56
2.08 M $\text{HNO}_3$ + 0.90 M $\text{H}_3\text{PO}_4$	67	80	104
2.08 M $\text{HNO}_3$ + 0.60 M $\text{H}_3\text{PO}_4$	110	135	184

Data for the solubility of gelatinous  $\text{Pu}(\text{HPO}_4)_2 \cdot y\text{H}_2\text{O}$  at 25° in 2.08 M  $\text{HNO}_3$  containing 0 - 1.20 M  $\text{H}_3\text{PO}_4$  and in 0.832 M  $\text{HNO}_3$  + 1.25 M  $\text{NaNO}_3$  with up to 1.21 M  $\text{H}_3\text{PO}_4$  are also reported by King, 1949.

PLUTONIUM SULFATE  $\text{Pu}(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O}$ 

SO

(Results of Anderson, 1949c)

Solvent			Solubility of Pu (gms./liter)
mg. $\text{H}_2\text{SO}_4$	ml. alcohol	total vol. (ml.)	
0.1	0	0.80	≥125
1.0	0	0.50	~90
9	0	0.200	1.66
12	0	0.300	3.13
2.7	$\text{CH}_3\text{OH}$ 0.100	0.380	5.6
7.2	$\text{C}_2\text{H}_5\text{OH}$ 0.0500	0.250	0.20
0.2 <sup>a</sup>	$\text{CH}_3\text{OH}$ 0.060	0.210	0.26
0.2 <sup>b</sup>	$\text{CH}_3\text{OH}$ 0.080	0.330	~ 0.40

<sup>a</sup>(+  $\text{CaSO}_4$ , 19 mg.)<sup>b</sup>(+  $\text{Na}_2\text{SO}_4$ , 14 mg.)

Anderson, 1949d reports the solubility of plutonium - thallium double sulfates  $\text{TlPu}(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O}$  and  $\text{Tl}_3\text{Pu}(\text{SO}_4)_4$  in  $\text{H}_2\text{SO}_4$  solutions. Solid solutions of varying Tl/Pu are formed.

RADIUM EMANATIONS, see RADON Rn



## Ra RADIUM

### Br RADIUM BROMIDE, CHLORIDE and NITRATE

#### SOLUBILITY OF EACH SEPARATELY IN WATER AT 20° (Erbacher, 1930)

The experiments were made on a scale about one-two hundredth that ordinarily employed for solubility determinations. The results are of special interest in connection with the separation of radium from barium by fractional crystallization of their salts. The results are compared in the following table with those for the corresponding bromides, chlorides and nitrates of calcium, strontium and barium.

Salt	Gms. per 100 gms. sat. solution of the salts of:			
	Ca	Br	Ba	Ra
Bromide	58.8	50.0	51.0	41.4
Chloride	42.7	35.0	26.3	19.7
Nitrate	54.8	41.5	7.9	12.2

Results for the coefficient of distribution of radium and barium in the fractional crystallization of solutions of their bromides, are given by Walter and Schlundt, 1928.

The distribution of  $\text{Ra}(\text{NO}_3)_2$  between solutions saturated with  $\text{Ba}(\text{NO}_3)_2$  and  $\text{Pb}(\text{NO}_3)_2$  and the solid salts and mixed crystals of these salts has been extensively studied by Chlopin and his students; Chlopin and Polessitsky, 1928; Chlopin, Polessitsky and Tolmatcheff, 1929; Polessitsky, 1932.

The distribution of radium nitrate between liquid and solid salts at their melting points was determined by Chlopin and Klokman, 1949 for the following cases: in  $\text{Pb}(\text{NO}_3)_2$  with  $\text{NaNO}_3$  added; in  $\text{Ba}(\text{NO}_3)_2$  with  $\text{NaNO}_3$  added, in  $\text{PbSO}_4$  with  $\text{Li}_2\text{SO}_4$  added, in  $\text{Sr}(\text{NO}_3)_2$  with  $\text{KNO}_3$  added.

Data for the distribution of radium and thorium X between the solid and liquid phases of the system  $\text{Ca}(\text{NO}_3)_2$  -  $\text{Ra}(\text{NO}_3)_2$  -  $\text{NaNO}_3$  are given by Khlopin, Klokman and Pekelnaya, 1953.

### SO RADIUM SULFATE $\text{RaSO}_4$

#### SOLUBILITY IN WATER AND IN AQUEOUS SOLUTIONS OF SULFURIC ACID AT 25° (Lind, Underwood and Whitmore, 1918)

Constant agitation was employed and equilibrium was approached from above and from below. The dissolved radium sulfate was determined by the "emanation" method.

SOLUBILITY IN WATER AND IN AQUEOUS SOLUTIONS  
OF SULFURIC ACID AT 25°--Cont.

Conc. of H <sub>2</sub> SO <sub>4</sub>	Gm. x 10 <sup>-3</sup> RaSO <sub>4</sub> per 25 cc. sat. sol.	Conc. of H <sub>2</sub> SO <sub>4</sub>	Gm. x 10 <sup>-3</sup> RaSO <sub>4</sub> per 25 cc. sat. sol.
0.0 (=H <sub>2</sub> O)	2.1	30%	2.3
0.01 normal	2.0 (3.0 at 35°)	45%	1.9
0.10 normal	2.2	50%	2.1
1.0 normal	2.2	55%	3.4
10%	2.4	60%	6.3
15%	2.4	65%	6.4
25%	2.3 (3.3 at 35° and 5.0 at 45°)	70%	>79.0 (not sat.)

Subsequent determinations of the solubility of radium sulfate in water by Erbacher and Nikitin, 1931, made with special reference to the sources of error in the method, resulting from the adsorption of radium by the filtering medium, gave 0.00014 gm. RaSO<sub>4</sub> per 100 cc. H<sub>2</sub>O at 20°. This value is about 67 times greater than the above result by Lind and co-workers. In a later paper Nikitin and Tolmatscheff, 1933, revised this value to 0.00021 gm. RaSO<sub>4</sub> per 100 cc. H<sub>2</sub>O at 20°. They also found that the solubility of radium sulfate in solutions which contain sulfate ions follows the mass action law, taking into consideration the activity coefficient of both ions. The activity product at 20° is equal to 4.25 10<sup>-11</sup>.

**RUBIDIUM TETRAPHENYLBORATE RbB(C<sub>6</sub>H<sub>5</sub>)<sub>4</sub>**

8

0.576 γ of RbB(C<sub>6</sub>H<sub>5</sub>)<sub>4</sub> dissolve in 100 ml of H<sub>2</sub>O at 20° (Geilmann and Gebauhr, 1953).

**RUBIDIUM FLUOBORATE RbBF<sub>4</sub>**

0.6 gms. RbBF<sub>4</sub> dissolve in 100 gms. H<sub>2</sub>O at 17° (deBoer and van Lempt, 1927; van Lempt, 1927).

**RUBIDIUM PENTABORATE Rb<sub>2</sub>B<sub>10</sub>O<sub>16</sub>**

SOLUBILITY OF RUBIDIUM PENTABORATE IN WATER  
(Rollet and Andres, 1930, 1931)

t°	Gms. Rb <sub>2</sub> O·5B <sub>2</sub> O <sub>3</sub> per 100 gms. sat. sol.	Solid Phase	t°	Gms. Rb <sub>2</sub> O·5B <sub>2</sub> O <sub>3</sub> per 100 gms. sat. sol.	Solid Phase
-0.43 <sup>e</sup>	1.57	Ice+Rb <sub>2</sub> O·5B <sub>2</sub> O <sub>3</sub> ·8H <sub>2</sub> O	45	5.75	Rb <sub>2</sub> O·5B <sub>2</sub> O <sub>3</sub> ·8H <sub>2</sub> O
+0.2	1.58	Rb <sub>2</sub> O·5B <sub>2</sub> O <sub>3</sub> ·8H <sub>2</sub> O	60	8.69	"
5	1.72	"	70.4	11.5	"
13.4	2.21	"	82.4	15.2	"
18	2.57	"	88.15	17.75	"
30	3.58	"	102b.pt.	23.75	"

e = eutectic

# Rb RUBIDIUM

## Br RUBIDIUM BROMIDE RbBr

### SOLUBILITY IN WATER (Rimbach, 1905)

t°	Gms. RbBr per 100 Gms.		t°	Gms. RbBr per 100 Gms.	
	Water	Solution		Water	Solution
0.5	89.6	47.26	25	-	53.69 <sup>b</sup>
5	98	49.50	39.7	131.85	56.87
16	104.8	51.17	57.5	152.47	60.39
18	-	50.02 <sup>a</sup>	113.5	205.21	67.24

<sup>a</sup>Lannung, 1934

<sup>b</sup>Fajans and Karagunis, 1931

### SOLUBILITY OF RUBIDIUM BROMIDE IN VARIOUS SOLVENTS

Solvent	t°	Solvent
Acetone	18	0.00505 gms. RbBr per 100 gms. solvent (Lannung, 1932)
	37	0.0047 gms. RbBr per 100 gms. solvent (Lannung, 1932)
Methanol	18	2.58 (d. = 0.809) gms. RbBr per 100 gms. solvent (Pavlopoulos and Strehlow, 1954)
	25	2.52 (d. = 0.804) gms. RbBr per 100 gms. solvent (Pavlopoulos and Strehlow, 1954)
Acetonitrile	18	0.061 gms. RbBr per 100 gms. solvent (Pavlopoulos and Strehlow, 1954)
	25	0.047 gms. RbBr per 100 gms. solvent (Pavlopoulos and Strehlow, 1954)
Formic acid	18	49.8 (d. = 1.602) gms. RbBr per 100 gms. solvent (Pavlopoulos and Strehlow, 1954)
	25	50.6 (d. = 1.595) gms. RbBr per 100 gms. solvent (Pavlopoulos and Strehlow, 1954)
Ethyl urethan	60	0.566 gms. RbBr per 100 cc. sat. sol. (Stuckgold, 1917)
Liquid ammonia	0	18.23 gms. RbBr per 100 gms. sat. sol. (Linhard and Stephen, 1934)

A solution containing 8.7 wt. % iodine in benzene is in equilibrium with excess solid iodine and rubidium bromide. (Foote and Fleischer, 1940.)

### THE SYSTEM RbBr - RbCl - H<sub>2</sub>O AT 25° (Durham, Rock and Frayn, 1953)

Liquid Solution Wt. %		Solid Solution Wt. % RbBr	Liquid Solution Wt. %		Solid Solution Wt. % RbBr
RbBr	RbCl		RbBr	RbCl	
0.0	48.48	0.0	24.85	28.82	54.4
4.29	45.33	1.06	34.79	18.69	82.9
13.78	37.90	17.72	34.90	18.69	82.3
13.63	37.95	16.82	44.84	8.35	94.6
21.41	31.87	39.8	52.72	0.0	100.0

Melting-point data are given for:

RbBr + AgBr	(Sandonnini, 1912a)
RbBr + LiBr	(Gromakov and Gromakova, 1953)
RbBr + PbBr <sub>2</sub>	(Gromakov, 1950)

Reaction in the system RbBr + CaF below the melting points was studied with X-rays by Link and Wood, 1940.

Solid solutions in the system RbBr - RbCl in the range 148 - 223°K are reported by Hovi, 1954.

#### RUBIDIUM IODO BROMIDE RbIBr<sub>2</sub>

Br

100 gms. sat. solution of rubidium iodo bromide in water contain about 44 gms. RbIBr<sub>2</sub> and the solution has d. = 3.84 at about 20°(?). (Wells and Wheeler, 1892.)

One liter sat. solution of rubidium iodo bromide in carbon tetrachloride contains 0.001 gm. mol. RbIBr<sub>2</sub> at 25°. (Cremer and Duncan, 1931.)

#### RUBIDIUM BROMATE RbBrO<sub>3</sub>

BrO

100 gms. H<sub>2</sub>O dissolve 2.93 gms. RbBrO<sub>3</sub> at 25°, 3.55 gms. at 30°, 4.28 gms. at 35° and 5.08 gms. at 40°. (Buell and McCrosky, 1921.)

#### RUBIDIUM METHIONATE and CHLORMETHIONATE

CH

##### SOLUBILITY OF EACH IN WATER AT 25°

Compound and Formula	Gms. Compound per 100 gms. H <sub>2</sub> O
Rubidium Methionate Rb <sub>2</sub> [CH <sub>2</sub> (SO <sub>3</sub> ) <sub>2</sub> ]	4.93
Rubidium Chlor Methionate Rb <sub>2</sub> [CHCl(SO <sub>3</sub> ) <sub>2</sub> ]	(Backer and Terpstra, 1929) 30.4
	(Backer, 1930)

# Rb RUBIDIUM

## RUBIDIUM FORMATE HCOORb

### SOLUBILITY OF RUBIDIUM FORMATE IN WATER (Sidgwick and Gentle, 1922)

t°	Gms. HCOORb per 100 gms.		Solid Phase	t°	Gms. HCOORb per 100 gms.		Solid Phase
	sat.	sol.			sat.	sol.	
- 1.82	6.23		Ice	16.3	84.61		HCOORb·H <sub>2</sub> O
- 5.62	15.93		"	16.5t	-		" + HCOORb· <sup>1</sup> / <sub>2</sub> H <sub>2</sub> O
- 7.82	20.62		"	28.3	83.60		HCOORb· <sup>1</sup> / <sub>2</sub> H <sub>2</sub> O
-10.62	25.79		"	43.6	87.77		"
CH -13.88	30.62		"	49.9	89.23		"
+ 3.3	78.86		HCOORb·H <sub>2</sub> O	46.9	80.23u		"
7.8	80.71		"	51.0t	-		" + HCOORb
9.5	81.37		"	60.8	90.06		HCOORb
14.0	83.59		"	101.7	93.89		"
				170.0m	100.0		"

t = transfer point

m = melting point

## RUBIDIUM ACETATE CH<sub>3</sub>COORb

### SOLUBILITY OF RUBIDIUM ACETATE IN WATER (Sidgwick and Gentle, 1922)

t°	Gms. CH <sub>3</sub> COORb per 100 gms.		Solid Phase	t°	Gms. CH <sub>3</sub> COORb per 100 gms.		Solid Phase
	sat.	sol.			sat.	sol.	
- 2.79	9.59		Ice	- 9.5	82.92		CH <sub>3</sub> COORb
- 5.27	16.11		"	+44.7	86.23		"
- 6.82	19.64		"	99.4	89.30		"
-10.27	25.57		"	125.2	91.35		"
				246.0m	100.00		"

m = melting point

## RUBIDIUM PHENYL ACETATE RbCH<sub>2</sub>C<sub>6</sub>H<sub>5</sub>COO

Fusion-point data for RbCH<sub>2</sub>C<sub>6</sub>H<sub>5</sub>COO + CH<sub>3</sub>C<sub>6</sub>H<sub>5</sub>COOH are given by Bakunin and Vitale, 1935.

## RUBIDIUM DIHYDROXY TARTARIC ACID Rb<sub>2</sub>C<sub>4</sub>H<sub>4</sub>O<sub>8</sub>·3H<sub>2</sub>O

100 gms. H<sub>2</sub>O dissolve 6.51 gms. Rb<sub>2</sub>C<sub>4</sub>H<sub>4</sub>O<sub>8</sub>·3H<sub>2</sub>O at 0°. (Fenton, 1898.) Because of the unstable character of the compound, only one-half hour was allowed for saturation of the solution.

RUBIDIUM BENZOATE  $C_6H_5COORb$ SOLUBILITY OF RUBIDIUM BENZOATE IN WATER  
(Sidgwick and Ewbank, 1922)

t°	Gms. $C_6H_5COORb$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $C_6H_5COORb$ per 100 gms. sat. sol.	Solid Phase
- 1.56	9.41	Ice	+15.0	56.06	$C_6H_5COORb$
- 4.71	21.15	"	51.5	59.70	"
- 9.04	33.32	"	82.0	63.23	"
-14.75	45.75	"	147.0	70.32	"

RUBIDIUM HYDROXYBENZOATES o, m and p  $C_6H_4OH \cdot COORb$ 

CH

SOLUBILITY OF EACH SEPARATELY IN WATER  
(Sidgwick and Ewbank, 1922)Results for Rubidium Ortho Hydroxy Benzoate ( = Rb Salicylate)

t°	Gms. (o) $C_6H_4OH \cdot COORb$ per 100 gms. sat. sol.	Solid Phase
- 1.62	12.34	Ice
- 3.69	23.48	"
- 6.34	33.81	"
- 8.82	42.77	"
- 13.17	53.40	"
+ 8.0	64.85	(o) $C_6H_4OH \cdot COORb \cdot H_2O$
21.5	68.15	"
27.0	69.84	"
49.0	74.97	(o) $C_6H_4OH \cdot COORb$
73.0	77.96	"
88.0	79.89	"
134.0	86.36	"

Results for Rubidium Meta Hydroxy Benzoate

t°	Gms. (m) $C_6H_4OH \cdot COORb$ per 100 gms. sat. sol.	Solid Phase
- 2.23	14.92	Ice
- 6.41	32.13	"
- 13.69	48.88	" + (m) $C_6H_4OH \cdot COORb \cdot H_2O$
+ 14.0	50.61	(m) $C_6H_4OH \cdot COORb \cdot H_2O$
32.5	54.94	"
45.0	60.02	"
64.0	65.04	(m) $C_6H_4OH \cdot COORb$
88.0	70.45	"
105.0	74.49	"
130.0	79.91	"

# Rb RUBIDIUM

## SOLUBILITY OF EACH SEPARATELY IN WATER--Cont.

### Results for Rubidium Para Hydroxy Benzoate

	%	t°	Gms. (p)C <sub>6</sub> H <sub>4</sub> OH·COORb per 100 gms.		Solid Phase
			sat.	sol.	
	- 1.17		9.92		Ice
	- 2.47		17.47		"
	- 4.22		26.22		"
	+ 17.5		35.66		(p)C <sub>6</sub> H <sub>4</sub> OH·COORb·H <sub>2</sub> O
	45.0		45.95		"
	68.0		55.73		"
CH	94.0		64.95		(p)C <sub>6</sub> H <sub>4</sub> OH·COORb
	120.5		74.00		"
	127.0		75.92		"

### RUBIDIUM MANDELATE (Racemic and Levo) RbC<sub>8</sub>H<sub>7</sub>O<sub>3</sub>

#### THE SYSTEM RACEMIC RUBIDIUM MANDELATE - RACEMIC MANDELIC ACID - WATER AT 25° (Ross and Morrison, 1936)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
C <sub>3</sub> H <sub>8</sub> O <sub>3</sub>	RbC <sub>8</sub> H <sub>7</sub> O <sub>3</sub>		C <sub>3</sub> H <sub>8</sub> O <sub>3</sub>	RbC <sub>8</sub> H <sub>7</sub> O <sub>3</sub>	
3.9	73.2	1.1	20.1	22.8	1.3
6.5	55.1	"	23.2	20.1	"
8.4	48.9	"	30.8	15.8	"
12.5	43.7	"	43.5	13.9	"
14.3	42.1	"	40.3	13.4	" + C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>
20.7	41.0	"	28.9	7.8	C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>
21.0	40.1	1.3	21.1	3.7	"
20.0	36.0	"	19.5	2.6	"
19.7	33.7	"	17.8	1.0	"
18.3	27.5	"	16.95	0.0	"

1.1 = RbC<sub>8</sub>H<sub>7</sub>O<sub>3</sub>·C<sub>8</sub>H<sub>8</sub>O<sub>2</sub>    1.3 = RbC<sub>8</sub>H<sub>7</sub>O<sub>3</sub>·3C<sub>8</sub>H<sub>8</sub>O<sub>3</sub>

#### THE SYSTEM LEVO RUBIDIUM MANDELATE - LEVO MANDELIC ACID - WATER AT 25° (Ross, Morrison and Johnstone, 1937)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>	RbC <sub>8</sub> H <sub>7</sub> O <sub>3</sub>		C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>	RbC <sub>8</sub> H <sub>7</sub> O <sub>3</sub>	
10.1	0.0	C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>	34.2	31.4	C <sub>8</sub> H <sub>8</sub> O <sub>3</sub>
10.0	3.1	"	39.0	33.8	"
10.5	6.1	"	41.2	34.3	"
11.3	8.7	"	45.3	40.8	"
13.0	13.7	"	45.8	41.7	"
20.7	21.8	"	45.8	41.7	"
26.9	27.9	"	45.5	44.9	"

(Cont.)

Owing to viscosity of the solutions other points on the curve could not be obtained and no acid salt was isolated.

## RUBIDIUM BENZENE SULFONATES

SOLUBILITY OF EACH SEPARATELY IN WATER AT 25°  
(Elgerama, 1929)

		Gms. Compound per 100 gms. H <sub>2</sub> O	
Rb -2- Nitro Benzene Sulfonate	Rb [C <sub>6</sub> H <sub>4</sub> (NO <sub>2</sub> )SO <sub>3</sub> ]	16.08	CM
Rb -3- Nitro Benzene Sulfonate	"	6.09	
Rb -4- Nitro Benzene Sulfonate	"	5.80	
Rb -2,4- Dinitro Benzene Sulfonate	Rb [C <sub>6</sub> H <sub>3</sub> (NO <sub>2</sub> ) <sub>2</sub> SO <sub>3</sub> ]	3.90	
Rb -2- Nitro-4-Chlor Benzene Sulfonate	Rb [C <sub>6</sub> H <sub>3</sub> (NO <sub>2</sub> )Cl.SO <sub>3</sub> ]	1.93	
Rb -2- Nitro-5-Chlor Benzene Sulfonate	"	1.07	
Rb -3- Nitro-6-Chlor Benzene Sulfonate	"	1.32	
Rb -2- Nitro-4-Brom Benzene Sulfonate	Rb [C <sub>6</sub> H <sub>3</sub> (NO <sub>2</sub> )BrSO <sub>3</sub> ]	1.80	

RUBIDIUM PICRATE Rb[C<sub>6</sub>H<sub>2</sub>(NO<sub>2</sub>)<sub>3</sub>O]

The salt is 8% soluble in acetonitrile at 25°. (Pleskov, 1948.)

Data for the solubilities of rubidium salts of hexyl, dihexyl, -hexyl, thiohexyl, tetranitro-acridone, 2,4-dinitronaphthosultam, tetranitrophenothiazine, 5,5-dioxide, benzenesulfonyl-2,4-ditronaphthylamine and picric acid in water are given by Toeï, 1957.

RUBIDIUM DIPICRYLAMINATE Rb[(NO<sub>2</sub>)<sub>3</sub>C<sub>6</sub>H<sub>2</sub>NHC<sub>6</sub>H<sub>2</sub>(NO<sub>2</sub>)<sub>3</sub>]

SOLUBILITY IN WATER  
(Treadwell and Hepenstrick, 1949)

Rb [(NO <sub>2</sub> ) <sub>3</sub> C <sub>6</sub> H <sub>2</sub> NHC <sub>6</sub> H <sub>2</sub> (NO <sub>2</sub> ) <sub>3</sub> ]		
t°	Gms. per liter	Moles per liter
20	0.294	5.6 x 10 <sup>-4</sup>
25	.391	7.5 x 10 <sup>-4</sup>

RUBIDIUM CARBONATE Rb<sub>2</sub>CO<sub>3</sub>

CO

100 gms. absolute alcohol dissolve 0.74 gm. Rb<sub>2</sub>CO<sub>3</sub>. (Bunsen.)

Melting points are given for the system by Rb<sub>2</sub>CO<sub>3</sub> + RbF by Schmitz-Dumont and Heckmann, 1949.



# Rb RUBIDIUM

## RUBIDIUM BICARBONATE $\text{RbHCO}_3$

100 gms. sat. solution in  $\text{H}_2\text{O}$  contain 53.73 gms.  $\text{RbHCO}_3$  at about  $20^\circ$ . (deForcrand, 1909.)

## CO RUBIDIUM OXALATE $\text{Rb}_2\text{C}_2\text{O}_4$

### THE SYSTEM RUBIDIUM OXALATE - ZIRCONIUM OXALATE - WATER AT $19^\circ$ (Boulanger, 1936)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{Rb}_2\text{C}_2\text{O}_4$	$\text{ZrOC}_2\text{O}_4$		$\text{Rb}_2\text{C}_2\text{O}_4$	$\text{ZrOC}_2\text{O}_4$	
26.68	0.0	$\text{Rb}_2\text{C}_2\text{O}_4$	11.0	1.2	2.1.1.2
22.5	trace	"	10.76	1.76	"
22.45	0.2	1.1.1.3	10.67	3.22	"
22.4	0.65	"	9.0	3.0	$\text{ZrO} \cdot \text{C}_2\text{O}_4 \cdot 4\text{H}_2\text{O} (?)$
17.4	0.74	"	8.63	2.63	"
14.5	0.77	"	6.5	2.0	"
12.7	0.91	"	3.50	0.55	"

1.1.1.3 =  $\text{Rb}_2\text{C}_2\text{O}_4 \cdot \text{ZrOC}_2\text{O}_4 \cdot (\text{COOH})_2 \cdot 3\text{H}_2\text{O}$

2.1.1.2 =  $2\text{Rb}_2\text{C}_2\text{O}_4 \cdot \text{ZrOC}_2\text{O}_4 \cdot (\text{COOH})_2 \cdot 2\text{H}_2\text{O}$

These double salts obtained only upon evaporation of the solutions.

## RUBIDIUM TELLURIC ACID OXALATE $\text{Rb}_2[\text{H}_6\text{TeO}_6 \cdot \text{C}_2\text{O}_4]$

### SOLUBILITY IN WATER (Rosenheim and Weinheber, 1910-11)

	$0^\circ$	$20^\circ$	$30^\circ$	$40^\circ$	$50^\circ$
Gms. $\text{Rb}_2(\text{H}_6\text{TeO}_6 \cdot \text{C}_2\text{O}_4)$ per 100 gms. $\text{H}_2\text{O}$	3.85	7.26	9.40	12.76	16.90

## CN RUBIDIUM FERROCYANIDE $\text{Rb}_4\text{Fe}(\text{CN})_6$

Deichman, 1957 reports solid solutions and the double salt  $\text{RbInFe}(\text{CN})_6$ .

## RUBIDIUM CHLORIDE RbCl

Cl

 SOLUBILITY IN WATER  
 (Rimbach, 1902; Berkeley, 1904)

t°	Mols. RbCl per Liter	Gms. RbCl per 100 Gms.		t°	Mols. RbCl per Liter	Gms. RbCl per 100 Gms.	
		Water	Solution			Water	Solution
0	5.17	77.0	43.5	50	6.67	109.3	52.2
10	5.55	84.4	45.8	60	6.90	115.5	53.6
18	-	-	45.9(d)	70	7.12	121.4	54.8
20	5.88	91.1	47.7	80	7.33	127.2	56.0
25	-	-	48.57(a)	90	7.52	133.1	57.1
-	-	-	48.12(b)	100	7.71	138.9	58.9
-	-	-	48.54(c)	112.9	7.95	146.6	59.5
30	6.17	97.6	49.4				
40	6.43	103.5	50.9				

aFoote and Levy, 1906

bBliden, 1956

cFajans and Karsenganis, 1931

dLannung, 1934

The following determinations of the Sp. Gr. of the sat. solutions are given by Berkeley.

t°	0.55	18.7	31.5	44.7	60.25	75.15	89.35	114 <sup>b</sup>
Sp. Gr.	1.4409	1.4865	1.5118	1.5348	1.5558	1.5746	1.5905	1.6148

b = boiling point

Data for the change in critical temperature as 0.1 - 0.5 M RbCl is added to steam is given by Schroer, 1927.

 THE SYSTEM RUBIDIUM CHLORIDE - BERYLLIUM CHLORIDE - WATER AT 25°  
 (Bliden, 1956)

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
BeCl <sub>2</sub>	RbCl	Solid Phase	BeCl <sub>2</sub>	RbCl	Solid Phase
41.72	0.0	BeCl <sub>2</sub> ·4H <sub>2</sub> O	23.16	18.25	RbCl
39.37	2.45	" + RbCl	20.18	21.40	"
37.14	5.16	RbCl	15.10	26.54	"
34.70	8.60	"	8.94	34.13	"
30.48	12.03	"	4.80	39.76	"
27.60	14.22	"	2.51	42.60	"
			0.0	48.12	"

## Rb RUBIDIUM

### RUBIDIUM IRIIDIUM CHLORIDES

#### SOLUBILITIES IN WATER (Delepine, 1908)

Salt	Formula	t°	Gms. Salt per 100 Gms. H <sub>2</sub> O
Rubidium Chloroiridate	Rb <sub>2</sub> IrCl <sub>6</sub>	19	0.0555
Trirubidium Hexachloroiridite	Rb <sub>3</sub> IrCl <sub>6</sub> ·H <sub>2</sub> O	19	0.91
Dirubidium Aquopentachloroiridite	Rb <sub>2</sub> IrCl <sub>5</sub> (H <sub>2</sub> O)	19	1.05

## C1 RUBIDIUM PLATINUM CHLORIDE Rb<sub>2</sub>PtCl<sub>6</sub>

#### SOLUBILITY OF RUBIDIUM CHLOROPLATINATE IN WATER (Archibald and Hallett, 1925)

Saturation obtained by constant agitation for long periods. A weighed amount of the salt was agitated with 100 gms. H<sub>2</sub>O and the undissolved portion was determined and the amount dissolved estimated by difference.

t°	Gms. Rb <sub>2</sub> PtCl <sub>6</sub> per 100 gms. H <sub>2</sub> O	t°	Gms. Rb <sub>2</sub> PtCl <sub>6</sub> per 100 gms. H <sub>2</sub> O	t°	Gms. Rb <sub>2</sub> PtCl <sub>6</sub> per 100 gms. H <sub>2</sub> O
0	0.0137	40	0.0565	80	0.1324
10	0.0200	50	0.0737	90	0.2472
20	0.0283	60	0.0997	100	0.3340
30	0.0397	70	0.1324		

## RUBIDIUM TELLURIUM CHLORIDE Rb<sub>2</sub>TeCl<sub>6</sub>

100 gms. aqueous HCl of 1.2 specific gravity dissolve 0.34 gm. Rb<sub>2</sub>TeCl<sub>6</sub> at 23°.

100 gms. aqueous HCl of 1.05 specific gravity dissolve 13.09 gms. Rb<sub>2</sub>TeCl<sub>6</sub> at 23°. (Wheeler, 1893.)

## RUBIDIUM THALLIUM CHLORIDE 3RbCl·TlCl<sub>3</sub>·2H<sub>2</sub>O

100 gms. H<sub>2</sub>O dissolve 13.3 gms. at 18°, and 62.5 gms. at 100°. (Godeffroy, 1886.)

# SOLUBILITY OF RUBIDIUM CHLORIDE IN VARIOUS SOLVENTS

Solvent	t°	Solubility	Reference
Methyl alcohol	18	1.30 (d.=0.800) gms. RbCl per 100 gms. solvent	(Pavlopoulos and Strehlow, 1954)
	25	1.34 (d.=0.797) gms. RbCl per 100 gms. solvent	(Pavlopoulos and Strehlow, 1954)
	25	1.41 gms. RbCl per 100 gms. solvent	(Turner and Bissett, 1913)
Ethyl alcohol	20	0.028 gms. RbCl per 100 ml. solvent	(Meier and Treadwell, 1951)
	25	0.078 gms. RbCl per 100 gms. solvent	(Turner and Bissett, 1913)
Propyl alcohol	25	0.015 gms. RbCl per 100 gms. solvent	(Turner and Bissett, 1913)
n-Butyl alcohol	16	0.00031 gms. RbCl per 100 ml. solvent	(Kato and Hagiwara, 1950)
Amyl alcohol	25	0.00033 gms. RbCl per 100 ml. solvent	(Kato and Hagiwara, 1950)
	25	0.0025 gms. RbCl per 100 gms. solvent	(Turner and Bissett, 1913)
Acetone	18	0.00021 gms. RbCl per 100 gms. solvent	(Lannung, 1932)
	37	0.00024 gms. RbCl per 100 gms. solvent	(Lannung, 1932)
Acetonitrile	18	0.0034 gms. RbCl per 100 gms. solvent	(Pavlopoulos and Strehlow, 1954)
	25	0.0036 gms. RbCl per 100 gms. solvent	(Pavlopoulos and Strehlow, 1954)
Formic acid	18	60.2 (d.=1.611) gms. RbCl per 100 gms. solvent	(Pavlopoulos and Strehlow, 1954)
	25	56.9 (d.=1.553) gms. RbCl per 100 gms. solvent	(Pavlopoulos and Strehlow, 1954)
Butyric acid	20	0.00408 gms. RbCl per 100 ml. solvent	(Kato and Hagiwara, 1950)
Methyl acetate	20	0.00396 gms. RbCl per 100 ml. solvent	(Kato and Hagiwara, 1950)
Ethyl acetate	19	0.00010 gms. RbCl per 100 ml. solvent	(Kato and Hagiwara, 1950)
Diethyl acetate	19	0.00103 gms. RbCl per 100 ml. solvent	(Kato and Hagiwara, 1950)
Selenium oxychloride	25	3.56 gms. RbCl per 100 gms. sat. sol.	(Wise, 1922)
Phosphorus oxychloride	20	0.87 gms. RbCl per liter	(Gutman, 1952)
Sulfur dioxide (liquid)	0	0.329 gms. RbCl per 100 gms. solvent	(Jander and Ruppolt, 1937)
	25	0.402 gms. RbCl per 100 gms. sat. sol.	(Shatenstein and Viktorov, 1937)
Hydrazine	room	5 gms. RbCl per 100 ml. solvent	(Welsh and Brodersen, 1915)
Ammonia	0	0.289 gms. RbCl per 100 gms. sat. sol.	(Linhard and Stephan, 1934)
	0	0.22 gms. RbCl per 100 gms. solvent	(Watt, Jenkins and Robertson, 1950)

:

# Rb RUBIDIUM

## RUBIDIUM DICHLOROIODIDE $\text{RbCl}_2\text{I}$

SOLUBILITY OF RUBIDIUM DICHLOROIODIDE IN HYDROCHLORIC ACID SOLUTIONS  
(Bender and Strehlow, 1948)

	Results at 0°		Results at 25°	
	Gms. $\text{RbCl}_2\text{I}$ per		Gms. $\text{RbCl}_2\text{I}$ per	
	100 gms. Sat. Sol.	100 cc. Sat. Sol.	100 gms. Sat. Sol.	100 cc. Sat. Sol.
Moles HCl per 1000 gms. $\text{H}_2\text{O}$ in Solvent				
1.998	25.20	31.68	44.02	64.92
4.909	17.51	21.50	28.73	38.20
8.989	10.66	12.98	17.51	22.17
12.48	8.75	10.83	13.58	17.16

Cl

Melting points are given for the following

$\text{RbCl} + \text{RbNO}_3$	(Rostkowski, 1930; Blidin, 1953)
$\text{RbCl} + \text{SrCl}_2$	(Hofmahn, 1927; Gromakov, 1950)
$\text{RbCl} + \text{AgCl}$	(Sandomini, 1911, 1914)
$\text{RbCl} + \text{TlCl}$	(Sandomini, 1911, 1914)
$\text{RbCl} + \text{NaCl}$	(Zemcznazy and Rimbach, 1910)
$\text{RbCl} + \text{Rb}_2\text{SO}_4$	(Dombrowskaya, 1933)
$\text{RbCl} + \text{RbF}$	(Banashek, 1950; Volkov and Tumash, 1953)
$\text{RbCl} + \text{CaF}$	(Link and Wood, 1940)
$\text{RbCl} + \text{ZnSO}_4$	(Voskresenskaya and Patsukova, 1955)
$\text{RbCl} + \text{MgCl}_2$	(Markov and Panchenko, 1955)
$\text{RbCl} + \text{CaCl}_2$	(Gromakov, 1950)
$\text{RbCl} + \text{ZnCl}_2$	(Markov, Panchenko and Kostenio, 1956)
$\text{RbCl} + \text{SnCl}_2$	(Markov and Chernov, 1958a)
$\text{RbCl} + \text{MnCl}_2$	(Gromakov, 1950; Markov and Chernov, 1958)

## ClO RUBIDIUM CHLORATE $\text{RbClO}_3$

SOLUBILITY IN WATER  
(Calzolari, 1912)

There is some uncertainty as to whether the results of Calzolari refer to 100 gms. of  $\text{H}_2\text{O}$  or 100 gms. of saturated solution.

$t^\circ$	Gms. $\text{RbClO}_2$ per 100 Gms. $\text{H}_2\text{O}$	$t^\circ$	Gms. $\text{RbClO}_2$ per 100 Gms. $\text{H}_2\text{O}$
0	2.138	42.2	12.48
8	3.07	50	15.98
15	3.1 <sup>a</sup>	76	34.12
19.8	5.36	99	62.80
30	8.00		

<sup>a</sup>Carlson, 1910;  $d_{15} = 1.07$

RUBIDIUM PERCHLORATE  $\text{RbClO}_4$ 

ClO

 SOLUBILITY IN WATER  
 (Carlson, 1910; Calzolari, 1912)

The figures in parentheses are densities of saturated solutions.

t°	Gms. $\text{RbClO}_4$ per 100 Gms. $\text{H}_2\text{O}$			Gms. $\text{RbClO}_4$ per 100 Gms. $\text{H}_2\text{O}$		
	(Calzolari)	(Carlson)		(Calzolari)	(Carlson)	
0	0.5	1.1	(1.007)	40	2.3	3.26 (1.017)
10	0.6	1.2		50	3.5	4.6
20 <sup>c</sup>	1.0	1.56	(1.010)	60	4.85	6.27 (1.028)
21.3	1.08 <sup>a</sup>	-		70	6.72	8.2
25 <sup>d</sup>	1.2	1.8		80	9.2	11.04 (1.050)
	1.320	-	(1.0060)	90	12.7	15.5
				100	18	22(?) (1.070)

<sup>a</sup>Longuimine, 1862

<sup>b</sup>Willard and Smith, 1923

<sup>c</sup>100 cc. sat. solution of rubidium perchlorate in water contain 1.004 gm.  $\text{RbClO}_4$  at 20°. (Moser and Ritchel, 1925)

<sup>d</sup>solubility at 25° reported as 0.071 moles per liter by Lange and Muller, 1930.

Data for the distribution of rubidium perchlorate between nitro-methane and water are given by Haugen and Friedman, 1956.

 SOLUBILITY OF RUBIDIUM PERCHLORATE IN AQUEOUS ETHANOL SOLUTIONS  
 (Flatt and Jordan, 1930, 1933)

t°	Vol. Percent $\text{C}_2\text{H}_5\text{OH}$ in Aq. solvent	Gms. $\text{RbClO}_4$ per 100 gms. solvent
25	0.0	1.276
25	50.0	0.520
25	75.0	0.204
40	50.0	0.954
40	75.0	0.370

 SOLUBILITY OF RUBIDIUM PERCHLORATE IN SEVERAL SOLVENTS, AT 25°  
 (Willard and Smith, 1923)

Solvent	d <sub>25</sub> 4 of sat. sol.	Gms. $\text{RbClO}_4$ per 100 gms. sat. sol.	Solvent	d <sub>25</sub> 4 of sat. sol.	Gms. $\text{RbClO}_4$ per 100 gms. sat. sol.
Water	1.0060	1.320	n-Butyl alcohol	0.8059	0.002
Methyl alcohol	0.7875	0.060	iso-Butyl alcohol	0.7982	0.004
Ethyl alcohol	0.7851	0.009	Acetone	0.7865	0.095 <sup>a</sup>
n-Propyl-alcohol	0.7989	0.006	Ethyl acetate	0.8945	0.0016

<sup>a</sup>0.098 - Miravittles, 1943

# Rb RUBIDIUM

## SOLUBILITY OF RUBIDIUM PERCHLORATE IN MIXTURES OF ETHYL ACETATE AND ALCOHOLS AT 25° (Smith, 1925)

Composition of solvent				Gms. RbClO <sub>4</sub> per 100 gms. sat. sol.
90 vol. %	CH <sub>3</sub> COOC <sub>2</sub> H <sub>5</sub>	+ 10 vol. %	CH <sub>3</sub> OH	0.24
80 "	"	+ 20 "	CH <sub>3</sub> OH	0.43
90 "	"	+ 10 "	C <sub>2</sub> H <sub>5</sub> OH	0.16
80 "	"	+ 20 "	C <sub>2</sub> H <sub>5</sub> OH	0.10
80 "	"	+ 20 "	93% alcohol	0.27
90 "	"	+ 10 "	n Butyl Alcohol	0.11
80 "	"	+ 20 "	n Butyl Alcohol	0.13

## C10 RUBIDIUM POTASSIUM PERCHLORATE Rb<sub>2</sub>K(ClO<sub>4</sub>)<sub>3</sub>

100 gms. sat. solution in H<sub>2</sub>O contain 1.55 gms. Rb<sub>2</sub>K(ClO<sub>4</sub>)<sub>3</sub> at 20°  
d<sub>20</sub> of the sat. solution = 1.013). (Carlson, 1910.)

## CrO RUBIDIUM CHROMATE Rb<sub>2</sub>CrO<sub>4</sub>

### SOLUBILITY IN WATER (Schreinemakers and Filippo, Jr., 1906)

t°	Gms. RbCrO <sub>4</sub> per 100 Gms. Solution	t°	Gms. RbCrO <sub>4</sub> per 100 Gms. Solution	t°	Gms. RbCrO <sub>4</sub> per 100 Gms. Solution
- 7	36.65	50	47.44	- 2.40	15.58
0	38.27	60.4	48.90	- 3.25	20.03
10	40.23	Solid Phase, Ice		- 4.14	24.28
20	42.42			- 5.55	30.15
30	44.11	- 0.6	0.95	- 6.71	34.31
40	46.13	- 1.1	7.22	about -7	36.65
		- 1.57	9.87		

### EQUILIBRIUM IN THE SYSTEM RUBIDIUM OXIDE, CHROMIUM TRIOXIDE AND WATER AT 30° (Schreinemakers and Filippo, Jr., 1906)

Gms. per 100 Gms. sat. sol.		Solid Phase	Gms. per 100 Gms. sat. sol.		Solid Phase
CrO <sub>3</sub>	Rb <sub>2</sub> O		CrO <sub>3</sub>	Rb <sub>2</sub> O	
0	60.56	RbOH	8.54	28.17	Rb <sub>2</sub> CrO <sub>4</sub>
0	56.82	Rb <sub>2</sub> CrO <sub>4</sub>	11.98	27.99	"
0.776	37.88	"	15.38	28.73	"
2.89	34.89	"	15.54	28.55	" + Rb <sub>2</sub> Cr <sub>3</sub> O <sub>7</sub>
4.96	30.20	"	13.69	23.87	Rb <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>

(Cont.)

## EQUILIBRIUM IN THE SYSTEM RUBIDIUM OXIDE, CHROMIUM TRIOXIDE AND WATER AT 30°--Cont.

Gms. per 100 Gms. sat. sol.			Gms. per 100 Gms. sat. sol.		
CrO <sub>3</sub>	Rb <sub>2</sub> O	Solid Phase	CrO <sub>3</sub>	Rb <sub>2</sub> O	Solid Phase
9.98	17.56	Rb <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	24.92	1.66	Rb <sub>2</sub> Cr <sub>3</sub> O <sub>10</sub>
5.72	8.47	"	37.34	1.61	"
4.58	7.98	"	48.20	1.54	"
4.87	4.60	"	53.87	1.67	"
8.16	3.57	"	54.29	1.28	" + Rb <sub>2</sub> Cr <sub>4</sub> O <sub>13</sub>
13.91	3.38	"	58.69	1.07	Rb <sub>2</sub> Cr <sub>4</sub> O <sub>13</sub>
15.05	3.45	" + Rb <sub>2</sub> Cr <sub>3</sub> O <sub>10</sub>	62.38	0.93	"
15.31	3.59	Rb <sub>2</sub> Cr <sub>3</sub> O <sub>7</sub>	62.74	0.93	"
15.19	3.19	Rb <sub>2</sub> Cr <sub>3</sub> O <sub>10</sub>	63.07	0.92	" + CrO <sub>3</sub>
18.96	2.37	"	62.28	0	CrO <sub>3</sub>

CrO

RUBIDIUM DICHROMATE Rb<sub>2</sub>Cr<sub>3</sub>O<sub>7</sub>

SOLUBILITY OF THE POLYMORPHIC FORMS IN WATER  
(Stortenbecker, 1907; see also Wyruboff, 1910)

t°	Gms. Rb <sub>2</sub> Cr <sub>3</sub> O <sub>7</sub> per 100 Gms. Sat. Sol.	
	Monoclinic Form	Triclinic Form
18	5.42	4.96
24	6.94	6.55
30	9.08	8.70
40	13.22	12.90
50	18.94	18.77
65	28.10	27.30

100 gms. sat. aq. solution contain 9.47 gms. Rb<sub>2</sub>Cr<sub>3</sub>O<sub>7</sub>, at 30°. (Schreinemakers and Filippo, Jr., 1906.)

## RUBIDIUM FLUORIDE RbF

F

100 gms. sat. solutions of rubidium fluoride in water contain 75.06 gm. RbF at 18°. (Lannung, 1934.) An earlier determination by de Forcrand, 1911 gave 56.6% at 18°. (Solid phase RbF·1<sup>1</sup>/<sub>2</sub>H<sub>2</sub>O)

RUBIDIUM FLUOPHOSPHATE RbPF<sub>6</sub>

One liter of sat. sol. contains 0.0758 moles RbPF<sub>6</sub> at 25°. (Lange and Muller, 1930.)



## Rb RUBIDIUM

### RUBIDIUM FLUOPLATINATE $\text{Rb}_2\text{PtF}_6$

100 ml. of sat. sol. contain 0.278 gms.  $\text{Rb}_2\text{PtF}_6$  at 25°. (Wheeler, Perros and Naeser, 1955.)

### RUBIDIUM FLUOSILICATE $\text{Rb}_2\text{SiF}_6$

100 gms.  $\text{H}_2\text{O}$  dissolve 0.16 gms.  $\text{Rb}_2\text{SiF}_6$  at 20°, and 1.36 gms. at 100°. (Stolba, 1867.)

### F RUBIDIUM FLUOTITANATE $\text{Rb}_2\text{TiF}_6$

100 ml. sat. sol. in water contain 0.8 gm.  $\text{Rb}_2\text{TiF}_6$  at 20 - 22°. (Ginsberg, 1932.)

1000 gms. acetone,  $(\text{CH}_3)_2\text{CO}$ , dissolve 0.0036 gm.  $\text{RbF}$  at 18° and 0.0039 at 37°. (Lannung, 1932.)

Melting point data are given for the following:

$\text{RbF} + \text{HF}$	(Webb and Prideaux, 1938)
$\text{RbF} + \text{YF}_3 + \text{LaF}_3 + \text{AlF}_3$	(Dergunov, 1948)
$\text{RbF} + \text{WO}_3$	(Schmitz-Dumont, Bruns and Heckmann, 1953)
$\text{RbF} + \text{MoO}_3$	(Schmitz-Dumont and Heckmann, 1952)
$\text{RbF} + \text{Rb}_2\text{MoO}_4 + \text{Rb}_2\text{CrO}_4 + \text{Rb}_2\text{WO}_4$	(Schmitz-Dumont and Weeg, 1951)
$\text{RbF} + \text{ErF}_3 + \text{SmF}_3 + \text{PrF}_3$	(Durgunov, 1952)
$\text{RbF} + \text{RbTi}_2\text{O}_5$	(Schmitz-Dumont and Schulz, 1952)
$\text{RbF} + \text{Rb}_2\text{SO}_4$	(Schmitz-Dumont and Heckmann, 1949)
$\text{RbF} + \text{BeF}_2$	(Grebenshchikov, 1957)

Reactions in the systems  $\text{RbF} - \text{CaCl}_2$ ,  $\text{RbF} - \text{CsBr}$ , and  $\text{RbF} - \text{CsI}$  below the melting points were studied with X-rays by Link and Wood, 1940.

### I RUBIDIUM IODIDE $\text{RbI}$

#### SOLUBILITY OF RUBIDIUM IODIDE IN WATER (Briggs, Conrad, Gregg, and Reed, 1941)

t°	Gms. $\text{RbI}$ per 100 gms. Sat. Sol.	Solid Phase	t°	Gms. $\text{RbI}$ per 100 gms. Sat. Sol.	Solid Phase
- 1.3	9.58	Ice	-12.2	48.11	Ice
- 3.5	20.13	"	-13.0	50.0	" + $\text{RbI}$
- 6.2	31.33	"	-10.0	51.18	$\text{RbI}$
- 8.4	38.43	"	- 2.7	54.51	"
- 8.6	39.15	"	0.0	55.5	"

(Cont.)

## SOLUBILITY OF RUBIDIUM IODIDE IN WATER--Cont.

t°	Gms. RbI per 100 gms. Sat. Sol.	Solid Phase	t°	Gms. RbI per 100 gms. Sat. Sol.	Solid Phase
3.2	57.05	RbI	25.6	62.90	RbI
6.9	57.9 <sup>a</sup>	"	35.6	64.70	"
13.7	60.20	"	48.5	66.76	"
17.4	60.3 <sup>a</sup>	"	59.4	68.61	"
18.0	58.98 <sup>b</sup>	"	77.2	70.89	"
24.3	63.66 <sup>c</sup>	"	93.0	73.01	"
25.0	62.05 <sup>d</sup>	"	111.5	75.05	"
	61.93 <sup>e</sup>	"			

<sup>a</sup>Reissig, 1863<sup>b</sup>Lannung, 1934<sup>c</sup>Buchanan, 1906<sup>d</sup>Fajans and Karagunis, 1931<sup>e</sup>Foote and Chalker, 1908THE SYSTEM RUBIDIUM IODIDE - IODINE - WATER  
(Briggs, Conrad, Gregg, and Reed, 1941)

Earlier data at 25° are given by Foote and Chalker, 1908.

Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.		
I	RbI	Solid Phase	I	RbI	Solid Phase
Results at 0°			Results at 25°--Cont.		
0.0	55.5	RbI	59.7	30.4	RbI <sub>3</sub>
2.6	55.9	RbI + RbI <sub>3</sub>	64.7	27.6	RbI <sub>3</sub> + Iodine
2.8	54.9	RbI <sub>3</sub>	56.2	28.5	Iodine
3.7	48.5	"	50.0	29.1	"
5.2	38.8	"	45.1	28.2	"
8.4	26.1	"	35.4	26.2	"
8.7	24.5	"	26.0	23.4	"
13.4	18.7	"	14.4	16.8	"
15.3	18.6	RbI <sub>3</sub> + Iodine	7.6	11.0	"
12.8	15.9	Iodine	Trace	0.0	"
Trace	0.0	"			
Results at 25°			Results at 70°		
0.0	62.0	RbI	0.0	70.1	RbI <sup>f</sup>
5.5	61.1	RbI + RbI <sub>3</sub>	12.30	63.51	"
8.0	54.2	RbI <sub>3</sub>	21.58	58.26	"
9.3	52.2	"	34.1	51.1	RbI + RbI <sub>3</sub>
14.7	46.2	"	47.4	42.2	RbI <sub>3</sub>
15.9	44.2	"	80.3	17.9	RbI <sub>3</sub> + Iodine
26.0	38.0	"	75.64	19.30	Iodine
30.1	37.1	"	69.00	20.77	"
40.6	35.6	"	64.07	21.76	"
46.7	34.8	"	63.23	22.08	"
47.6	33.9	"	30.82	20.97	"
53.8	32.5	"	21.80	17.79	"
56.7	31.1	"	16.95	15.29	"
			9.46	10.01	"
			0.2	0.0	"

(Cont.)

# Rb RUBIDIUM

## THE SYSTEM RUBIDIUM IODIDE - IODINE - WATER--Cont.

Gms. per 100 gms. Sat. Sol.		Solid Phase
I	RbI	
<u>Results at 90°</u>		
0.0	72.7	RbI
44.0	46.6	RbI + RbI <sub>3</sub>
84.0	16.0	RbI <sub>3</sub>
87.7	12.3	Iodine
77.6	14.9	Iodine + 2 Liquids
67.31	19.24	2 Liquids
66.16	19.47	"
42.38	21.61	"
26.3	17.7	Iodine + 2 Liquids
0.3	0.0	Iodine

### Invariant Points in the System

t°	Gms. per 100 gms. Sat. Sol.		Solid Phase
	I	RbI	
0	Trace	0.0	Ice + Iodine + Liquid
-13.0	0.0	50.0	Ice + RbI + Liquid
80.8	84.9	15.1	RbI <sub>3</sub> + Iodine + Liquid
188	59.4	40.6	RbI <sub>3</sub> + RbI + Liquid
98.2	0.4	0.0	Iodine + Liquid + Vapor
113	99.9	0.0	Iodine + Liquid + Vapor
116.0	0.0	75.5	RbI + Liquid + Vapor
238	58.2	41.8	RbI + Liquid + Vapor
-13.9	1.7	50.1	Ice + RbI + RbI <sub>3</sub> + Liquid
-2.6	13.0	16.9	Ice + RbI <sub>3</sub> + Iodine + Liquid
98.4	21.5	15.4	Iodine + Two Liquids + Vapor
98.4	83.4	10.9	Iodine + Two Liquids + Vapor

Additional polythermal data for the system are also given.

The system RbI + SbI<sub>3</sub> + H<sub>2</sub>O at 12° was studied by Francois, 1937, but the author gives his results only in the form of a small diagram from which numerical values can not be obtained. The double salt 3RbI.2SbI<sub>3</sub> was identified and the existence of another probably of the composition 3RbI.SbI<sub>3</sub> was indicated.

The temperature-composition data for the system RbI + I for the range 60° to 238° are given by Briggs and Patterson, 1932. The solid phases in contact with the melt are I, RbI<sub>3</sub> and RbI.

SOLUBILITY OF RUBIDIUM IODIDE IN ACETONE  
(Evertz and Livingston, 1949)

t°	Gms. RbI per 100 gms. Sat. Sol.	t°	Gms. RbI per 100 gms. Sat. Sol.
-78.5	3.77	25	0.72
-60	2.98		(0.493) <sup>b</sup>
-40	2.25		(0.674) <sup>a</sup>
-2.0	1.64		(0.624) <sup>c</sup>
0	1.15	30	0.65
	(0.96) <sup>a</sup> ,		
18	(0.648) <sup>b</sup>		
20	0.79		

<sup>a</sup>Walden, 1906 (data in gms. per 100 cc. sat. sol.)

<sup>b</sup>Lanning, 1932

<sup>c</sup>Miravittles, 1943, 1945

SOLUBILITY OF RUBIDIUM IODIDE IN OTHER SOLVENTS

Solvent	t°	Solubility
Acetonitrile	0	1.478 gms. per 100 cc. sat. sol. (Walden, 1906)
	18	1.84 gms. per 100 gms. solvent (d.=0.798) (Pavlopoulos and Strehlow, 1954)
	25	1.68 gms. per 100 gms. solvent (d.=0.793) (Pavlopoulos and Strehlow, 1954)
		1.350 gms. per 100 cc. sat. sol. (Walden, 1906)
		"3%" (Pleskov, 1948)
Propionitrile	0	0.274 gms. per 100 cc. sat. sol. (Walden, 1906)
	25	0.305 gms. per 100 cc. sat. sol. (Walden, 1906)
Nitromethane	0	0.567 gms. per 100 cc. sat. sol. (Walden, 1906)
	25	0.518 gms. per 100 cc. sat. sol. (Walden, 1906)
Furfurol	25	4.930 gms. per 100 cc. sat. sol. (Walden, 1906)
Methyl alcohol	18	10.1 gms. per 100 gms. solvent (d.=0.860) (Pavlopoulos and Strehlow, 1954)
	25	10.1 gms. per 100 gms. solvent (d.=0.859) (Pavlopoulos and Strehlow, 1954)
iso Butyl alcohol	25	0.0624 wt. % (Bregman, 1914)
iso Amyl alcohol	25	0.0425 wt. % (Bregman, 1914)
Ethyl urethan	60	4.079 gms. per 100 cc. sat. sol. (Stuckgold, 1917)
formic acid	18	46.1 gms. per 100 gms. solvent (d.=1.583) (Pavlopoulos and Strehlow, 1954)
	25	47.4 gms. per 100 gms. solvent (d.=1.581) (Pavlopoulos and Strehlow, 1954)

# Rb RUBIDIUM

## THE SYSTEM RUBIDIUM IODIDE - IODINE - BENZENE (Foote and Fleischer, 1940)

Results at 6°				Results at 25°	
Gms. Iodine per 100 gms. Sat. Sol.	Solids	Gms. Iodine per 100 gms. Sat. Sol.	Solids	Gms. Iodine per 100 gms. Sat. Sol.	Solids
0.18	A + B	5.97	C	0.37	A + B
.61	B	6.92	C	0.99	B
3.71	B.	6.99	C + D	6.05	B
4.08	B + C	7.17	D	8.06	B
4.24	C	7.58	D	9.16	B + C
4.49	C	7.88	D	9.68	C
4.99	C	7.95	D	9.79	C
5.34	C	8.15	D	10.04	C
5.70	C	8.53	D	10.90	C + D
5.75	C	8.71	D + E	11.61	D
				12.85	D
				13.44	D
				13.65	D
				14.20	D + E

A = RbI  
 B = RbI<sub>3</sub>  
 C = RbI<sub>7</sub>·4C<sub>6</sub>H<sub>6</sub>  
 D = RbI<sub>8</sub>·4C<sub>6</sub>H<sub>6</sub>  
 E = I<sub>2</sub>

## THE SYSTEM RUBIDIUM IODIDE - IODINE - TOLUENE (Foote and Fleischer, 1940)

Results at 6°		Results at 25°	
Gms. Iodine per 100 gms. Sat. Sol.	Solid Phase	Gms. Iodine per 100 gms. Sat. Sol.	Solid Phase
0.20	RbI + RbI <sub>3</sub>	0.40	RbI + RbI <sub>3</sub>
0.76	RbI <sub>3</sub>	1.83	RbI <sub>3</sub>
1.02	"	14.90	"
7.03	"	15.07	"
10.26	RbI <sub>3</sub> + I <sub>2</sub>	15.40	RbI <sub>3</sub> + I <sub>2</sub>

100 gms. sat. solution of rubidium iodide in liquid ammonia contain 65.15 gm. RbI at 0°. (Linhard and Stephan, 1934.)

Results for the vapor-pressure, temperature relations of the system RbI + SO<sub>2</sub> are given by Foote and Fleischer, 1931.

Fusion-point data for RbI + AgI are given by Sandonnini (1912a).

Reaction in the system RbI - CsF below the melting points has been studied with X-rays by Link and Wood, 1940.

RUBIDIUM IODATE  $\text{RbIO}_3$ 

10

SOLUBILITY IN WATER AND AQUEOUS SOLUTIONS AT 25°  
(Larson and Renier, 1952)

In Aqueous $\text{HNO}_3$ Solutions			In Aqueous $\text{KNO}_3$ Solutions		
Moles $\text{HNO}_3$ per 1000 gms. solvent	Moles $\text{RbIO}_3$ per liter sat. sol.	density sat. sol.	Moles $\text{KNO}_3$ per 1000 gms. solvent	Moles $\text{RbIO}_3$ per liter sat. sol.	density sat. sol.
0.0	0.0919	1.0160	0.0	0.0919	1.0160
0.05020	0.1051	1.0216	0.05001	0.0972	1.0196
0.1006	0.1175	1.0250	0.1004	0.1018	1.0236
0.1511	0.1297	1.0290	0.1511	0.1054	1.0285
0.2016	0.1415	1.0337	0.2021	0.1070	1.0318
0.2516	0.1533	1.0385	0.2547	0.1118	1.0370
0.2933	0.1626	1.0414	0.2940	0.1143	1.0396
0.4056	0.1546	1.0472	0.4069	0.1192	1.0475
0.5006	0.1495	1.0506	0.5025	0.1220	1.0538

100 gms.  $\text{H}_2\text{O}$  dissolve 2.1 gms.  $\text{RbIO}_3$  at 23°. (Wheeler, 1892.)

RUBIDIUM PERIODATE  $\text{RbIO}_4$ 

100 gms.  $\text{H}_2\text{O}$  dissolve 0.65 gm.  $\text{RbIO}_4$  at 13°,  $d_{16}^4$  of sat. solution = 1.0052. (Barker, 1908.)

RUBIDIUM PERMANGANATE  $\text{RbMnO}_4$ 

MnO

One liter of aqueous solution contains 6.03 gms.  $\text{RbMnO}_4$  at 7°. (Muthmann and Kuntze, 1894.)

100 cc. sat. aqueous solution contain 0.46 gm.  $\text{RbMnO}_4$  at 2°, 1.06 gms. at 19° and 4.68 gms. at 60°. (Patterson, 1906.)

RUBIDIUM MOLYBDATE  $\text{Rb}_2\text{MoO}_4$ 

MoO

The solubility in water at 18° is 6.4 moles per liter, or 67.88 gms.  $\text{Rb}_2\text{MoO}_4$  per 100 gms. sat. sol. (Spitsyn and Kuleshov, 1951.)

RUBIDIUM PARAMOLYBDATE  $5\text{Rb}_2\text{O} \cdot 0.12\text{MoO}_3 \cdot \text{H}_2\text{O}$ 

100 cc. sat. aq. solution contain 1.941 gms. of the salt at 24°. (Wempe, 1912.)

# Rb RUBIDIUM

## RUBIDIUM SILICO MOLYBDATE and Other Salts

SOLUBILITY OF EACH SEPARATELY IN WATER AT 20°  
(Moser and Ritschel, 1925)

Salt	Formula	Gms. salt per 1000 cc. sat. sol.
Rubidium Silico Molybdate	-	4.1
Rubidium Picrate	$C_6H_2(NO_2)_3ORb$	3.8
Rubidium Phosphotungstate	-	0.075
Rubidium Bitartrate	$RbHC_4H_4O_6$	8.52

## N RUBIDIUM AZIDE $RbN_3$

100 gms. sat. solution of rubidium azide in water contain 51.7 gms.  $RbN_3$  at 16° and 53.3 gms. at 17°. (Curtius and Rissom, 1898.)

## NO RUBIDIUM NITRATE $RbNO_3$

SOLUBILITY IN WATER  
(Berkeley, 1904)

t°	Mols. $RbNO_3$ Per Liter	Gms. $RbNO_3$ per 100 Gms.		t°	Mols. $RbNO_3$ Per Liter	Gms. $RbNO_3$ per 100 Gms.	
		Water	Solution			Water	Solution
0	1.27	19.5	16.3	60	7.99	200	66.7
10	2.04	33.0	24.8	70	9.02	251	71.5
20	3.10	53.3	34.6	80	9.93	309	75.6
30	4.34	81.3	44.8	90	10.77	375	78.9
40	5.68	116.7	53.9	100	11.54	452	81.9
50	6.88	155.6	60.9	118.3	12.76	617	86.1

The following specific gravity determinations are also given by Berkeley, 1904.

t°	0.6	15.85	31.55	45.85	63.4	75.60	90.95	118.3 <sup>b</sup>
Sp. Gr. of Sat. Sol.	0.1389	1.2665	1.4483	1.6216	1.8006	1.9055	2.0178	2.1867

<sup>b</sup>boiling-point

THE SOLUBILITY AND SUPERSOLUBILITY ICE CURVES FOR RUBIDIUM NITRATE  
AND WATER  
(Jones, 1908)

t° of Cryst. of Ice	Gms. RbNO <sub>3</sub> per 100 Gms. H <sub>2</sub> O		t° of Cryst. of Ice	Gms. RbNO <sub>3</sub> per 100 Gms. H <sub>2</sub> O	
	Solubility Curve	Supersolubility Curve		Solubility Curve	Supersolubility Curve
-0.4	1.16	-	-3.5	-	9.94
-1.8	-	1.24	-2.3	13.97	-
-2.1	-	-4.2	-4.2	-	13.97
-1.7	9.94	-	-2.7*	17.11	-

\*Cryohydrate

NO

A few solubility determinations in the system  $\text{RbNO}_3 - \text{Ca}(\text{NO}_3)_2 - \text{H}_2\text{O}$  at 20° indicate the formation of the double salt  $\text{Ca}(\text{NO}_3)_2 \cdot \text{RbNO}_3 \cdot 3\text{H}_2\text{O}$ . (Sarnowski, Krawczyk and Zygodto, 1955.)

Melting points are given for:

$\text{RbNO}_3 + \text{Sr}(\text{NO}_3)_2$	(Plyushchev, Markina and Skhlover, 1956)
$\text{RbNO}_3 + \text{Ba}(\text{NO}_3)_2$	(Plyushchev, Markina and Skhlover, 1956, 1956a)
$\text{RbNO}_3 + \text{CsNO}_3$	(Protsenko and Belova, 1955)
$\text{RbNO}_3 + \text{Ca}(\text{NO}_3)_2$	(Protsenko and Belova, 1957)
$\text{RbNO}_3 + \text{LiNO}_3 + \text{AgNO}_3$	(Protsenko and Kiparenko, 1955)

RUBIDIUM NIOBATE  $\text{RbNbO}_3$

SOLUBILITY IN WATER  
(Lapitskii, Shishkina, Pchelkina and Stepanov, 1955)

t°	$\text{RbNbO}_3$	
	Moles per liter sat. sol.	Mg./100 ml. sat. sol.
0	0.00009	2.0
25	0.00011	2.5
50	0.00023	5.1
75	0.00034	7.6
100	0.00045	10.2

RUBIDIUM HYDROXIDE  $\text{RbOH}$

OH

A phase diagram of the system  $\text{RbOH} - \text{H}_2\text{O}$  is given by Rollet, Cohen-Adad, Michaud and Tranguard, 1958. 4, 3, 2, 1 and  $\frac{1}{3}$  hydrates are formed (3 -  $\text{H}_2\text{O}$  is metastable). Invariant points are as follows:



## Rb RUBIDIUM

### Invariant Points in the system $\text{RbOH} - \text{H}_2\text{O}$

$t^\circ$	Wt. % RbOH	Solid Phase
-72.5	47.4	$\text{Ice} + \text{RbOH} \cdot 4\text{H}_2\text{O}$
-76.7	48.8 <sup>m</sup>	$\text{Ice} + \text{RbOH} \cdot 3\text{H}_2\text{O}$
-52.5	55.9	$\text{RbOH} \cdot 4\text{H}_2\text{O} + \text{RbOH} \cdot 2\text{H}_2\text{O}$
-57.0	55.5 <sup>m</sup>	$\text{RbOH} \cdot 3\text{H}_2\text{O} + \text{RbOH} \cdot 2\text{H}_2\text{O}$
-73.5	65.4	$\text{RbOH} \cdot 3\text{H}_2\text{O} + \text{RbOH} \cdot 4\text{H}_2\text{O} + \text{RbOH} \cdot 2\text{H}_2\text{O}$
+47	73.8	$\text{RbOH} \cdot 2\text{H}_2\text{O} + \text{RbOH} \cdot \text{H}_2\text{O}$
145 m. pt.	85.0	$\text{RbOH} \cdot \text{H}_2\text{O}$
95	90.6	$\text{RbOH} \cdot \text{H}_2\text{O} + \text{RbOH} \cdot \frac{1}{3}\text{H}_2\text{O}$
104	91.4	$\text{RbOH} \cdot \frac{1}{3}\text{H}_2\text{O} + \text{RbOH} - \alpha$
235	95.5	$\text{RbOH} - \alpha + \text{RbOH} - \beta$

OH

<sup>m</sup>metastable

100 gms. sat. aqueous solution contain 63.39 gms. RbOH at  $30^\circ$   
(Schreinemakers and Philipp, 1906.)

100 gms. sat. aqueous solutions contain 64.17 gms. RbOH at  $15^\circ$ .  
(de Forcrand, 1909a.)

The solubility of RbOH in liquid  $\text{HN}_3$  is 0.9 gms. per 100 ml.  
at  $-40^\circ$ .

Fusion-point data for mixtures of  $\text{RbOH} + \text{NaOH}$  are given by  
v. Hevesy, 1900.

## ReO RUBIDIUM PERRHENATE $\text{RbReO}_4$

### SOLUBILITY IN WATER

Results of Smith and Long, 1948		Results of Moddak and Moddak, 1931	
$t^\circ$	Gms. $\text{RbReO}_4$ per 100 gms. $\text{H}_2\text{O}$	$t^\circ$	Gms. $\text{RbReO}_4$ per 100 ml. sat. sol.
0	0.389	19.2	1.05
30	1.570	24.6	1.46
50.3	3.52		

Data for the distribution of  $\text{RbReO}_4$  between nitromethane and water  
at  $25^\circ$  are reported by Friedman and Haugen, 1954.

## S RUBIDIUM PENTASULFIDE $\text{Rb}_2\text{S}_5$

Fusion-point data for the system  $\text{Rb}_2\text{S}_5 + \text{S}$  are given by Biltz and  
Wilke-Dörfurt, 1906.

RUBIDIUM METABISULFITE  $\text{Rb}_2\text{S}_2\text{O}_5$ 

100 gms. liquid sulfur dioxide dissolve 0.040 gm.  $\text{Rb}_2\text{S}_2\text{O}_5$  at  $0^\circ$ .  
(Jander and Wickert, 1936; Jander and Ruppolt, 1937.)

RUBIDIUM SULFATE  $\text{Rb}_2\text{SO}_4$ 

SO

SOLUBILITY IN WATER  
(Etard, 1894; Berkeley, 1904)

t°	Mols. $\text{Rb}_2\text{SO}_4$ per Liter	Gms. $\text{Rb}_2\text{SO}_4$ per 100 Gms.		t°	Mols. $\text{Rb}_2\text{SO}_4$ per Liter	Gms. $\text{Rb}_2\text{SO}_4$ per 100 Gms.	
		Water	Solution			Water	Solution
0	1.27	36.4	27.3	60	2.15	67.4	40.3
10	1.46	42.6	29.9	70	2.25	71.4	41.7
20	1.64	48.2	32.5	80	2.34	75.0	42.9
30	1.79	53.5	34.9	90	2.42	78.7	44.0
40	1.92	58.5	36.9	100	2.49	81.8	45.0
50	2.04	63.1	38.7	102.4	2.50	82.6	45.2

The following Sp. Gr. determinations are also given by Berkeley.

t°	0.5	15.80	31.6	44.2	57.90	74.75	89.45	102.4 <sup>b</sup>
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Sp. Gr.

of Sat. Sol.	1.2740	1.3287	1.3704	1.3998	1.4232	1.4480	1.4649	1.4753
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<sup>b</sup>boiling point

SOLUBILITY OF RUBIDIUM DOUBLE SULFATES IN WATER AT  $25^\circ$   
(Locke, 1902)

Formula	Per 100 cc. $\text{H}_2\text{O}$		Formula	Per 100 cc. $\text{H}_2\text{O}$	
	Gms. Anh. Salt	Mols. Salt		Gms. Anh. Salt	Mols. Salt
$\text{Rb}_2\text{Cd}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$	76.7	0.1615	$\text{Rb}_2\text{Mn}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$	35.7	0.0857
$\text{Rb}_2\text{Co}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$	9.28	0.022	$\text{Rb}_2\text{Mg}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$	20.2	0.0521
$\text{Rb}_2\text{Cu}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$	10.28	0.0241	$\text{Rb}_2\text{Ni}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$	5.98	0.0142
$\text{Rb}_2\text{Fe}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$	24.28	0.0579	$\text{Rb}_2\text{Zn}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$	10.10	0.0236

# Rb RUBIDIUM

## RUBIDIUM ALUMS

### SOLUBILITY IN WATER (Locke, 1901)

	Alum	Formula	t°	Gms. Alum per 100 Gms. H <sub>2</sub> O		
				Anhydrous	Hydrated	G. Mols.
SO	Rb Aluminum Alum	RbAl(SO <sub>4</sub> ) <sub>2</sub> ·12H <sub>2</sub> O	25	1.81	3.15	0.0059
	"	"	30	2.19	-	0.0072
	"	"	35	2.66	-	0.0087
	"	"	40	3.22	-	0.0106
	Rb Chromium Alum	RbCr(SO <sub>4</sub> ) <sub>2</sub> ·12H <sub>2</sub> O	25	2.57	4.34	0.0079
	"	"	30	3.17	-	0.0096
	"	"	35	4.11	-	0.0128
	"	"	40	5.97	-	0.0181
	Rb Vanadium Alum	RbV(SO <sub>4</sub> ) <sub>2</sub> ·12H <sub>2</sub> O	25	5.79	9.93	0.0177
	Rb Iron Alum	RbFe(SO <sub>4</sub> ) <sub>2</sub> ·12H <sub>2</sub> O	25	9.74	16.98	0.0294
	"	"	30	20.24	-	0.0617

Biltz and Wilke, 1906, find for the solubility of rubidium iron alum in water, at 6.6°, 4.55 gms. per 100 cc. solution; at 25°, 29 gms; and at 40°, 52.6 gms.

100 cc. sat. solution in absolute H<sub>2</sub>SO<sub>4</sub> contain 58.81 gms. Rb<sub>2</sub>SO<sub>4</sub>. (Bergius, 1910.)

Fusion-point data for mixtures of Rb<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>Cl<sub>2</sub> are given by Dombrovskaya, 1933.

## SeO RUBIDIUM SELENATE Rb<sub>2</sub>SeO<sub>4</sub>

100 gms. H<sub>2</sub>O dissolve 158.9 gms. Rb<sub>2</sub>SeO<sub>4</sub> at 12°. (Tutton, 1897.)

### SOLUBILITY OF MIXED CRYSTALS OF RUBIDIUM ACID SELENATE AND RUBIDIUM ACID TELLURATE AND OF RUBIDIUM ACID SULFATE AND RUBIDIUM ACID TELLURATE IN WATER AT 25° (Pellini, 1909)

Results for RbHSeO <sub>4</sub> + RbHTeO <sub>4</sub>			Results for RbHSO <sub>4</sub> + RbHTeSO <sub>4</sub>		
Gms. per 1000 cc. Sat. Sol.		Mol. % Selenate in Solid Phase	Gms. per 1000 cc. Sat. Sol.		Mol. % Sulfate in Solid Phase
RbHSeO <sub>4</sub>	RbHTeO <sub>4</sub>		RbHSO <sub>4</sub>	RbHTeO <sub>4</sub>	
76.46	39.51	51.55	26.675	38.403	47.91
95.82	35.30	52.22	32.117	31.58	50.33
171.70	22.98	53.95	42.917	26.764	50.74
462.80	5	56.33	59.074	20.182	50.99
859.30	3.40	67.46	498.25	0.02887	52.52

RUBIDIUM SILICOTUNGSTATE  $\text{Rb}_8\text{SiW}_{12}\text{O}_{42}$ 

100 gms.  $\text{H}_2\text{O}$  dissolve 0.65 gm.  $\text{Rb}_8\text{SiW}_{12}\text{O}_{42}$  at  $20^\circ$ , and 5.1 gms. at  $100^\circ$ . (Godeffroy, 1876.)

RUBIDIUM TUNGSTATE  $\text{Rb}_2\text{WO}_4$ 

WO

SOLUBILITY IN WATER  
(Spitsyn, 1947)

t°	Gms. $\text{Rb}_2\text{WO}_4$ per 100 gms. sat. sol.
7	80.7
17	80.0

Melting points in the system  $\text{Rb}_2\text{WO}_4 - \text{WO}_3$  are given by Spitsyn and Kuleshov, 1950.

## RHENIUM Re

Re

The distribution of rhenium in the system  $\text{Fe} + \text{FeS}$  at the eutectic temperature was determined by Noddack, Noddack, and Bohnstedt, 1940.

## RHENIUM FLUORIDE

Data for the partition of rhenium between ethyl ether and aqueous HF solutions are given by Bock and Herrmann, 1956.

RHENIUM SULFIDE  $\text{Re}_2\text{S}_7$ SOLUBILITY IN SULFIDE SOLUTIONS AT ABOUT  $20^\circ$   
(Geilmann and Bode, 1950)

The approach to equilibrium was slow both from under saturation U and from supersaturation S. Data are mg.  $\text{Re}_2\text{S}_7$  per 100 ml. sat. sol. after 30 days.

Solvent	<u>U</u>	<u>S</u>	Solvent	<u>U</u>	<u>S</u>
0.25 M $\text{Na}_2\text{S}$	0.31	0.80	0.25 M yellow $(\text{NH}_4)_2\text{S}_2$	0.11	0.95
0.25 M $\text{Na}_2\text{S}_2$	0.14	0.88	0.25 M yellow $(\text{NH}_4)_2\text{S}_x$	0.06	0.92
0.25 M $\text{Na}_2\text{S}_4$	0.15	0.80	conc. $(\text{NH}_4)_2\text{S}$	0.04	0.24
0.25 M $(\text{NH}_4)_2\text{S}$	0.13	0.90			

## Rh RHODIUM

## Rh RHODIUM Rh

The distribution of rhodium in the system Fe + FeS at the eutectic temperature was determined by Noddack, Noddack and Bohnstedt, 1940.

### RHODIUM AMMINE SALTS

Salt	t°	Solubility
$[\text{Rh}(\text{NH}_3)_6]\text{Cl}_3$	8	13.3 gms. per 100 gms. $\text{H}_2\text{O}$ (Jorgensen 1883, 1886, 1891)
$[\text{Rh}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$	0	0.00945 moles per liter sat. sol. (Bronsted and Petersen, 1921)
	17	0.56 gms. per 100 gms. $\text{H}_2\text{O}$ (Jorgensen 1883, 1886, 1891)
	20	0.020 moles per liter sat. sol. (Bronsted and Petersen, 1921)
	25	0.828 gms. per 100 gms. sat. sol. (Semzusni, 1927)
$[\text{Rh}(\text{NH}_3)_5\text{Br}]\text{Cl}_2$	20	0.015 moles per liter sat. sol. (Bronsted and Petersen, 1921)
$[\text{Rh}(\text{NH}_3)_6](\text{NO}_3)_3$	room	2.1 gms. per 100 gms. $\text{H}_2\text{O}$ (Jorgensen 1883, 1886, 1891)
$[\text{Rh}(\text{NH}_3)_3(\text{NO}_2)_3]$	10	0.0146 gms. per 100 gms. $\text{H}_2\text{O}$ (Petkov, 1949)
	20	0.0315 gms. per 100 gms. $\text{H}_2\text{O}$ (Petkov, 1949)
	25	0.0394 gms. per 100 gms. $\text{H}_2\text{O}$ (Petkov, 1949)
$[\text{Rh}(\text{NH}_3)_6]_2(\text{SO}_4)_3 \cdot 5\text{H}_2\text{O}$	20	2.3 gms. per 100 gms. $\text{H}_2\text{O}$ (Jorgensen 1883, 1886, 1891)
d,1 diammino cyclopentanes		(see Jaeger and Blumendal, 1928)

## RADON Rn

Early work referred to radon as "radium emanations."

### SOLUBILITY OF RADON IN WATER

Lawrence, et al (1946) reviewed the work of von Antropoff (1910, 1919) Valentiner (1927, 1930), Estreicher (1899), and Meyer (1913) on the solubility of radon in water and drew a smooth curve through the points given by all the authors. The agreement among the various results is not good, but those of Valentiner approximate the average curve. Other results are reported by Boyle, 1911 and Kofler, 1913. The data below were read from the average curve of Lawrence:

## SOLUBILITY OF RADON IN WATER--Cont.

t°	$\beta$	t°	$\beta$
0	0.51	40	0.14
10	.33	50	.115
20	.23	60	.098
30	.17	70	.088

$\beta$  = Bunsen adsorption coefficient: ml. gas measured at 0°, 760 mm. which dissolve in 1 ml. of solvent when the partial pressure of the gas is 760 mm.

## SOLUBILITY OF RADON IN ORGANIC SOLVENTS

(Compare values in each of the three tables following.)

## Results of Schulze, 1920

The results are given in terms of the Ostwald solubility expression  $l$ , which is the relation of the concentration of the gas in the liquid to that in the gas space.

Solubility of Radium Emanations,  $l$  in:

t°	Toluene	Ether	CHCl <sub>3</sub>	Acetone	CS <sub>2</sub>	CH <sub>3</sub> COOC <sub>2</sub> H <sub>5</sub>	C <sub>2</sub> H <sub>5</sub> OH	Hexane
- 18	27.0	29.1	28.4	10.7	50.3	13.6	11.4	35.2
- 10	22.5	-	23.8	9.3	41.5	-	-	28.5
- 5	20.6	21.9	21.6	8.5	37.0	-	-	25.7
0	18.4	19.9	19.6	8.0	33.4	9.41	8.28	23.4
+ 5	17.0	18.2	18.1	7.4	-	-	-	21.4
10	15.7	16.9	16.7	6.9	27.2	8.0	6.93	19.6
15	13.9	15.8	15.6	6.5	-	-	-	17.9
18	13.2	15.1	15.0	6.3	23.1	7.16	6.17	16.6
20	-	14.8	14.6	6.1	-	-	6.03	-
25	11.4	14.0	13.8	5.8	21.5	6.57	-	14.7
30	10.5	13.3	13.1	5.6	20.1	-	5.30	13.3
40	8.87	-	11.9	5.2	18.1	5.64	4.72	-
50	7.6	-	11.2	-	-	5.22	4.26	-
60	6.42	-	-	-	-	4.9	-	-

The solubility  $l$  in aniline is 4.43 at 0° and 3.8 at 18°.

The solubility  $l$  in benzene is 12.82 at 18°.

The author also quotes data for the densities of the solvents at the several temperatures.

## Results of Ramstedt, 1911; Swinne, 1913

Solvent	At 0°		At 18°		At 14° (Boyle, 1911)
	$l_0$	Sp.Gr. of Sol.	$l_{18}$	Sp.Gr. of Sol.	
Water	0.52	0.9999	0.285	0.9986	0.30
Sea Water	-	-	-	-	0.255*
Ethyl Alcohol	8.28	0.8065	6.17	0.7911	7.34
Amyl Alcohol	-	-	-	-	9.31
Acetone	7.99	0.8186	6.30	0.7972	-

(Cont.)

## SOLUBILITY OF RADON IN ORGANIC SOLVENTS--Cont.

Results of Ramstedt, 1911; Swinne, 1913--Cont.

Solvent	At 0°		At 18°		At 14° (Boyle, 1911)
	$\ell_0$	Sp.Gr. of Sol.	$\ell_{18}$	Sp.Gr. of Sol.	
Aniline	4.43	1.0379	3.80	1.0210	-
Benzene	-	-	12.82	0.8811	-
Carbon Disulfide	33.4	1.2921	23.14	1.2640	-
Chloroform	20.5	1.5264	15.08	1.4907	-
Chlohexane	-	-	18.04	0.7306	-
Ethyl Acetate	9.41	0.9244	7.34	0.9029	-
Ethyl Ether	20.9	0.7362	15.08	0.7158	-
Glycerol	-	-	0.21	1.262	-
Hexane	23.4	0.6769	16.56	0.6612	-
Toluene	18.4	0.8842	13.24	0.8666	13.7

## Results of Semenchenko and Shakparonov, 1948 at 18°

Solvent	Moles Rn per Cubic Meter of Solution		Solvent	Moles Rn per Cubic Meter of Solution		Solvent	Moles Rn per Cubic Meter of Solution	
C <sub>6</sub> H <sub>14</sub>	0.6800		(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	0.6190		C <sub>6</sub> H <sub>5</sub> NH <sub>2</sub>	0.1561	
C <sub>6</sub> H <sub>6</sub>	.5270		Cyclohexane	.7400		(CH <sub>3</sub> ) <sub>2</sub> CO	.2585	
C <sub>6</sub> H <sub>5</sub> CH <sub>3</sub>	.5440		CHCl <sub>3</sub>	.6195		C <sub>2</sub> H <sub>5</sub> OH	.2535	
CS <sub>2</sub>	.9500		CH <sub>3</sub> COOC <sub>2</sub> H <sub>5</sub>	.3015		Glycerin	.0082	
						H <sub>2</sub> O	.0117	

SOLUBILITY OF RADON IN OLIVE OIL  
(Lurie, 1910)

22°	$\beta = 0.25$
37°	$\beta = 0.19$

SOLUBILITY OF RADON IN FATTY ACIDS AND TRIGLYCERIDES  
(Nussbaum and Hursh, 1958)

Solvent	Ostwald Coeff. $\ell$			Solvent	Ostwald Coeff. $\ell$		
	25°	37°	50°		25°	37°	50°
formic acid	1.05	0.96	0.95	acrylic acid	-	5.01	-
acetic acid	4.43	3.53	3.30	oleic acid	8.10	6.72	5.86
propionic	6.52	5.23	5.47	linoleic acid	7.96	6.32	-
butyric	7.52	6.82	5.99	triacetin	3.42	2.88	-
valeric	8.64	6.82	6.06	tributylin	6.42	5.01	-
hexanoic	9.03	7.23	6.16	trihexanoin	7.25	6.10	5.17
heptanoic	8.75	7.15	6.33	trioctanoin	7.55	6.12	5.63
octanoic	9.03	6.89	6.16	olive oil	7.70	6.26	-
nonanoic	8.32	6.89	6.00	Italian olive oil	7.71	6.24	-
decanoic	-	7.13	-	butterfat	-	5.91	-
undecanoic	-	6.89	-	rat fatty acids	-	5.85	-
lauric	-	-	5.93	human fat	-	6.33	-
tridecanoic	-	-	5.95				

## RUTHENIUM Ru

Ru

The distribution of ruthenium in the system Fe + FeS at the eutectic temperature was determined by Noddack, Noddack, and Bohnstedt, 1940.

## RUTHENIUM NITROSO CHLORIDES

SOLUBILITIES IN WATER  
(Howe, 1894)

		t°	Gms. Salt per 100 gms. H <sub>2</sub> O
Ruthenium Potassium Nitrosochloride	K <sub>2</sub> RuCl <sub>5</sub> NO	25	12
Ruthenium Potassium Nitrosochloride	K <sub>2</sub> RuCl <sub>5</sub> NO	60	80
Ruthenium Ammonium Nitrosochloride	(NH <sub>4</sub> ) <sub>2</sub> RuCl <sub>5</sub> NO	25	5
Ruthenium Ammonium Nitrosochloride	(NH <sub>4</sub> ) <sub>2</sub> RuCl <sub>5</sub> NO	60	22
Ruthenium Rubidium Nitrosochloride	Rb <sub>2</sub> RuCl <sub>5</sub> NO	25	0.57
Ruthenium Rubidium Nitrosochloride	Rb <sub>2</sub> RuCl <sub>5</sub> NO	60	2.13
Ruthenium Rubidium " (hydrated)	Rb <sub>2</sub> RuCl <sub>5</sub> NO.2H <sub>2</sub> O	25	114.3
Ruthenium Caesium Nitrosochloride	Cs <sub>2</sub> RuCl <sub>5</sub> NO	25	0.20
Ruthenium Caesium Nitrosochloride	Cs <sub>2</sub> RuCl <sub>5</sub> NO	60	0.56
Ruthenium Caesium " (hydrated)	Cs <sub>2</sub> RuCl <sub>5</sub> .NO.2H <sub>2</sub> O	25	105.8

RUTHENIUM TETRAOXIDE RuO<sub>4</sub>

Data for the distribution of RuO<sub>4</sub> between carbon tetrachloride and aqueous solutions of acids, bases and salts are given by Martin, 1954.

## SULFUR S

SOLUBILITY OF SULFUR IN AQUEOUS SODIUM SULFIDE SOLUTIONS  
(Kuster and Heberlein, 1905)

The results are expressed in terms of  $x$  which represents the number of S atoms dissolved for each Na<sub>2</sub> in the solution. The figures, therefore, show the atomic ratio of S to Na<sub>2</sub> in the saturated solution and at the same time, the sulfur content of the compound Na<sub>2</sub>S <sub>$x$</sub>  which is formed. In order to find the actual amount of sulfur dissolved per liter, it is only necessary to multiply the  $x$  value by the normality of the aqueous sodium sulfide solution used as solvent in the particular case.

A series of determinations made at 25°, by agitating aqueous sodium sulfide solutions with crystalline sulfur until equilibrium was reached, and then diluting each solution with an equal volume of water and shaking with excess of sulfur until equilibrium was again reached, gave the following results:



# S SULFUR

## SOLUBILITY OF SULFUR IN AQUEOUS SODIUM SULFIDE SOLUTIONS--Cont.

Normality of the Aq. Na <sub>2</sub> S Solution	$\bar{x}$ in the Result- ing Na <sub>2</sub> S <sub>x</sub>	Normality of the Aq. Na <sub>2</sub> S Solution	$\bar{x}$ in the Result- ing Na <sub>2</sub> S <sub>x</sub>
4	4.475	0.125 (32 hrs.)	5.225
2 (2 hrs.)	4.666	0.0625	5.239
1	4.845	0.03125	5.198
0.5	4.984	0.015625	5.034
0.25	5.115	0.007812 (r28 hrs.)	4.456

The figures in parentheses in the above table show the number of hours required for attainment of equilibrium in these three cases. The authors also made determinations of the influence of temperature on the amount of sulfur dissolved, and found that for a normal Na<sub>2</sub>S solution, the  $\bar{x}$  value did not vary appreciably from the figure given above, over the range 0° to 50°.

Results are also given showing the influence of the presence of NaCl and of KOH on the amount of sulfur dissolved by aqueous Na<sub>2</sub>S solutions. In the former case the solubility was distinctly lowered, while in the latter it was notably increased.

## SOLUBILITY OF SULFUR IN AQUEOUS SOLUTIONS OF ALKALIES AT THE ORDINARY TEMPERATURE (Caleagni, 1920)

	Gms. S per 100 cc. of sat. solution
Aq. Ammonia ( $\bar{d}$ = 0.888)	1.367
Aq. 66% KOH	17.70
Aq. 66% NaOH	24.55
Aq. saturated Mg(OH) <sub>2</sub>	0.014
Aq. saturated Ca(OH) <sub>2</sub>	0.112
Aq. saturated Ba(OH) <sub>2</sub>	2.60

No difference was found between solutions which had been kept in the dark and in the light.

## SOLUBILITY OF SULFUR IN AQUEOUS ACETONE AT 25°

Wt. % Acetone in Solvent	Sulfur per 100 cc. Solution		Sp. Gr. of Solution
	Millimols.	Gms.	
100	65	2.084	0.7854
95.36	45	1.442	0.7911
90.62	33	1.058	0.8165
85.38	25.3	0.811	0.8295

## SOLUBILITY OF SULFUR IN ETHYL, METHYL AND AMYL ALCOHOLS

t°	Alcohol	Gms. per 100 Gms. Alcohol	Authority
15	Abs. Ethyl	0.051	Pohl
18.5	"	0.053	deBruyn, 1892
25.3	"	0.066	(per 100 cc soln)(monoclinic)
	"		Bronsted, 1906
	"	0.052	(per 100 cc soln)(rhombic)
	"		Bronsted, 1906
b.pt.	"	0.42	Payen, 1852
18.5	Abs. Methyl	0.028	deBruyn, 1892
95	Abs. Amyl	1.5	Solid S saturating; Gerardin, 1865
110	"	2.1-2.2	Solid S saturating; Gerardin, 1865
112	"	2.6-2.7	Liquid S saturating; Gerardin, 1865
120	"	3.0	Liquid S saturating; Gerardin, 1865
131	"	5.3	Liquid S saturating; Gerardin, 1865

## SOLUBILITY OF SULFUR IN HYDROGEN SULFIDE

(Walton and Whitford, 1928)

The mixtures were constantly stirred in a quartz tube with a quartz stirrer and the solution analyzed repeatedly until equilibrium had been reached. The analysis was made by adding acetone to decompose the persulfide. The solvents were then allowed to evaporate spontaneously and the residue of rhombic sulfur dried at 90° to constant weight as "sulfur not evolved as hydrogen sulfide." The existence of a compound having the composition  $H_2S_6$ , and stable below  $-1.45^\circ$  was established. Hydrogen disulfide ( $H_2S_2$ ) and hydrogen trisulfide ( $H_2S_3$ ) dissolve sulfur copiously. When these two liquids are saturated with sulfur at a given temperature the two resulting liquid phases have the same composition. The following results were obtained for the solubility of sulfur in the trisulfide of hydrogen.

t°	% S in sat. sol. not evolved as $H_2S$	t°	% S in sat. sol. not evolved as $H_2S$	t°	% S in sat. sol. not evolved as $H_2S$
-34.72	53.56	- 1.45	82.50	35.4	89.46
-15.42	71.18	+ 0.05	82.97	45.15	91.00
-10.6	75.16	17.92	86.77	55.3	92.49
- 3.75	80.71	25.4	87.98		

## SOLUBILITY OF SULFUR IN CARBON DISULFIDE

Etard, 1894; Cossa, 1865; at  $10^\circ$ , Retgers, 1893; below  $77^\circ$ , Arctowski, 1895-96. See also the results of Jacek, 1915 (below) which differ from these.

Gms. S per 100 Gms.			Gms. S per 100 Gms.			Gms. S per 100 Gms.		
t°	Solution	$CS_2$	t°	Solution	$CS_2$	t°	Solution	$CS_2$
-110	3.0	3.1	-10	13.5	15.6	50	59.0	143.9
-100	3.5	3.6	0	18.0	22.0	60	66.0	194.1
- 80	4.0	4.2	10	23.0 <sup>a</sup>	29.9	70	72.0	257.1
- 60	3.5	3.6	20	29.5	41.8	80	79.0	376.1
- 40	6.0	6.4	25	33.5	50.4	90	86.0	614.1
- 20	10.5	11.7	30	38.0	61.3	100	92.0	1150.0
			40	50.0	100.0			

<sup>a</sup>26.4 R.

## S SULFUR

Specific gravity of solution saturated at 15° containing 26 gms. S per 100 gms. solution = 1.372.

### SOLUBILITY OF SULFUR IN CARBON DISULFIDE (Jacek, 1913)

Saturation was secured by constant agitation and all necessary precautions were taken for accurate work. Also see table above.

t°	Gms. S per 100 gms. CS <sub>2</sub>	t°	Gms. S per 100 gms. CS <sub>2</sub>	t°	Gms. S per 100 gms. CS <sub>2</sub>
-109.5	1.05	-65	3.674	-36.5	7.950
-86.0	2.24	-59	4.387	-25.0	10.960
-81.5	2.443	-47	5.889	-17.0	13.96
-74.0	2.89	-44	6.440	0.0	23.13

The following determinations upon this system were made by Hammik, Cousnes and Langford, 1928, by the method of chilling liquified sulfur.

t°	Percent S <sub>μ</sub> dissolved by CS <sub>2</sub>	t°	Percent S <sub>μ</sub> dissolved by CS <sub>2</sub>	t°	Percent S <sub>μ</sub> dissolved by CS <sub>2</sub>
155	4.3	196	35.0	260	38.6
160	9.1	210	38.7	263	37.7
170	18.4	213	38.8	271	39.9
175	22.7	223	37.1	279	37.9
178	23.5	227	39.0	280	39.3
186	28.7	229	40.7	287	39.9
240	33.9 <sup>a</sup>	242	39.6	271	35.9 <sup>a</sup>
245	24.2 <sup>a</sup>	260	33.7 <sup>a</sup>	290	33.2 <sup>a</sup>
254	30.8 <sup>a</sup>	261	32.6 <sup>a</sup>	299	31.7 <sup>a</sup>
		266	34.8 <sup>a</sup>		

<sup>a</sup>In these cases the droplets of sulfur were graded as fair, in all other cases, as good.

The surface tension and density of solutions of sulfur in carbon disulfide at 12°, 17°, and 25° have been accurately determined by Kapustinsky and Golutvin, 1947.

### SOLUBILITY OF SULFUR (S) IN CARBON DISULFIDE AND CARBON TETRACHLORIDE (Wigand, 1910)

When "insoluble" sulfur (S<sub>μ</sub>) is treated with CS<sub>2</sub> or CCl<sub>4</sub>, a small amount dissolves, depending upon the length of time of contact, temperature and nature of the solvent but not on the relative amount of solvent. This action is explained on the assumption that a partial transformation of S<sub>μ</sub> to soluble sulfur S<sub>λ</sub>, takes place.

Data for the fusion points of mixtures of rhombic sulfur and "insoluble" sulfur (S<sub>μ</sub>) and for monoclinic sulfur and "insoluble" sulfur (S<sub>μ</sub>) are given by Kruyt (1908).

## SOLUBILITY OF SULFUR IN CARBON TETRACHLORIDE

Hildebrand and Jenks, 1921; Delaplace, 1922; Jacek, 1926; Hoffman Kirmreuther and Thal, 1910.

t°	Gms. S per 100 gms. sat. sol.	t°	Gms. S per 100 gms. sat. sol.	t°	Gms. S per 100 gms. sat. sol.
-24.0	0.148 (J.)	0.0	0.339 (H. & J.)	25	0.86 (H.K.T.)
-20.75	0.185 "	15.5	0.641 (D.)		0.831 (H. & J.)
-11.25	0.255 "	18	0.720 "	35	1.155 "
- 9.0	0.277 "	22	0.748 "	45	1.564 "
0.0	0.366 "	23.25	0.841 (J.)	54	2.008 "

## SOLUBILITY OF SULFUR IN OTHER CHLORINATED SOLVENTS

C1

- |                      |                                         |
|----------------------|-----------------------------------------|
| (1) Delaplace, 1922  | (5) Hoffman, Kirmreuther and Thal, 1910 |
| (2) Bronsted, 1906   | (6) Wester and Bruins, 1914             |
| (3) Cossa, 1868      | (7) Hildebrand and Jenks, 1921          |
| (4) Gemmellaro, 1940 |                                         |

(See Siver, 1950 for additional data)

Solvent	t°	Solubility	Ref.
CHCl <sub>3</sub>	0	0.788 g/100 cc. soln.	(2)
	12.2	0.75 wt. %	(2)
	13	0.790 wt. %	(1)
	15	0.868 wt. %	(1)
	15.5	1.253 g/100 cc. soln.	(2)
	19.3	0.91 25. %	(2)
	22	1.19 wt. %	(3)
	24	1.216 wt. %	(1)
	40	2.4 g/100 cc. soln.	(2)

## Results for Monoclinic Sulfur:

CHCl <sub>3</sub>	0	1.101 g/100 cc. soln.	(2)
	15.5	1.658 g/100 cc. soln.	(2)
	40	2.9 g/100 cc. soln.	(2)
	25	1.26-1.28 wt. %	(5)
	25	1.183 wt. %	(5)
C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>	25	0.826 wt. %	(7)
	40	1.380 wt. %	(7)
	79	5.43 wt. %	(7)
	97.5	9.97 wt. %	(7)
C <sub>2</sub> HCl <sub>3</sub>	15	1.16 g/100 g. solvent	(6)
	15.5	0.85 g/100 g. solvent	(4)
	25	1.63 g/100 g. solvent	(5)
	40	1.5 g/100 g. solvent	(4)
	60	2 g/100 g. solvent	(4)
	70	2.5 g/100 g. solvent	(4)
	80	3.15 g/100 g. solvent	(4)
	87(b.pt.)	4.1 g/100 g. solvent	(4)
C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>	15	1.05 g/100 g. solvent	(4)
	25	1.23 g/100 g. solvent	(5)
	40	1.60 g/100 g. solvent	(4)

(Cont.)

# S SULFUR

## SOLUBILITY OF SULFUR IN OTHER CHLORINATED SOLVENTS--Cont.

Solvent	t°	Solubility	Ref.
C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>	60	2.15 g/100 g solvent	(4)
	70	2.70 g/100 g solvent	(4)
	80	3.45 g/100 g solvent	(4)
	90	8.15 g/100 g solvent	(4)
	100	18 g/100 g solvent	(4)
	110	39 g/100 g solvent	(4)
	120	100 g/100 g solvent	(4)
C <sub>2</sub> HCl <sub>5</sub>	25	1.183 wt. %	(5)

## RECIPROCAL SOLUBILITY OF PARA DICHLOROBENZENE AND SULFUR (Bruni and Pelizzola, 1921)

C1

Initial temp. of cryst.	Gms. C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> per 100 gms. mixture	Initial temp. of cryst.	Gms. C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> per 100 gms. mixture	Initial temp. of cryst.	Gms. C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> per 100 gms. mixture
52.9	100.0	79.6	85	96.5	40
52.6	99	86.6	80	97.4	30
52.2	97	94.6	70	98.4	25
51.0 <sup>e</sup>	-	97.1	60	99.05	20
51.5	95	96.8	55	101.4	10
67.8	90	96.9	50	107.2	5
				113	0 (=pure S)

## SOLUBILITY OF SULFUR IN TIN TETRACHLORIDE (Gerardin, 1865)

t°	Gms. S per 100 Gms. SnCl <sub>4</sub>	Solid Phase
99	5.8	Solid S
101	6.2	"
110	8.7 - 9.1	"
112	9.4 - 9.9	Liquid S
121	17.0	

## SOLUBILITY OF SULFUR IN SULFUR MONOCHLORIDE (Aten)

In a series of papers by Aten (1905-06, 1912, 1912-13, 1913, 1914 and 1914a), the preparation and properties of the four known modifications of sulfur are described. These are designated by the symbols, S<sub>λ</sub>, S<sub>μ</sub>, S<sub>π</sub> and S<sub>ρ</sub>.

S<sub>λ</sub> is ordinary rhombic sulfur and its molecule is considered to be composed of eight atoms of sulfur, S<sub>8</sub>.

S<sub>μ</sub> is the insoluble, so-called amorphous sulfur.

S<sub>π</sub> is obtained when ordinary sulfur is heated above its melting-point and quickly cooled; it is especially easily prepared by warming

$S_\lambda$  in sulfur chloride. Its molecule is probably represented by  $S_4$ .

$S_\rho$  was discovered by Engel and is prepared by mixing concentrated HCl, cooled to  $0^\circ$ , with saturated sodium thiosulfate solution. The precipitated NaCl is removed by filtration and the solution extracted with toluene. The aqueous layer soon yields a cloudy precipitate of  $S_\rho$ . The molecule of this sulfur is considered to have the composition  $S_6$ .

SOLUBILITY OF SULFUR ( $S_\lambda$ ) IN SULFUR MONOCHLORIDE ( $S_2Cl_2$ ) DETERMINED  
BY THE MELTING-POINT METHOD  
(Aten, 1905-06)

t° of Melting	Mol. % $S_8$ in Mixture	Solid Phase	t° of Melting	Mol. % $S_8$ in Mixture	Solid Phase	Cl
-16	4.3	Rhombic S	83.5	67	Rhombic S	
0	6	"	95.6	81.8	"	
+17.9	9.9	"	86	81.8	Monoclinic S	
36.8	17.1	"	103.2	88.4	"	
55.2	28.5	"	110.4	95	"	
65.6	40.3	"	118.8	100	"	
77.7	55.4	"				

More recent determinations of freezing-points in the above system are given by Lowry, McHatton and Jones, 1927.

Results for the solubility of sulfur in sulfur chloride, determined by the synthetic method upon mixtures as such and after preheating to various temperatures, are given by Hammick and Zvegintzof, 1928. These authors point out that the conclusions of Lowry, McHatton and Jones are incorrect in certain respects.

SOLUBILITY OF SULFUR ( $S_\mu$ ) IN SULFUR MONOCHLORIDE ( $S_2Cl_2$ )  
(Aten, 1912-13)

A preliminary experiment showed that if a solution of  $S_\lambda$  in sulfur monochloride, saturated at  $20^\circ$ , is heated to  $170^\circ$  and cooled, it will then dissolve as much  $S_\lambda$  as already required to saturate it. The following determinations were made by sealing known amounts of  $S_\lambda$  and  $S_2Cl_2$  in tubes, heating them to  $100^\circ$  for several hours and then cooling quickly to the indicated temperatures and shaking for  $\frac{1}{2}$  hour in the case of the  $0^\circ$  and  $25^\circ$  results and 2 hours in the case of the  $-60^\circ$  results. The saturated solutions were analyzed by oxidizing with HCl +  $HNO_3$  + Br and titrating the  $H_2SO_4$  after removing the volatile acids.

Atoms S per 100 Atoms S+S <sub>2</sub> Cl <sub>2</sub> in:				Atoms S per 100 Atoms S+S <sub>2</sub> Cl <sub>2</sub> in:			
Original Mixture	Saturated Solution at:			Original Mixture	Saturated Solution at:		
	-60°	0°	+25°		-60°	0°	+25°
0	11.6	36.1	53.5	79.4	65.2	72	-
10	18.1	40.1	57.6	80.1	66.1	71.6	-
28.7	31.9	47.4	62	89.9	-	-	82.1
49.9	42.9	56	66.4	90.1	-	80.5	-
60.1	47.7	59.9	69.4	94.6	-	-	87.7
69.1	-	-	72.8	98	-	-	93.4

## S SULFUR

Results similar to the above are also given (Aten, 1912), for mixtures previously heated to 50°, 75° and 125°. All the data confirm the formation of the the new modification  $S_{\eta}$ .

### SOLUBILITY OF SULFUR ( $S_{\eta}$ ) IN SULFUR MONOCHLORIDE ( $S_2Cl_2$ ) AT 25° (Aten, 1912, 1913)

The samples were heated to the temperatures indicated and rapidly cooled and powdered. The method of determining the solubilities is not described.

Cl

	Atoms S Dis- solved per 100 Atoms $S+S_2Cl_2$
Unheated Sulfur	53.5
Mixture of Rhombic and Amorphous Sulfur	54.5
Rhombic Sulfur heated to 125°	56--58.5 (depending on excess of S present)
Rhombic Sulfur heated to 165°	60 (determined immediately)
Rhombic Sulfur heated to 165°	59.5 (determined after 1 hr.)
Rhombic Sulfur heated to 165°	57.5 (determined after 24 hrs.)
Rhombic Sulfur heated to 165°	53.2 (determined after 8 days)

100 gms. sat. sol. of sulfur in selenium monochloride ( $Se_2Cl_2$ ) contain 48.81 gms. S at 25°. (Lenher and Kao, 1926.)

### SOLUBILITY OF SULFUR IN BROMINATED SOLVENTS

In $C_2H_4Br_2$ (Etard, 1894)				In $CHBr_3$	
t°	Gms. S per 100 Gms. Solution	t°	Gms. S per 100 Gms. Solution	At 5.6° the solubility is 3.64 wt. % (Amadori, 1922)..	
0	1.2	50	6.4	Additional results for the system sulfur + bromoform are given by Rheinboldt and Schneider, 1929.	
10	1.7	60	8.4		
20	2.3	70	11.4		
25	2.8	80	16.5		
30	3.3	90	24.0		
40	4.4	100	36.5	In $C_2H_5Br$ (Bronsted, 1906)	
				Gms. S per 100 cc sat. sol.	
				t°	monoclinic rhombic
				0	0.852 0.611
				25.3	1.676 1.307

SOLUBILITY OF SULFUR IN BENZENE  
(Etard, 1894; also see Siver, 1950)

t°	Gms. S per 100 Gms. Solution	t°	Gms. S per 100 Gms. Solution
0	1.0	60	6.0
10	1.3	70	8.0
15.2	1.5 <sup>b</sup>	80	10.5
19.3	1.7 <sup>b</sup>	84	13.02 <sup>a</sup>
20	1.7	90	13.8
25	2.1	100	17.5
	2.074 <sup>a</sup>	110	23.0
30	2.4	120	29.0
40	3.2	130	36.0
50	4.3		
54	5.165 <sup>a</sup>		

Cl

<sup>a</sup>Hildebrand and Jenks, 1921<sup>b</sup>Bronsted, 1906; some results for mono-clinic sulfur are also given.

Results at Higher Temperatures

(Alexejew, 1886)

(Kruyt, 1908-09)

t°	Gms. C <sub>6</sub> H <sub>6</sub> per 100 Gms.		Wt. % S in Mixture	Limiting t° of Homogeneity	
	S Layer	C <sub>6</sub> H <sub>6</sub> Layer		Lower	Upper
100	6	75	41.5	146	247
110	8	72.5	55.2	158	230
120	10	70	74.5	157	226
130	12	66	79.8	141	230
140	16	61	81.4	138	above 246
150	19	55	83.4	131	above 272
160	25	45			
164 <sup>c</sup>		35			

Data for the solubility of sulfur in benzene with added C<sub>2</sub>H<sub>4</sub>Cl<sub>2</sub> are given by Krishtalik, 1950.

SOLUBILITY OF SULFUR IN BENZENE, ACETIC ACID AND THEIR MIXTURES  
(Anders, 1933)

t°	Wt. % CH <sub>3</sub> COOH in C <sub>6</sub> H <sub>6</sub> Solvent	Gms. S per 100 gms. sat. sol.	t°	Wt. % CH <sub>3</sub> COOH in C <sub>6</sub> H <sub>6</sub> Solvent	Gms. S per 100 gms. sat. sol.
0	39.86	0.307	30	0.0	2.019
20	0.0	1.768	30	37.76	0.603
20	37.57	0.541	30	67.76	0.186
20	70.78	0.156	30	100.0	0.037
20	100.00	0.032			



SOLUBILITY OF SULFUR IN TOLUENE  
(Jacek, 1926; Delaplace, 1922; Hildebrand and Jenks, 1921)  
(Also Siver, 1950)

t°	Gms. S per 100 gms. sat. sol.	t°	Gms. S per 100 gms. sat. sol.	t°	Gms. S per 100 gms. sat. sol.
-58.25	0.079(J)	-16.0	0.480(J)	20	1.827(D)
-40.25	0.169(J)	-10	0.576(J)	23	1.889(D)
-33.75	0.214(J)	0	0.923(J)	25	2.018(H and J)
-28.50	0.296(J)	0	0.897(H and J)	35	2.722(H and J)
-21.0	0.380(J)	13	1.515(D)	54	4.85 (H and J)
-17.75	0.437(J)	15.5	1.649(J)	83.5	11.64 (H and J)

Experiments by Aten, 1918, showed that when rhombic sulfur is heated in sulfur chloride or toluene solutions, its solubility is increased, due to the transformation of rhombic sulfur to another form,  $S_7$ . This is accompanied by a change in the color of the solution. The increase in solubility is greater the more concentrated the original solution. The author studied the influence of temperature and of concentration, upon the transformation of sulfur dissolved in toluene. The mixtures containing different concentrations of sulfur, were heated respectively for 6 hours at 140°, 4 hours at 150° and 2 hours at 160°. They were cooled and the amount of sulfur remaining in solution after addition of a small quantity of rhombic sulfur and stirring for one hour at 0° was determined.

Mixtures heated at 140°		Mixtures heated at 150°		Mixtures heated at 160°	
% conc. of original solution	Gms. S per 100 gms. sat. sol. at 0°	% conc. of original solution	Gms. S per 100 gms. sat. sol. at 0°	% conc. of original solution	Gms. S per 100 gms. sat. sol. at 0°
3.4	1.18	3.6	1.25	3.2	1.25
6.2	1.42	6.6	1.50	6.2	1.54
9.2	1.64	10.6	1.79	15.0	2.40
22.0	2.69	22.6	2.96	21.6	3.00
27.6	3.23	30.1	3.54	30.0	3.64

The quantity of  $S_7$  formed in  $CS_2$  solutions is about equal to that formed in toluene and is much smaller than the quantity formed in sulfur chloride solutions.

SOLUBILITY OF SULFUR ( $S_7$ ) IN TOLUENE AT 0° AND AT 25°  
(Aten, 1913)

Comp. of Mixture in Atom % S	Solubility in Atom % S		Comp. of Mixture in Atom % S	Solubility in Atom % S	
	At 0°	At 25°		At 0°	At 25°
35	2.88	5.94	74	4.05	7.52
47	-	6.65	77	3.90	-
54	3.26	6.76	80	4.22	-
57	3.30	6.88	83	-	7.93
73	-	7.45	85	-	8.08

These results show that the greater the excess of  $S_{\pi}$ , the greater the solubility. It was found that under the same conditions, unchanged rhombic sulfur gives constant figures irrespective of the excess of S present. At 0°, 2.59 atom per cent  $S_{\lambda}$  was found and at 25°, 5.65 atom per cent.

RESULTS AT HIGHER TEMPERATURES, DETERMINED BY THE SYNTHETIC METHOD  
(Kruyt, 1908-09)

Wt. % S in Mixture	Limiting t° of Homogeneity		Wt. % S in Mixture	Limiting t° of Homogeneity	
	Lower	Upper		Lower	Upper
50.5	167	250	75.7	178	221
62	179	223	77.9	174	-
69.6	180	222	83.3	160	223
73	180	222	90.5	124	above 250

Data for the solubility of sulfur in toluene with added  $C_2H_4Cl_2$  are given by Krishtalik, 1950.

SOLUBILITY OF SULFUR IN META XYLENE  
(Hildebrand and Jenks, 1921; also see Siver, 1950)

	t°:	25	45	80
Gms. S per 100 gms. sat. sol.		1.969	3.604	10.29

RESULTS AT HIGH TEMPERATURES, DETERMINED BY THE SYNTHETIC METHOD  
(Kruyt, 1908-09)

Wt. % S in Mixture	Limiting t° of Homogeneity		Wt. % S in Mixture	Limiting t° of Homogeneity	
	Lower	Upper		Lower	Upper
50.9	181	213	39.9	152	none (230)
49.1	177	228	84.2	none	none
47.7	172.5	none (?)	86.1	164.5	199
44.2	161.5	none (255)	87	159	202.5
40.4	153.5	none (215)	90	139	none (220)

SOLUBILITY OF SULFUR IN PARA XYLENE  
(Hammick and Holt, 1926)

Results for the Solid-Liquid Equilibria

t°	Gms. S per 100 gms. sat. sol.	Solid Phase	t°	Gms. S per 100 gms. sat. sol.	Solid Phase
92.5	13.95	Rhombic S	98.2	16.25	Monoclinic S
100.5	17.95	"	98.0	16.3	"
85.0	11.0	"	106.0	20.38	"
107.0	21.8	Monoclinic S	103.3	17.85	"

# S SULFUR

## SOLUBILITY OF SULFUR IN PARA XYLENE--Cont.

### Results for the Liquid-Liquid Equilibria

$t_1--t_2$	Gms. S per 100 gms. sat. sol.	$t_1--t_2$	Gms. S per 100 gms. sat. sol.	$t_1--t_2$	Gms. S per 100 gms. sat. sol.
about 80	16.25	149-150	34.9	184	81.0
94	20.38	158-165	39.9	175	85.6
101-109	21.8	167-174(235)	44.0	156	85.5
117-121	25.9	171-179	45.7	162-177(187)	87.9
124-129	27.95	175-183(220)	46.3	150-155(203)	90.0
130-134	30.22	175-196(206)	48.3	143-147(205)	91.0
137-141	31.95	190	61.7	84	96.2
144-148	34.6	190	71.2		

$t_1$  is the temperature at which the second liquid phase first dissolves.

$t_2$  is the temperature at which the second liquid phase finally dissolves.

The figures in parentheses show the temperatures at which mixtures that have become homogeneous at lower temperatures again separate into two liquid layers.

## SOLUBILITY OF SULFUR IN TRIPHENYL METHANE, DETERMINED BY THE SYNTHETIC METHOD

### Results of Smith, Holmes and Hall, 1905

% Tri-phenyl Methane in Mixture	t° of First Limit of Mixing	% Tri-phenyl Methane in Mixture	t° of First Limit of Mixing
69.1	108.5	35.5	214.5
58.8	127	32.5	211
50.8	136.5	28.4	206
46.6	141	24.5	203
42.8	144	21.6	200
37.8	146	19.2	199
33.7	146.5	15.4	198
30.3	147		
25.4	146		

### Results of Kruyt, 1908-09

% Tri-phenyl Methane in Mixture	t° of First Limit of Mixing	% Tri-phenyl Methane in Mixture	t° of First Limit of Mixing
66.7	113	7	211.5
60.2	125.3	9.3	201.5
50.2	136.8	12	198.8
41	144.2	13.7	199.5
30.8	146	16.4	200.4
20	145.2	19.8	202.1
13.2	137.6	23.5	203.7
8.1	118.6	28.7	208
7	crystals	34.5	215.2

Later results for this system are given by Mondain-Monval and Schneider, 1928.

SOLUBILITY OF SULFUR IN HEXANE  
(Etard)

t°	Gms. S per 100 Gms. Solution	t°	Gms. S per 100 Gms. Solution	t°	Gms. S per 100 Gms. Solution
-20	0.07	60	1.0	130	5.2
0	0.16	80	1.7	140	6.0
20	0.25	100	2.8	160	7.2
40	0.55	120	4.4	180	8.2

SOLUBILITY OF SULFUR IN BENZINE  
(Delaplace, 1922)

t°	Gms. S per 100 gms. sat. solution
15	1.56
20	1.96

SOLUBILITY OF SULFUR IN HEPTANE  
(Hildebrand and Jenks, 1921)

t°:	0	25	35	45	54
Gms. S per 100 gms. sat. sol.	0.124	0.362	0.512	0.698	0.926

SOLUBILITY OF SULFUR IN RAIL ROAD LIGHT OIL  
(Thompson and Odeen, 1920)

t°:	0	24	28
Gms. per 100 cc. sat. sol.	0.198	0.324	0.364

SOLUBILITY OF SULFUR IN CYCLOHEXANE  
(Brooke, 1951)

t°:	11.1	22.2	26.1	44.2	57.6	70.6
Wt. % S in sat. sol.:	0.716	1.018	1.090	2.016	2.938	4.385

# S SULFUR

## SOLUBILITY OF SULFUR IN COAL TAR OIL, LINSEED OIL AND IN OLIVE OIL (Pelouze, 1869; Pohl)

Grams S per 100 Grams Coal Tar Oil of:						
t°	Sp.Gr.: 0.87 b.pt.:80°-100°	0.88 85°-120°	0.882 120°-220°	0.885 150°-200°	1.01 210°-300°	1.02 220°-300°
15	2.1	2.3	2.5	2.6	6.0	7.0
30	3.0	4.0	5.3	5.8	8.5	8.5
50	5.2	6.1	8.3	8.7	10.0	12.0
80	11.8	13.7	15.2	21.0	37.0	41.0
100	15.2	18.7	23.0	26.4	52.5	54.0
110	-	23.0	26.2	31.0	105.0	115.0
120	-	27.0	32.0	38.0	∞	∞
130	-	-	38.7	43.8	∞	∞

G. S per 100 Gms.		
t°	Linseed Oil	Olive Oil of 0.885 Sp. Gr.
15	0.4	2.3
30	0.6	4.3
50	1.2	9.0
80	2.2	18.0
100	3.0	25.0
110	3.5	30.0
120	4.2	37.0
130	5.0	43.0
160	10.0	

100 gms. oil of turpentine dissolve 1.35 gms. S at 16°, and 16.2 gms. ab b. pt. (Payen, 1852.)

## SOLUBILITY OF SULFUR IN PHENOL, DETERMINED BY THE SYNTHETIC METHOD (Smith, Holmes and Hall, 1905)

The mixtures of sulfur and phenol were heated until they were homogeneous and then cooled to the temperature at which clouding appeared.

t° of Clouding	Gms. S per 100 Gms. Phenol	t° of Clouding	Gms. S per 100 Gms. Phenol	t° of Clouding	Gms. S per 100 Gms. Phenol
89.5	9.1	155	26.3	166	31.6
96.5	10.4	157.5	27.1	167.5	32.4
122.5	15.3	160.5	28.6	170	33.5
138	19.9	162	29.6	172	34.9
148.5	23.6	164.5	30.7	175	36.5

SOLUBILITY OF SULFUR ( $S_8$ ) IN  $\beta$  NAPHTHOL, DETERMINED BY THE  
SYNTHETIC METHOD

(Smith, Holmes and Hall, 1905)

The mixtures of sulfur and  $\beta$  naphthol were heated until they were homogeneous and then cooled to the temperature at which clouding appeared.

t° of Clouding	Gms. S per 100 Gms. $\beta$ Naphthol	t° of Clouding	Gms. S per 100 Gms. $\beta$ Naphthol	t° of Clouding	Gms. S per 100 Gms. $\beta$ Naphthol
118	34	154	84.1	164	209.7
132.5	46.6	157	97.4	163.8	238.1
134.5	48.8	160.5	119.3	163.8	264.8 <sup>a</sup>
143.5	59.3	162.5	145.1	163	300 <sup>a</sup>
149.5	70	163.5	177.6		

<sup>a</sup>Solid phase,  $\beta$  naphthol

SOLUBILITY OF SULFUR IN PYRIDINE

(Hammick and Holt, 1926)

The temperature of weighed mixtures of the constituents, contained in sealed tubes, was raised or lowered until the point was reached at which the sulfur phase increased or diminished. The observations of the end point were accurate to 0.3 - 0.5°.

<u>Solid-Liquid Equilibria</u>			<u>Liquid-Liquid Equilibria</u>			
t°	Wt. % S	Solid Phase	t°	Wt. % S	t°	Wt. % S
84.5	10.5	Rhombic S	About 80	13.35	160.5	59.0
91.5	13.35	"	98.0	19.2	161.0	70.0
95.2	15.9	"	116.0	24.65	156.0	79.7
97.5	16.9	"	127.5	29.8	147.0	87.78
101	19.2	Monoclinic S	144.0	38.8	132.5	88.4
110	98.0	"	157.0	50.7	137.0	90.0
					127.0	91.94

100 gms. pyridine dissolve 1.5 gm. S at about 20° and 63.0 gms. at the b. pt. (Le fevre, 1932.)

SOLUBILITY OF SULFUR IN QUINOLINE

(Hammick and Holt, 1926)

The determinations were made as described above.

<u>Solid-Liquid Equilibria</u>							
Rhombic Sulfur		Monoclinic Sulfur		Rhombic Sulfur		Monoclinic Sulfur	
t°	Wt. % S	t°	Wt. % S	t°	Wt. % S	t°	Wt. % S
74.5	13.8	88.75	24.0	96.0	32.95	101.1	49.5
85.8	19.8	91.0	25.9	98.5	41.9	101.4	57.0
93.2	25.9	96.0	32.8	99.5	49.5	101.8	66.75
93.8	27.35	97.1	35.8	99.5	49.7	102.0	73.8
94.2	28.7	98.5	39.0	100.0	65.3	102.3	79.0
94.6	30.4	99.2	41.9	101.0	85.5	104.7	90.4
96.5	32.8	100.9	45.5			111.5	97.8

## S SULFUR

### SOLUBILITY OF SULFUR IN QUINOLINE--Cont.

#### Liquid-Liquid Equilibria (Metastable)

(The mixtures were cooled without being seeded with sulfur.)

t°	Wt. % S	t°	Wt. % S	t°	Wt. % S	t°	Wt. % S
60.0	27.35	89.2	45.4	94.8	57.0	93.9	79.0
72.6	32.8	90.2	46.8	95.2	60.9	92.6	79.8
78.0	35.8	91.6	49.5	96.0	65.3	91.9	80.5
82.5	39.0	91.6	49.7	95.5-96.2	66.3	85.4	85.2
85.0	41.5	94.3	55.4	96.5	66.75	70.0	90.4
85.5	41.9	94.5	55.5	94.8	73.8		

### SOLUBILITY OF SULFUR IN VARIOUS OTHER SOLVENTS

Solvent	t°	Solubility
Ethyl ether	0	0.080 g. rhombic S per 100 cc sat. sol. (Bronsted, 1906)
		0.113 g. monoclinic S per 100 cc sat. sol. (Bronsted, 1906)
	13	0.187 gms. per 100 gms. sat. sol. (Delaplace, 1922)
	23	0.283 gms. per 100 gms. sat. sol. (Delaplace, 1922)
	25.3	0.200 g. rhombic S per 100 cc sat. sol. (Bronsted, 1906)
		0.253 g. monoclinic S per 100 cc sat. sol. (Bronsted, 1906)
Ethyl formate	0	0.019 g. rhombic S per 100 cc sat. sol. (Bronsted, 1906)
		0.028 g. monoclinic S per 100 cc sat. sol. (Bronsted, 1906)
Aniline	130	85.3 g. S per 100 g. solvent (Cossa, 1868)
Glycerol	15.5	0.14 g. S per 100 g. solvent (Ossendowski, 1907)
Methylene Iodide	10	10 g. S per 100 g. solvent (Retgers, 1893)
Nicotine	100	10.6 g. S per 100 g. solvent (Kleven, 1872)
Lanoline (anhyd.)	45	0.38 g. S per 100 g. solvent (Klose, 1907)
Hydrazine	room	54 (decomp.) g. S per 100 g. solvent (Welsh and Broderson, 1915)
Benzoyl chloride	0	1 gm. per 100 gm. sat. sol. (Bogousky, 1905)
	134	55.8 gm. per 100 gm. sat. sol. (Bogousky, 1905)

Additional data for the solubility of sulfur in several slightly polar solvents is given by Negisi, 1940.

### SOLUBILITY OF SULFUR IN RUBBER (Venable and Greene, 1922)

Thin strips of rubber stock, which had been compounded with 0 to 20 per cent of sulfur, were packed in flowers of sulfur and kept at desired temperatures until equilibrium was established. The samples

were then analyzed for free and combined sulfur. Equilibrium was approached from above and below, and was reached fairly quickly from below but from above, little of any of the excess sulfur migrated to the outside of the sheet. Consequently all the samples were given a preliminary heating to insure complete solution of the crystals before being placed in the pack. The results are given only in the form of curves and from these, the following approximate values were read. They show that the solubility increases as a "straight line function of the amount of combined sulfur up to a vulcanization coefficient of about 7."

Per cent combined Sulfur	Per cent free Sulfur at		
	55°	75°	95°
1.0	2.8	4.8	7.1
3.0	2.9	5.2	8.1
5.0	3.0	5.4	9.1
7.0	3.1	5.8	10.0

#### SOLUBILITY OF SULFUR IN RUBBER (Morris, 1932)

Mixtures of weighed amounts of pale crepe uncured rubber and sulfur were prepared in a laboratory mill and thin sheets of these were mounted between microscope slides and kept at controlled temperatures. Observation of these sheets by transmitted light with the aid of a microscope were made at a series of temperatures, and the point ascertained at which the solubility of the sulfur in the rubber is complete. The results are given in the form of a small diagram from which the following approximate values were read.

t°	Gms. S per 100 gms. rubber	t°	Gms. S per 100 gms. rubber
30	0.8	70	2.9
40	1.2	80	3.6
50	1.7	90	4.7
60	2.3	100	6.0

#### DISTRIBUTION OF SULFUR BETWEEN RUBBER AND AMYL ALCOHOL AND BETWEEN RUBBER AND n BUTYL ALCOHOL (Kelly and Ayers, 1924)

The determinations were made by two methods: (1) The sulfur was mixed with rubber and the mixture kept in contact with amyl alcohol. After attainment of equilibrium the sulfur in the amyl alcohol was determined. (2) The rubber was kept in contact with n butyl alcohol saturated with sulfur, and after attainment of equilibrium, the sulfur in the n butyl alcohol was determined.

The solubility of sulfur in n butyl alcohol at 30° was found to be 0.187 gm. S per 100 gms. alcohol. Assuming that the same ratio holds at saturation as that found by the distribution experiments, the solubility of sulfur in rubber was calculated to be  $(0.187 \times 5.4 = )$  1.01 gm. S per 100 gms. rubber at 30°.

A series of experiments made by suspending slabs of rubber, having different coefficients of vulcanization, in n butyl alcohol saturated



with sulfur, and stirring gently, gave results for the solubility which increased linearly with the coefficient of vulcanization up to a value of 17. This corresponds to the point where about 35 per cent of the double bonds of the rubber are saturated with sulfur. The results show that rubber dissolves but does not adsorb sulfur.

Results for Rubber and Amyl Alcohol  
by method (1) and at 40°

Results for Rubber and *n* Butyl  
Alcohol by method (2) and at 30°

% S in original S + Rubber mixture	Distribution of Sulfur Gms. S per 100 gms.			Gms. Rubber per 100 cc. Butyl alc. sat. with S	Distribution of Sulfur Gms. S per 100 gms.		
	Amyl alcohol (C <sub>1</sub> )	Rubber (C <sub>2</sub> )	$\frac{C_2}{C_1}$		Butyl alcohol (C <sub>1</sub> )	Rubber (C <sub>2</sub> )	$\frac{C_2}{C_1}$
0.42	0.0395	0.336	8.50	2	0.168	0.840	5.0
0.42	0.0395	0.342	8.68	4	9.148	0.79	5.3
0.80	0.0466	0.536	11.5	6	0.136	0.72	5.3
0.80	0.0455	0.556	12.5	8	0.123	0.67	5.4
0.95	0.0497	0.570	11.5	10	0.109	0.64	5.9
0.95	0.0499	0.592	11.8	12	0.106	0.55	5.2
1.21	0.0681	0.729	11.7	14	0.098	0.52	5.3
1.41	0.0783	0.850	10.7				

#### SOLUBILITY OF SULFUR IN RUBBER

The solubility and rate of diffusion of sulfur in natural crepe and in several synthetic rubbers was determined by Kemp, Malm, and Stiratelli, 1944 as a function of temperature and previous treatment. Data are also given by Kemp, Malm, and Winspear, 1940.

Data for the solubility of sulfur in styrene - butadiene copolymer is given by Williams, 1943.

Results are given for equilibrium in the following systems.

S + CHI <sub>3</sub> (Iodoform)	(1)
S + CH <sub>2</sub> I <sub>2</sub> (Methylene Iodide)	(1)
S + C <sub>2</sub> I <sub>4</sub> (Tetra iodo ethylene)	(1)
S + C <sub>2</sub> H <sub>2</sub> I <sub>2</sub> (Di iodo ethylene)	(1)
S + C <sub>2</sub> I <sub>2</sub> (Di iodo acetylene)	(1)
S + C <sub>2</sub> H <sub>2</sub> I <sub>2</sub> (1.2 Di iodo ethane)	(1)
S + C <sub>2</sub> Br <sub>4</sub> (Tetra brom ethylene)	(1)
S + C <sub>2</sub> NO <sub>2</sub> I <sub>3</sub> (Tri iodo nitro ethylene)	(1)
S + [(C <sub>6</sub> H <sub>5</sub> ) <sub>2</sub> I] <sub>3</sub> (Di phenyl iodonium tri iodide)	(1)
S + C <sub>6</sub> H <sub>4</sub> I <sub>2</sub> (Di iodo benzene)	(1)
S + C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> (p Di chlor benzene)	(2)
S + C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub> S (Di-2-chlor ethyl sulfide)	(3)
S + CO(NH <sub>2</sub> ) <sub>2</sub> (Urea)	(4)
S + NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub> (Ethyl Urethan)	(4)

- (1) Rheinboldt and Schneider, 1929
- (2) Bruni and Pelizzola, 1921
- (3) Wilkinson, Neilson and Wylde, 1920
- (4) Hrynakowski and Adamansis, 1934

(Cont.)

## Equilibrium Results, continued:

S + C <sub>6</sub> H <sub>4</sub> OHCO <sub>2</sub> C <sub>6</sub> H <sub>5</sub> (Salol)	(4)
S + C <sub>6</sub> H <sub>4</sub> (OH) <sub>2</sub> (m) (Resorcinol + αC <sub>10</sub> H <sub>7</sub> (Naphthalamin))	(5)
S + C <sub>6</sub> H <sub>5</sub> NHCOCH <sub>3</sub> (Acetanilid)	(4)
S + αC <sub>10</sub> H <sub>7</sub> (αNaphthylamine)	(4)
S + C <sub>10</sub> H <sub>13</sub> NO <sub>2</sub> (Phenacetin)	(4)
S + C <sub>10</sub> H <sub>20</sub> O (Menthol)	(4)
S + C <sub>11</sub> H <sub>12</sub> N <sub>2</sub> O (Antipyrine)	(4)
S + C <sub>20</sub> H <sub>24</sub> N <sub>2</sub> O <sub>2</sub> (Quinine)	(4)
S + Dibutyl phthalate	(9)
S + Diphenylamine	(7)
S + 2-Naphthylamine	(7)
S + C <sub>6</sub> H <sub>5</sub> COOH (benzoic acid)	(6)
S + Anthracene	(8)

- (4) Hryankowski and Adamansis, 1934  
 (5) Hryankowski, Staszeroski and Szinzt, 1937  
 (6) Hammick and Holt, 1927  
 (7) Krupatkin, 1953  
 (8) Ketelaar and Jibben, 1948  
 (9) Brooke, 1950

## Melting-point data are given for:

S + Sb	(Pelabon, 1909; Jaeger, 1911; Guertier and Schack, 1923)
S + Se	(Matsumoto, 1916)
S + Sn	(Pelabon, 1909)
S + Te	(Pelabon, 1909; Pellini, 1909; Chikashige, 1911, 1911-12 Jaeger and Menke, 1912; Losana, 1923)
S + Pb; S + Ag; S + Au; S + As	(Pelabon, 1909)
S + Tl	(Hahn and Klingler, 1949)
S + Br + I	(Denisova, 1956)

SULFUR MONOBROMIDE S<sub>2</sub>Br<sub>2</sub>

Br

Fusion-point data are given for S<sub>2</sub>Br<sub>2</sub> + SbBr<sub>3</sub> and S<sub>2</sub>Br<sub>2</sub> + SnBr<sub>4</sub> by Pusin and Makuc, 1938.

SULFUR HEXAFLUORIDE SF<sub>6</sub>

F

## SOLUBILITY IN WATER

Morrison and Johnstone, 1955 (S); Friedman, 1954 (ℓ). S = cc SF<sub>6</sub> (N.T.P.) per 1000 g. H<sub>2</sub>O at a gas pressure = 1 atm.; ℓ = Ostwald coefficient.)

t°	S	ℓ	t°	S	ℓ
0	-	0.0147	19.6	6.2	-
10.9	7.9	0.0076	24.85	-	0.0055
12.5	7.4	-	25	5.4	-
14.2	7.0	-	27.8	5.2	-
14.9	-	-	29.6	5.1	-

## S SULFUR

### SOLUBILITY OF SF<sub>6</sub> IN AQUEOUS SALT SOLUTIONS AT 25° (Morrison and Johnstone, 1955)

Salting-out coefficients  $k = \frac{\log S_0/S}{C}$  where  $S_0$  is the solubility in pure H<sub>2</sub>O (5.4 cc N.T.P. per 1000 gms. H<sub>2</sub>O),  $S$  is the solubility in the salt solution and  $C$  is the concentration of the salt in moles/1000 gms. H<sub>2</sub>O.

F	Salt	$k$	Salt	$k$
	NaCl	0.195	KI	0.145
	LiCl	0.145	KBr	0.160
	HCl	0.040	KNO <sub>3</sub>	0.120
	KCl	0.165	(CH <sub>3</sub> ) <sub>4</sub> NI	0.010
	NH <sub>4</sub> Cl	0.090	(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> NBr	0.010
	1/2 BaCl <sub>2</sub>	0.195	1/2 Na <sub>2</sub> SO <sub>4</sub>	0.295

### SOLUBILITY OF SF<sub>6</sub> IN NITROMETHANE (Friedman, 1954)

t°	Ostwald Coeff. $l$
0.1	0.372
19.35	0.363
24.85	0.377

The Ostwald coefficient in water saturated with nitromethane at 24.85° is  $l = 0.0055$ .

## N SULFUR NITRIDE S<sub>4</sub>N<sub>4</sub>

### SOLUBILITY OF SULFUR NITRIDE IN SEVERAL SOLVENTS (Vosnesenskiĭ, 1927)

t°	Gms. S <sub>4</sub> N <sub>4</sub> per 1000 cc of:		
	CS <sub>2</sub>	C <sub>6</sub> H <sub>6</sub>	C <sub>2</sub> H <sub>5</sub> OH
0	3.705	2.266	0.645
10	6.845	4.260	0.830
20	9.391	6.301	1.050
30	13.188	8.692	1.271
40	16.887 (?)	11.107	1.478
50	-	13.721	1.640
60	-	17.100	-

SULFUR DIOXIDE SO<sub>2</sub>

0

## SOLUBILITY OF SULFUR DIOXIDE IN WATER

The partial pressure of sulfur dioxide over its aqueous solutions has been determined by Benschlein and Simenson, 1940, Campbell and Maas, 1930, and Morgan and Maas, 1931 with results that do not agree with those of previous workers (for example those summarized by Sherwood, 1925). The best recent review is given by Plummer, 1950. The data of B. and S. overlap and extend those found in the International Critical Tables and have been put into equation and nomograph form by Davis, 1941. The approximate data listed below were read from curves drawn by B. and S. and M. and M.

- Partial pressure of SO<sub>2</sub> cm. Hg. -

t°	Gms. SO <sub>2</sub> per 100 gms. of H <sub>2</sub> O						
	1	2	4	6	8	10	15
* 0	2	5	11	17.5	24	31	50
*10	3.5	7.5	17	27	37	47	73.5
*18	5	11	24.5	38	51.5	65	
20	3	11	27	43	58		
*25	6	15	32	50.5	67	84	
30	7	17	38	58	78		
40	11	25	51	77			
50	16	34	70				
60	21	45	92				
70	27	115					
80	34						
90	44						
100	55						

\*Data of Morgan and Maass, 1931

TOTAL VAPOR PRESSURES OF AQUEOUS SULFUR DIOXIDE SOLUTIONS  
(Maass and Maass, 1928)

Pressures are given in cm. of mercury at 0°.

Wt. % SO <sub>2</sub>	Cm. Hg.	Wt. % SO <sub>2</sub>	Cm. Hg.	Wt. % SO <sub>2</sub>	Cm. Hg.	Wt. % SO <sub>2</sub>	Cm. Hg.
10°		16.5°		22°		25°	
4.57	24.3	4.48	31.0	4.40	37.8	7.9	66.2
8.19	45.2	8.03	57.2	7.88	69.3	22.4	246.9
11.64	67.4	11.42	84.4	11.17	102.2		
14.75	87.4	14.31	111.4	14.04	132.6		
18.91	124.5	18.57	151.9	18.22	178.3		
19.86	128.8	19.52	156.0	19.14	186.1		
23.10	154.3	22.71	188.4	22.32	222.2		
						4.32	44.8
						7.71	81.0
						10.95	118.3
						13.74	152.8
						17.85	206.9
						21.86	255.6

## S SULFUR

### PARTIAL VAPOR PRESSURES OF AQUEOUS SOLUTIONS OF SULFUR DIOXIDE (Sherwood, 1925)

The author collected the available data on the partial vapor pressure of sulfur dioxide in water and from the plotted results constructed the following table. He assumed that the dissociation is constant at any particular temperature and that Henry's law applies to the undissociated solute. On the basis of this assumption it has been shown (Haslam, Her'shey and Keen, Ind. Eng. Chem, 16, 1225, 1924) that

$$S = H_p + \sqrt{KH_p} \text{ or } \frac{S}{\sqrt{p}} = H \sqrt{p} + \sqrt{KH},$$

when  $S$  = gms.  $\text{SO}_2$  dissolved in 1000 gms.  $\text{H}_2\text{O}$ ;  $p$  = partial pressure of  $\text{SO}_2$  in mm. Hg;  $H$  = Henry's law constant and  $K$  = dissociation constant of the  $\text{H}_2\text{SO}_3$ . The results of Schonfeld, Sims, Roozeboom, Lindner, Freeze, Smith and Parkhurst and Watts, were used.

Gms. $\text{SO}_2$ per 1000 gms. $\text{H}_2\text{O}$	Partial pressure of $\text{SO}_2$ in mm. Hg at							
	0°	7°	10°	15°	20°	30°	40°	50°
0.2	0.25	0.3	0.3	0.3	0.5	0.6	0.8	1.3
0.5	0.6	0.7	0.75	0.8	1.2	1.7	2.8	4.3
1.0	1.2	1.5	1.75	2.2	3.2	4.7	7.5	12.0
1.5	1.9	2.6	3.1	3.8	5.8	8.1	12.9	20.0
2.0	2.8	3.7	4.6	5.7	8.5	11.8	13.3	31.0
3.0	5.1	6.9	7.9	10.0	14.1	19.7	57.0	82.0
5.0	9.9	13.5	15.6	19.3	26.0	36.0	87.0	116.0
7.0	15.2	20.6	23.6	28.0	39.0	52.0	121.0	172.0
10.0	23.3	31.0	37.0	44.0	59.0	79.0	186.0	266.0
15.0	38.0	51.0	59.0	71.0	92.0	125.0	322.0	458.0
25.0	69.0	92.0	105.0	127.0	161.0	216.0	665.0	
50.0	148.0	198.0	226.0	270.0	336.0	452.0		
75.0	228.0	307.0	349.0	419.0	517.0	688.0		
100.0	308.0	417.0	474.0	567.0	698.0			
150.0	474.0	637.0	726.0					
200.0	646.0	857.0						

### SOLUBILITY OF SULFUR DIOXIDE IN WATER

The determinations of Hudson were made by bubbling the gas through the solution until saturation was reached. Special care was taken to obtain accurate results. Attention is called to the sources of error in the determinations of Schönfeld, 1855.

Freeze, 1920, gives results for the solubility of sulfur dioxide in water which are identical with those of Schönfeld, 1855.

(Cont.)

## SOLUBILITY OF SULFUR DIOXIDE IN WATER--Cont.

## Results of Hudson, 1925

t°	Gms. SO <sub>2</sub> per 100 gms. H <sub>2</sub> O*
10	15.39
15	12.73
20	10.64
29.9	7.58
40	5.54
48.15	4.39
60	3.25
70	2.61
80	2.13
90	1.805

## Results of Smith and Parkhurst, 1922

t°	Pressure of SO <sub>2</sub> in mm. Hg	Gms. SO <sub>2</sub> per 100 cc. H <sub>2</sub> O
5	474.8	11.55
20	198.6	2.97
20	224.4	3.34
20	366.6	5.22
20	1107.8	15.01
40	306.4	2.21
40	373.8	2.68
60	175.7	0.84

\*(at partial pressure of 760 mm. Hg)

0

## SOLUBILITY OF SULFUR DIOXIDE IN WATER AT LOW PARTIAL PRESSURES

Pmm = partial pressure of SO<sub>2</sub> in mm. Hg.; that is the total pressure minus the partial pressure of the H<sub>2</sub>O

Pat. = partial pressure of SO<sub>2</sub> in atmospheres.

Conrad and  
Benschlein, 1934

## Johnstone and Leppla, 1934

At 25°		At 25°		At 35°	
Pmm	Gms. SO <sub>2</sub> per 100 gms. H <sub>2</sub> O	P at.	Gm. Mols. SO <sub>2</sub> per 1000 gms. H <sub>2</sub> O	P at.	Gm. Mols. SO <sub>2</sub> per 1000 gms. H <sub>2</sub> O
299	3.63	0.00027	0.002484	0.00103	0.00419
308	3.72	0.00120	0.006203	0.00249	0.00745
593	6.89	0.00229	0.009546	0.00412	0.00999
611	6.99	0.00267	0.01084	0.00580	0.01356
640	7.28	0.00671	0.02059	0.00955	0.01987
730	8.37	0.00911	0.02561		
		0.01350	0.03328		
At 50°					
				0.00230	0.00467
				0.00383	0.00637
				0.00538	0.00838
				0.00879	0.01057

SOLUBILITY OF SULFUR DIOXIDE IN WATER AT DIFFERENT PRESSURES  
(Lindner, 1912)

## Results at 0°

## Results at 25°

## Results at 50°

Pressure in mm. Hg	Gms. SO <sub>2</sub> per 100 cc. Sat. Sol.	Pressure in mm. Hg	Gms. SO <sub>2</sub> per 100 cc. Sat. Sol.	Pressure in mm. Hg	Gms. SO <sub>2</sub> per 100 cc. Sat. Sol.
0.4	0.0537	1.4	0.0534	4.9	0.0525
3.5	0.237	11.75	0.234	30.5	0.2276
29.4	1.227	87.9	1.212	204.5	1.181
109.4	3.804	313	3.750	696	3.628

# S SULFUR

## SOLUBILITY IN WATER (Schönfeld, 1855; Sims, 1861; Roozeboom, 1884)

Schönfeld				Sims		
t°	Vols. SO <sub>2</sub> (at 0° and 760 mm.) per 1 Vol.:		Gms. SO <sub>2</sub> per 100 Gms. H <sub>2</sub> O at total pressure 760 mm.	t°	SO <sub>2</sub> per 1 Gm. H <sub>2</sub> O	
	Sat. SO <sub>2</sub> + Aq.	H <sub>2</sub> O			Gms.	Vols.
0	68.86	79.79	22.83	8	0.168	58.7
5	59.82	67.48	19.31	10	0.154	53.9
10	51.38	56.65	16.21	14	0.130	45.6
15	43.56	47.28	13.54	20	0.104	36.4
20	36.21	39.37	11.29	26	0.087	30.5
25	30.77	32.79	9.41	30	0.078	27.3
30	25.82	27.16	7.81	36	0.065	22.8
35	21.23	22.49	-	40	0.058	20.4
40	17.01	18.77	5.41	46	0.050	17.4
				50	0.045	15.6

### Roozeboom

t°	SO <sub>2</sub> Dissolved per 1 pt. H <sub>2</sub> O at 760 mm. pressure
0	0.236
2	0.218
4	0.201
6	0.184
7	0.176
8	0.168
10	0.154
12	0.142

Sp. Gr. of sat. solution at 0° = 1.061; at 10°, 1.055; at 20° = 1.024.

The results of Sims are discussed and recalculated by Fulda, 1909.

1 gm. H<sub>2</sub>O dissolves 0.0909 gm. SO<sub>2</sub> = 34.73 cc. (measured at 25°) at 25° and 760 mm. pressure. (Walden and Centnerszwer, 1902-03.)

Data for the solubility of sulfur dioxide in water at atmospheric pressure from 0° to 100° is given by Oman, 1924.

## FREEZING-POINT DATA FOR THE SYSTEM SULFUR DIOXIDE - WATER

(Results of Baume and Tykociner, 1914)

At the temperature +12.1° and extending over the range of concentration 11 to 95.1 mols. per cent SO<sub>2</sub> a second phase rich in SO<sub>2</sub> separates. This crystallizes at -74° and the diagram is consequently composed of two lines parallel to the axis of concentration, the one at the +12.1° level corresponding to the SO<sub>2</sub> hydrate, and the other at the -74° level, to the SO<sub>2</sub> rich phase. The diagram is terminated by a very

short branch rising from  $-74^{\circ}$  to the temperature of solidification of pure  $\text{SO}_2$  ( $-72.3^{\circ}$ ).

t° of Freezing	Mols. $\text{SO}_2$ per 100 Mols. $\text{SO}_2 + \text{H}_2\text{O}$		Solid Phase	t° of Freezing	Mols. $\text{SO}_2$ per 100 Mols. $\text{SO}_2 + \text{H}_2\text{O}$		Solid Phase
0	0		Ice	7.7	5.1		$\text{SO}_2$ Hydrate
-0.2	0.8		"	8.3	5.9		"
-3 *	-		" + $\text{SO}_2$ Hydrate	9.3	7.1		"
-0.2	2.8		$\text{SO}_2$ Hydrate	12.1	11		"
+3.5	3.3		"				
6.8	5.5		"	12.2	95.1		"

\*Eutectic

More recent determinations of the equilibrium in the system  $\text{SO}_2 + \text{H}_2\text{O}$ , made by the synthetic method, are described by Terres and Ruhl, 1934. A hitherto unrecognized second modification of solid  $\text{SO}_2$  was obtained. Its formation is apparently caused by traces of  $\text{H}_2\text{O}$ . Its melting point is  $-63.5^{\circ}$  instead of  $-71^{\circ}$  the m.pt. of the ordinary form of solid  $\text{SO}_2$ . The numerical results of the determinations are given only in the complete report of the work published *Beihefte zu den Zeitschriften des Vereins deutscher Chemiker* No. 8, 1934, Verlag Chemie Berlin W35 Cornelius Str. 3.

For data near the critical point in the system  $\text{SO}_2 - \text{H}_2\text{O}$  see Butcher and Hanson, 1957.

FREEZING POINTS IN THE SYSTEM  $\text{SO}_2 - \text{H}_2\text{O}$   
(Fischer and Burger, 1943)

Wt. % $\text{SO}_2$	t° C	Wt. % $\text{SO}_2$	t° C	Wt. % $\text{SO}_2$	t° C
0.96	-0.1	5.80	-2.0	8.23	+0.4
1.94	-0.6	6.32	-2.1	9.66	2.2
3.53	-1.2	*6.7	-2.4	11.08	4.2
4.46	-1.5	7.40	-1.6	12.92	6.6

\*Eutectic

SOLUBILITY OF SULFUR DIOXIDE IN SULFURIC ACID SOLUTIONS

(Results of Dunn, 1882)

				In Sulfuric Acid of 1.84 Specific Gravity	
	Sp.Gr.of H <sub>2</sub> SO <sub>4</sub>	Approximate Per cent H <sub>2</sub> SO <sub>4</sub>	Coefficient of Absorption		Coefficient of Sat. Absorption (760 mm.)
t°	Solution			t°	Solution
6.9	1.139	20	48.67	0	-
6.9	1.300	40	45.38	10	1.8232
8.6	1.482	58	39.91	20	1.8225
9.8	1.703	78	29.03	25	1.8221
5.5	1.067	10	36.78	30	1.8216
6.0	1.102	15	34.08	40	1.8205
15.2	1.173	25	31.82	50	1.8186
16.8	1.151	21	31.56	60	1.8165
14.8	1.277	36	30.41	70	1.8140
15.1	1.458	56	29.87	80	1.8112
15.6	1.609	70	25.17	90	1.8080
15.0	1.739	81	20.83		



### S SULFUR

#### SOLUBILITY OF SULFUR DIOXIDE IN SULFURIC ACID SOLUTIONS--Cont.

(Results of Miles and Fenton, 1920 at 20°)

The solutions were saturated by means of a stream of  $\text{SO}_2$  passing through the actively stirred mixture. The dissolved  $\text{SO}_2$  was determined iodometrically.

% $\text{H}_2\text{SO}_4$ in acid mixture	Gms. $\text{SO}_2$ per 100 gms. acid mixture	% $\text{H}_2\text{SO}_4$ in acid mixture	Gms. $\text{SO}_2$ per 100 gms. acid mixture	% $\text{H}_2\text{SO}_4$ in acid mixture	Gms. $\text{SO}_2$ per 100 gms. acid mixture
55.1	5.13	84.2	2.88	94.0	3.31
59.6	4.90	85.3	2.83	94.6	3.50
61.6	4.82	85.8	2.80	95.5	3.69
68.9	4.16	86.5	2.82	95.6	3.77
74.1	3.63	88.1	2.90	96.5	3.83
78.3	3.23	90.8	3.10	98.0	3.98
80.2	3.12	92.8	3.21	98.5	4.03
82.5	2.99	93.7	3.27		

Calculations of the above results showing that the solubility of  $\text{SO}_2$  is the sum of its solubility in  $\text{H}_2\text{O}$  and  $\text{H}_2\text{SO}_4 \cdot \text{H}_2\text{O}$  are given by Friend, 1931.

(Results of Johnstone and Lappla, 1934 at 25°)

Partial Pressure of $\text{SO}_2$ in Atmospheres	Gm. Mols. per 1000 gms. $\text{H}_2\text{O}$		Partial Pressure of $\text{SO}_2$ in Atmospheres	Gm. Mols. per 1000 gms. $\text{H}_2\text{O}$	
	$\text{H}_2\text{SO}_4$	$\text{SO}_2$		$\text{H}_2\text{SO}_4$	$\text{SO}_2$
0.00130	0.0879	0.00193	0.00571	0.5174	0.00796
0.00571	0.0879	0.01129	0.01022	0.5174	0.01345
0.01022	0.0879	0.01878	0.00130	1.103	0.00134
0.00130	0.5174	0.00161	0.00573	1.103	0.00719
			0.01022	1.103	0.01253

(Results of Cupr, 1926, 1928 at 760mm  $\text{SO}_2$ )

Results at 41°			Results at 62°		
% $\text{H}_2\text{SO}_4$ in Solvent	Gms. $\text{SO}_2$ per 100 gms. solvent	cc $\text{SO}_2$ per 1 cc. sat. sol.	% $\text{H}_2\text{SO}_4$ in Solvent	Gms. $\text{SO}_2$ per 100 gms. solvent	cc $\text{SO}_2$ per 1 cc. sat. sol.
0	4.81	16.7	0.0	2.15	7.37
7.32	3.65	13.3	10.0	1.71	6.28
18.02	3.35	12.8	30.26	1.26	5.25
44.34	2.57	11.9	54.06	1.20	5.90
71.86	1.68	9.47	79.07	1.19	6.95
86.20	1.36	8.40	84.34	1.15	6.95
93.28	1.81	11.5	90.73	1.19	7.36
97.69	2.15	13.6	93.68	1.16	7.26
			96.10	1.16	7.29

## SOLUBILITY OF SULFUR DIOXIDE IN SULFURIC ACID SOLUTIONS--Cont.

(Results of Milbauer, 1936)

Results for $\text{H}_2\text{SO}_4$ of $d = 1.824$ (= 90.8%)		Results for $\text{H}_2\text{SO}_4$ of $d = 1.53$ (= 62.61%)		0
t°	Gms. $\text{SO}_2$ per 100 gms. solvent	t°	Gms. $\text{SO}_2$ per 100 gms. solvent	
23	3.075	25	3.1582	
30	2.270	45	1.4597	
50	1.525	60	1.0200	
100	0.436	80	0.5813	
150	0.171	100	0.4908	
200	0.053	100+	Uncertain results	
237	0.043			

(Results of Lopatto and Savinaev, 1934)

Wt. % $\text{H}_2\text{SO}_4$ in Solvent	% $\text{SO}_2$ in $\text{SO}_2$ + Air Mixture	% $\text{SO}_2$ in Acid				
		20°	30°	40°	50°	60°
61.59	9	-	0.345	0.262	0.194	0.153
	12	-	.587	.449	.314	.250
	24	-	1.990	1.495	1.00	1.730
66.71	7.2	0.304	0.221	0.167	-	-
	17.6	.809	.560	.401	-	-
	23.8	1.172	0.734	-	-	-
	37.6	2.058	1.317	1.043	-	-
70.74	9	-	0.255	0.175	0.137	0.104
	12	-	.362	.270	.199	.162
	18	-	.522	.420	.344	.271
	24	-	.744	.542	.418	.355
73.64	9	-	.415	.327	.249	.169
	12	-	.523	.395	.270	.210
	24	-	.854	.609	.474	.371
78.04	9	-	.380	.262	.209	.146
	12	-	.455	.353	.252	.194
	18	-	.586	.439	.340	.263
	24	-	.779	.542	.452	.364

(Results of Miles and Carson, 1946 in Sulfuric Acid and Oleum Solutions)

The authors plotted their data and drew curves which show minima or inflections at compositions corresponding to  $\text{H}_2\text{SO}_4 \cdot \text{H}_2\text{O}$ ,  $\text{H}_2\text{SO}_4$ , and  $\text{H}_2\text{SO}_4 \cdot \text{SO}_3$ , but the accuracy of the determinations seems to justify only the drawing of a smooth curve having a single minimum near 70% total  $\text{SO}_3$  [ $\text{H}_2\text{SO}_4 \cdot \text{H}_2\text{O}$ ]. Results are given for a partial pressure of  $\text{SO}_2 = 760$  mm. and were read from the smooth curve.

## S SULFUR

### SOLUBILITY OF SULFUR DIOXIDE IN SULFURIC ACID SOLUTIONS--Cont.

(Results of Miles and Carson, 1946 in Sulfuric Acid and Oleum Solutions)

0	Results at 20°		Results at 40°		Results at 60°	
	Gms. SO <sub>3</sub> per 100 gms. SO <sub>3</sub> + H <sub>2</sub> O	Gms. SO <sub>2</sub> per 100 gms. Acid	Gms. SO <sub>3</sub> per 100 gms. SO <sub>3</sub> + H <sub>2</sub> O	Gms. SO <sub>2</sub> per 100 gms. Acid	Gms. SO <sub>3</sub> per 100 gms. SO <sub>3</sub> + H <sub>2</sub> O	Gms. SO <sub>2</sub> per 100 gms. Acid
	82	4.2	57	1.72	57	1.05
	84	4.9	60	1.55	60	.90
	86	6.2	65	1.45	65	.85
	88	8.2	70	1.5	70	.90
	90	10.5	75	1.7	75	1.00
	92	15.0	80	2.1	80	1.3
	93	18.0	85	2.9	85	1.7
	94	21.5				
	95	27.2				

Data for the solubility of sulfur dioxide in water and 0 - 95% sulfuric acid solutions from 2° to 120° is given by Kuznetsov, 1941.

### SOLUBILITY OF SULFUR DIOXIDE IN AQUEOUS SOLUTIONS OF ACETIC ACID AT 27°, AND 760mm PRESSURE (Cupr, 1926, 1928)

% CH <sub>3</sub> COOH in Solvent	Gms. SO <sub>2</sub> per 100 gms. solvent	cc. SO <sub>2</sub> per 1 cc. sat. sol.	% CH <sub>3</sub> COOH in Solvent	Gms. SO <sub>2</sub> per 100 gms. solvent	cc. SO <sub>2</sub> per 1 cc. sat. sol.
0	8.10	26.1	63.51	16.35	61.6
16.72	8.86	31.6	83.59	22.83	84.8
45.58	12.04	44.1	91.89	26.49	97.8
			100	31.5*	112.8

\*At 0°, 725mm 96.1 gms. SO<sub>2</sub> dissolve in 100 gms. acetic acid. (Schulze, 1881.)

### SOLUBILITY OF SULFUR DIOXIDE IN AQUEOUS SALT SOLUTIONS (Fox, 1902).

Results in terms of the Ostwald Solubility Expression (ml. SO<sub>2</sub> at t°, 1 atm. per ml solvent).

Aqueous Salt Solution	Solubility Coefficient $l$ of SO <sub>2</sub> in aq. Solutions of Concentrations:						
	0.5	Normal	1.0 N.	1.5 N.	2.0 N.	2.5 N.	3.0 N.
NH <sub>4</sub> Cl	$l_{25} = 34.58$	36.37	38.06	39.76	41.37	42.78	
NH <sub>4</sub> Br	$l_{25} = 36.25$	39.46	42.78	46.06	49.17	52.25	
NH <sub>4</sub> CNS	$l_{25} = 37.78$	42.74	47.26	52.26	47.01	61.46	

(Cont.)

## SOLUBILITY OF SULFUR DIOXIDE IN AQUEOUS SALT SOLUTIONS--Cont.

Results in terms of the Ostwald Solubility Expression (ml.  $\text{SO}_2$  at  $t^\circ$ , 1 atm. per ml solvent).

Aqueous Salt Solution	Solubility Coefficient $l$ of $\text{SO}_2$ in aq. Solutions of Concentrations:					
	0.5 Normal	1.0 N.	1.5 N.	2.0 N.	2.5 N.	3.0 N.
$\text{NH}_4\text{NO}_3$	$l_{25} = 33.96$	35.07	36.28	37.27	38.01	39.14
$\text{NH}_4\text{NO}_3$	$l_{35} = 23.35$	24.23	24.78	25.57	26.66	27.43
$(\text{NH}_4)_2\text{SO}_4$	$l_{25} = 33.35$	33.82	34.33	34.95	35.47	35.96
$(\text{NH}_4)_2\text{SO}_4$	$l_{35} = 22.91$	23.14	23.49	23.93	24.23	24.60
$\text{CdCl}_2$	$l_{25} = 31.66$	30.55	29.46	28.16	27.09	26.06
$\text{CdCl}_2$	$l_{35} = 21.73$	21.23	20.55	20.02	19.23	18.68
$\text{CdBr}_2$	$l_{25} = 31.91$	31.01	30.17	29.27	28.15	27.46
$\text{CdBr}_2$	$l_{35} = 21.88$	21.46	20.81	20.60	19.70	19.17
$\text{CdI}_2$	$l_{25} = 33.27$	33.76	34.16	34.74	34.98	35.77
$\text{CdI}_2$	$l_{35} = 22.75$	23.06	23.36	23.71	23.99	24.30
$\text{CdSO}_4$	$l_{25} = 31.11$	29.71	28.24	26.58	25.14	23.76
$\text{CdSO}_4$	$l_{35} = 21.45$	20.43	19.42	18.31	17.41	16.25
$\text{KCl}$	$l_{25} = 34.42$	36.05	37.76	39.32	40.96	42.27
$\text{KCl}$	$l_{35} = 23.74$	25.15	26.54	27.94	28.93	30.02
$\text{KBr}$	$l_{25} = 35.94$	39.11	42.41	44.96	48.87	52.26
$\text{KBr}$	$l_{35} = 24.83$	27.49	29.64	31.93	34.12	36.14
$\text{KCNS}$	$l_{25} = 37.57$	42.38	47.02	51.81	55.87	61.26
$\text{KCNS}$	$l_{35} = 25.63$	28.79	32.03	35.05	38.13	42.94
$\text{KI}$	$l_{25} = 38.66$	44.76	50.58	56.75	62.63	68.36
$\text{KI}$	$l_{35} = 26.30$	30.25	34.64	38.04	41.87	45.43
$\text{KNO}_3$	$l_{25} = 33.80$	34.79	35.77	36.66	37.57	38.52
$\text{KNO}_3$	$l_{35} = 23.27$	24.03	24.79	25.72	26.54	27.33
$\text{K}_2\text{SO}_4$	$l_{25} = 33.20$	33.61	-	-	-	-
$\text{NaBr}$	$l_{25} = 33.76$	34.54	35.27	36.26	36.84	37.74
$\text{NaCl}$	$l_{25} = 32.46$	32.25	31.96	31.76	31.51	31.36
$\text{NaCNS}$	$l_{25} = 35.44$	38.24	40.78	43.37	45.86	48.34
$\text{Na}_2\text{SO}_4$	$l_{25} = 31.96$	31.14	30.45	29.51	28.66	28.44
$\text{Na}_2\text{SO}_4$	$l_{35} = 21.88$	21.35	20.81	20.21	19.75	19.27

The author also gives a series of determinations in which a mixture of  $\text{SO}_2 + \text{CO}_2$  is used for saturating the solutions, thus changing the concentration of the  $\text{SO}_2$  and yielding results for certain partial pressures of this gas.

Additional data for the solubility of sulfur dioxide in aqueous salt solutions are given by Walden and Centnerszwer (1902-03) but these

authors present their results in terms of the difference between the amount of  $\text{SO}_2$  dissolved in water and in the aqueous solution. The exact manner in which these calculations were made is not clearly explained.

SOLUBILITY OF SULFUR DIOXIDE IN AQUEOUS SALT SOLUTIONS  
AT 25° and 760mm PRESSURE  
(Bancroft and Gould, 1934)

Aq. solvents containing 0.5 gm. mol. of the following salts, per liter	Abs. Coef. of $\text{SO}_2$	Aq. solvents containing 0.5 gm. mol. of the following salts, per liter	Abs. Coef. of $\text{SO}_2$
$\text{H}_2\text{O}$ alone	32.76	$\text{KNO}_3$	30.97
$\text{Na}_2\text{SO}_4$	29.28	$\text{KCl}$	31.53
$\text{NaCl}$	29.74	$\text{KBr}$	32.97
$\text{NaBr}$	30.93	$\text{KCNS}$	34.42
$\text{NaCNS}$	32.47	$\text{KI}$	35.42
$\text{K}_2\text{SO}_4$	30.42		

SOLUBILITY OF SULFUR DIOXIDE IN AQUEOUS SOLUTIONS OF POTASSIUM CHLORIDE  
AT A PARTIAL PRESSURE OF 760 MM  
(Hudson, 1925)

Gms. per 100 gms. $\text{H}_2\text{O}$			Gms. per 100 gms. $\text{H}_2\text{O}$			Gms. per 100 gms. $\text{H}_2\text{O}$		
t°	KCl	$\text{SO}_2$	t°	KCl	$\text{SO}_2$	t°	KCl	$\text{SO}_2$
10	5.55	17.05	29.9	10.11	8.80	48.15	32.72	6.18
10	10.22	18.58	29.9	20.82	10.05	60	5.30	3.45
10	15.85	20.28	29.9	29.86	11.26	60	10.67	3.52
10	20.78	21.96	40.0	5.17	5.96	60	21.12	3.92
10	29.90	25.40	40.0	10.20	6.32	60	30.98	4.24
15	10.39	15.32	40.0	15.44	6.675	70	8.74	2.80
15	19.91	17.64	40.0	20.14	7.07	70	21.68	3.05
15	30.71	20.59	40.0	24.83	7.45	70	30.73	3.26
20	5.14	11.62	40.0	28.95	7.75	80	8.66	2.27
20	10.30	12.52	48.15	5.06	4.70	80	21.35	2.415
20	15.61	13.55	48.15	10.14	4.945	80	29.68	2.52
20	24.98	15.38	48.15	15.82	5.24	90	9.23	1.855
20	30.38	16.65	48.15	21.11	5.48	90	19.49	1.97
29.9	5.19	8.21	48.15	25.09	5.74	90	32.75	2.11

SOLUBILITY OF SULFUR DIOXIDE IN AQUEOUS SOLUTIONS OF  
SODIUM SULFATE AT A PARTIAL PRESSURE OF 760 MM  
(Hudson, 1925)

Results at 20°

Gms. per 100 gms. $\text{H}_2\text{O}$		Gms. per 100 gms. $\text{H}_2\text{O}$	
$\text{Na}_2\text{SO}_4$	$\text{SO}_2$	$\text{Na}_2\text{SO}_4$	$\text{SO}_2$
0.0	10.64	10.00	10.07
1.94	10.66	15.00	9.66
4.93	10.57	20.0	9.17
7.95	10.36		

(Cont.)

SOLUBILITY OF SULFUR DIOXIDE IN AQUEOUS SOLUTIONS OF SODIUM SULFATE AT  
A PARTIAL PRESSURE OF 760 MM--Cont.

Results at 30°		Results at 40°		Results at 60°	
Gms. per 100 gms. H <sub>2</sub> O		Gms. per 100 gms. H <sub>2</sub> O		Gms. per 100 gms. H <sub>2</sub> O	
Na <sub>2</sub> SO <sub>4</sub>	SO <sub>2</sub>	Na <sub>2</sub> SO <sub>4</sub>	SO <sub>2</sub>	Na <sub>2</sub> SO <sub>4</sub>	SO <sub>2</sub>
0.0	7.608	0.0	5.585	0.0	4.214
2.04	7.709	2.49	5.812	2.49	4.508
3.99	7.776	5.04	5.910	5.04	4.678
5.47	7.773	7.95	5.927	-	-
7.83	7.716	10.00	5.882	10.04	4.728
10.0	7.586	14.94	5.802	14.94	4.730
20.0	7.006	20.01	5.630	19.99	4.648

0

The amounts of free and combined SO<sub>2</sub> in solutions saturated with SO<sub>2</sub> and MgSO<sub>4</sub>·6H<sub>2</sub>O at 15° and 25° up to one atmosphere total pressure are given by Conrad and Brice, 1948.

In addition to the above results given by Smith and Parkhurst, 1922. These authors also determined the solubility of sulfur dioxide in aqueous suspensions of calcium and magnesium hydroxides.

The solubility of SO<sub>2</sub> in dilute NH<sub>4</sub>HSO<sub>3</sub> solutions at 15, 20, 25 and 30° was measured by Domansky and Rendos, 1957.

Data for the solubility of sulfur dioxide in calcium bisulfite solutions is given by White, Vivian, and Whitney (1948), Schmied (1955), Conrad and Bueschlein (1937), and Euckell (1925). For an extensive review see Dickens and Plummer (1957).

Euckell (1925) gives data for the solubility in water, sulfuric acid, and sodium sulfate solutions from 40° to 90°. Jager (1957) gives results in aqueous ZnSO<sub>4</sub> solutions from 20 - 100°.

Data for the solubility of sulfur dioxide in disodium hydrogen phosphate solutions is given by Luchinskii and Tavorovakaya, 1940.

DISTRIBUTION OF SULPHUR DIOXIDE AT 20° BETWEEN:  
(McCrae and Wilson, 1903)

Water and Chloroform

Gms. SO <sub>2</sub> per Liter in:		Gm. Equiv. $\frac{1}{2}$ SO <sub>2</sub> per Liter in:		Gms. SO <sub>2</sub> per Liter in:		Gm. Equiv. $\frac{1}{2}$ SO <sub>2</sub> per Liter in:	
Aq. Layer	CHCl <sub>3</sub> Layer	Aq. Layer	CHCl <sub>3</sub> Layer	Aq. Layer	CHCl <sub>3</sub> Layer	Aq. Layer	CHCl <sub>3</sub> Layer
1.738	1.123	0.0543	0.0351	4.226	3.626	0.1319	0.1132
1.753	1.122	0.0547	0.0350	5.269	4.798	0.1645	0.1498
2.346	1.703	0.0732	0.0532	6.584	6.183	0.2057	0.1930
2.628	1.897	0.0821	0.0592	31.92	33.84	0.9968	1.056
3.058	2.385	0.0955	0.0745	33.26	37.25	1.038	1.163
3.735	3.062	0.1166	0.0956				

(Cont.)

# S SULFUR

## DISTRIBUTION OF SULPHUR DIOXIDE AT 20° BETWEEN--Cont.

### Aqueous HCl and Chloroform

Conc. of HCl	Gms. SO <sub>2</sub> per Liter in:		Gm. Equiv. $\frac{1}{2}$ SO <sub>2</sub> per Liter in:	
	Aq. Layer	CHCl <sub>3</sub> Layer	Aq. Layer	CHCl <sub>3</sub> Layer
0.05	1.86	1.46	0.0581	0.0456
0.05	3.07	2.83	0.0960	0.0884
0.05	4.28	4.07	0.1336	0.1271
0.05	5.34	5.42	0.1667	0.1692
0.10	1.25	1.41	0.039	0.044
0.10	2.78	3.08	0.0868	0.0962
0.10	3.86	4.08	0.1199	0.1275
0.10	5.161	5.72	0.1612	0.1784
0.2	1.268	1.51	0.0396	0.0471
0.2	1.914	2.27	0.0597	0.0710
0.2	2.464	3.04	0.0769	0.0949
0.2	3.967	4.90	0.1239	0.1530
0.4	1.202	1.61	0.038	0.0504
0.4	1.894	2.26	0.059	0.0706

## SOLUBILITY OF SULFUR DIOXIDE IN ALCOHOLS (de Bruyn, 1892)

In Methyl Alcohol at 760 mm.

In Ethyl Alcohol at 760 mm.\*

t°	Gms. SO <sub>2</sub> per 100 Gms.		t°	Gms. SO <sub>2</sub> per 100 Gms.	
	Solution	CH <sub>3</sub> OH		Solution	C <sub>2</sub> H <sub>5</sub> OH
0	71.1	246.0	0	53.5	115.0
7	54.9	149.4	7	45.0	81.0
12.3	52.2	109.2	12.3	39.9	66.4
17.8	44.0	78.6	18.2	32.8	48.6
26.0	31.7	46.4	26.0	24.4	32.3

\*Additional data are given by Carius, 1855

## SOLUBILITY OF SULFUR DIOXIDE IN CHLOROFORM (Lindner, 1912)

Results at 0°

Results at 25°

Pressure in mm. Hg	Gms. SO <sub>2</sub> per 100 cc. Sat. Sol.	Pressure in mm. Hg	Gms. SO <sub>2</sub> per 100 cc. Sat. Sol.
2.7	0.0701	5.7	0.0669
5.6	0.1790	12.9	0.1712
22	0.6982	48	0.6728
90.2	3.097	200.2	2.954
219.6	8.217	488.8	7.839

SOLUBILITY OF SULFUR DIOXIDE IN BENZENE  
(Ipatieff and Monroe, 1942)

(Also see results in the three tables following)

t°	Total Pressure atm. (absolute)	Gms. SO <sub>2</sub> per 100 gms. Benzene
26	1.20	24.7
26	1.75	37.6
27	2.40	84.8
25	2.65	125.5

SOLUBILITY OF SULFUR DIOXIDE IN SEVERAL ORGANIC SOLVENTS AT 25°  
AND VARYING PRESSURES  
(Horiuti, 1931)

0

Results for:

CCl <sub>4</sub>		C <sub>6</sub> H <sub>5</sub> Cl		C <sub>6</sub> H <sub>6</sub>		(CH <sub>3</sub> ) <sub>2</sub> CO		CH <sub>3</sub> CO <sub>2</sub> CH <sub>3</sub>	
Pmm	S	Pmm	S	Pmm	S	Pmm	S	Pmm	S
112.4	0.0	11.6	0.0	93.7	0.0	229.2	0.0	213.4	0.0
265.5	1.26	274.9	6.02	294.3	6.18	304.2	14.2	324.4	14.3
357.7	2.08	506.3	11.63	493.7	12.47	381.8	23.7	456.7	25.4
508.6	3.48	669.4	16.66	663.7	17.83	473.4	30.8	602.5	33.6
646.3	4.90	778.3	18.76	808.9	22.52	574.0	36.8	754.4	40.6
814.4	6.73	895.4	22.02	923.2	26.05	740.1	44.5	894.3	45.6
991.8	8.80	1048.5	26.35	1012.2	29.09	99.43	51.9	1038.5	49.7

Pmm = Pressure in millimeters; S = Gm. Mols. SO<sub>2</sub> per 100 gm. mols.  
sat. solution.

SOLUBILITY OF SULFUR DIOXIDE IN SEVERAL ORGANIC SOLVENTS  
(Horiuti, 1931)

t°	Solubility of SO <sub>2</sub> in terms of the Ostwald Solubility Expression, in:				
	CCl <sub>4</sub>	C <sub>6</sub> H <sub>5</sub> Cl	C <sub>6</sub> H <sub>6</sub>	(CH <sub>3</sub> ) <sub>2</sub> CO	CH <sub>3</sub> CO <sub>2</sub> CH <sub>3</sub>
0	-	169.3	-	-	-
10	30.96	97.4	126.4	276.4	254.9
25	18.45	59.14 (20°)	70.01	216.4	182.1
40	12.52	29.92	43.01	171.3	133.8
50	-	22.88	32.63	-	-
60	-	17.83	25.36	-	-
80	-	12.23	-	-	-



## S SULFUR

### SOLUBILITY OF SULFUR DIOXIDE IN SEVERAL SOLVENTS (Lloyd, 1918)

The dry, air free,  $\text{SO}_2$  was passed through the solvent until saturation was reached and 5 cc. (usually) of the saturated solution were mixed with a large volume of water and titrated with standardized iodine solution.

t°	Gms. $\text{SO}_2$ per Liter of Saturated Solution in:				
	Benzene	Nitrobenzene	Toluene	o Nitrotoluene	Acetic Anhydride
- 5	-	-	-	-	196
0	-	-	-	-	148 (d = 1.22)
+ 5	-	-	-	-	136
10	-	-	-	-	122
15	-	311.4	-	290.8	114
20	-	267.4	217.5	236	106
25	-	227.9	170.4	192.2	99
30	127.5	190	124.4	160.7	90
40	82.9	132	93.6	118.5	-
50	60.3	98.7	77.2	87.2	-
60	34	78.6	54.7	68.8	-

### SOLUBILITY OF SULFUR DIOXIDE IN CAMPHOR AND TERPENE SOLUTIONS AT 20° (Weissenberger and Hadwiger, 1927)

Solvent	Ml. $\text{SO}_2$ absorbed per ml. of Solvent
Cyclohexanone	22.80
10 Wt. % Camphor in Cyclohexanone	15.20
20 Wt. % Camphor in Cyclohexanone	14.70
m-Methylcyclohexanol	16.72
10 Wt. % Camphor in m-Methylcyclohexanol	17.30
20 Wt. % Camphor in m-Methylcyclohexanol	11.00
Decahydronaphthalin	7.50
Hydroterpine (Density = 0.883)	14.5
Turpentine	8.3
10 Wt. % Camphor in Tetrahydronaphthalin	6.95

At 0°, 725 mm 0.880 gms.  $\text{SO}_2$  dissolve in 1 gm camphor (Schulze, 1881).

### SOLUBILITY OF SULFUR DIOXIDE IN SOLAR OIL (PETROLEUM) (Avdeeva and Pitelina, 1947)

See note Vol. I, p. 494.

t°	Gms. $\text{SO}_2$ per Liter	Moles $\text{SO}_2$ per Liter	t°	Gms. $\text{SO}_2$ per Liter	Moles $\text{SO}_2$ per Liter
10	40.60	0.635	60	14.68	0.229
14	38.10	.596	110	6.44	.105
30	23.40	.366	115	6.00	.094

The miscibility gap in each of the following ternary liquid systems has been determined by Satterfield, Powell and Oster, Jr., 1955.

SO<sub>2</sub> + n-hexane + benzene at -20° F  
 SO<sub>2</sub> + n-butane + benzene at -20° F  
 SO<sub>2</sub> + n-heptane + benzene at 0°, -20°, -35° F  
 SO<sub>2</sub> + n-decane + benzene at -20° F  
 SO<sub>2</sub> + cyclohexane + benzene at -20° F  
 SO<sub>2</sub> + n-heptane + toluene at -20° F  
 SO<sub>2</sub> + n-decane + sec-butylbenzene at -20° F  
 SO<sub>2</sub> + n-decane + mixed xylenes at -20° F

#### RECIPROCAL SOLUBILITY OF LIQUID SULFUR DIOXIDE AND TOLUENE (Zerner, Weisz and Opaliski, 1922)

0

The accurately weighed mixtures were sealed in tubes of resistance glass and the temperatures determined at which clouding and clearing occurred. The liquid SO<sub>2</sub> contained 0.56% H<sub>2</sub>O and 0.67% oily residue.

t° of clouding	17.0	21.0	21.0	13.5	7.0	About -25.0°
% SO <sub>2</sub> in mixture	21.64	24.21	34.56	54.50	72.07	92.95

The correctness of the above results is questioned by Fontein, 1923, who points out that the observed clouding is due to the water content of the SO<sub>2</sub> used. A repetition of the determinations showed Zerner Weisz and Opulski that both toluene and tetralin are completely miscible with sulfur dioxide.

405 vol. of SO<sub>2</sub> (0°, 1 atm) dissolve in 1 vol. of dimethylformamide at 25° C. (Dupont, 1955.)

0.323 gms SO<sub>2</sub> dissolve in 1 gm SO<sub>2</sub>Cl<sub>2</sub> at 0°, 725 mm. (Schulze, 1881.)

0.821 gms SO<sub>2</sub> dissolve in 1 gm formic acid at 0°, 725 mm. (Schulze, 1881.)

#### SOLUBILITY OF SO<sub>2</sub> IN DIMETHYL SULFOXIDE (CH<sub>3</sub>)<sub>2</sub>SO (Smedslund, 1950)

t°	Wt. % SO <sub>2</sub> in sat. sol. in (CH <sub>3</sub> ) <sub>2</sub> SO	t°	Wt. % SO <sub>2</sub> in sat. sol. in (CH <sub>3</sub> ) <sub>2</sub> SO contg. 10% H <sub>2</sub> O
18	60.13	19	54.3
20	59.12(50- vol/vol D.M.S.)	77	22.1
100	17.9	135	6.0
161	3.2	147	2.5

A 1:1 mixture of butadiene and isoprene sulfones dissolves 37% of its weight of SO<sub>2</sub> at 28° and 95% at 10°. (Grummitt and Ardis, 1946.)

SOLUBILITY OF SULFUR DIOXIDE IN RUBBER  
(Venable and Fuwa, 1922)

100 cc. of rubber saturated with sulfur dioxide at 21° dissolve 1950 cc. SO<sub>2</sub> (0° and 760 mm.). The determination was made by pumping out the gas with a Topler pump and measuring it over mercury. In the same way 100 cc. of H<sub>2</sub>O at 21° was found to dissolve 3,661.7 cc. SO<sub>2</sub> (0° and 760 mm.). The authors also give results for the effect of pressure and temperature upon the solubility of sulfur dioxide in rubber.

Vapor pressure measurements between -20° and +30° are given by Foote and Fleischer, 1934, for the systems composed of SO<sub>2</sub> and each of the following compounds:

0

* Aniline	Di phenyl amine	Di phenyl ether
* Methyl aniline	* Toluidine	α Naphthol
* Ethyl aniline	Naphthalene	β Naphthol
Di ethyl aniline	Di phenyl	Ethylene glycole

Solid addition compounds were formed with those marked with an asterisk.

Data for the reciprocal solubility of SO<sub>2</sub> (also of air, CO<sub>2</sub>, NH<sub>3</sub>, and HCl) and the vapors of ether, methyl alcohol, acetone and chloroform, as determined by measuring at 25° the change in pressure produced by adding a weighed amount of the volatile liquid to a given volume of SO<sub>2</sub> are given by MacFarlane and Wright, 1934.

Freezing-point data are given for:

SO <sub>2</sub> + SiCl <sub>4</sub>	(Bond and Stephens, 1929)
SO <sub>2</sub> + SnBr <sub>4</sub>	(Bond and Beach, 1926)
SO <sub>2</sub> + SnCl <sub>4</sub>	(Bond and Beach, 1926)
SO <sub>2</sub> + SnI <sub>4</sub>	(Beach and Bond, 1925)
SO <sub>2</sub> + TiBr <sub>4</sub>	(Bond and Crone, 1934)
SO <sub>2</sub> + GeCl <sub>4</sub>	(Bond and Crone, 1934)
SO <sub>2</sub> + CCl <sub>4</sub>	(Bond and Beach, 1926; Beach and Bond, 1925)
SO <sub>2</sub> + Methyl Alcohol	(Baume and Pamfil, 1914)
SO <sub>2</sub> + Methyl alcohol + Propionic Acid	(Baume et al., 1914)
SO <sub>2</sub> + Methyl Ester	(Baume et al., 1914; Baume, 1914)
SO <sub>2</sub> + Benzene	(Seyer and Peck, 1930; DeCarli, 1926, 1926a)
SO <sub>2</sub> + Cyclohexane	(Seyer and Dunbar, 1922; Seyer and King, 1933)
SO <sub>2</sub> + Cyclohexene	(Seyer and King, 1933)
SO <sub>2</sub> + Cyclohexadiene	(Seyer and King, 1933)
SO <sub>2</sub> + n Hexane	(Seyer and Todd, 1931)
SO <sub>2</sub> + n Butane	(Seyer and Todd, 1931)
SO <sub>2</sub> + Pyridine	(Hoffman and Van der Werf, 1946)
SO <sub>2</sub> + α-Picoline	(Hoffman and Van der Werf, 1946)
SO <sub>2</sub> + β-Picoline	(Hoffman and Van der Werf, 1946)
SO <sub>2</sub> + γ-Picoline	(Hoffman and Van der Werf, 1946)
SO <sub>2</sub> + Acetic Acid	(Scheub and McCrosky, 1944)
SO <sub>2</sub> + Ethylene Oxide	(Albertson and Fernelius, 1943)
SO <sub>2</sub> + Dioxane	(Albertson and Fernelius, 1943)
SO <sub>2</sub> + Anisole	(Albertson and Fernelius, 1943)
SO <sub>2</sub> + Acetone	(Albertson and Fernelius, 1943)
SO <sub>2</sub> + Diethylsulfide	(Albertson and Fernelius, 1943)
SO <sub>2</sub> + Methylaniline	(Albertson and Fernelius, 1943)

(Cont.)

## Freezing-point data, continued:

SO <sub>2</sub> + Cetene	(Seyer and Ball, 1926)
SO <sub>2</sub> + Cetyl alcohol	(Seyer and Ball, 1926)
SO <sub>2</sub> + n Decane	(Seyer and Todd, 1931)
SO <sub>2</sub> + Octane	(Seyer and Todd, 1931; Seyer and Gallanger, 1926)
SO <sub>2</sub> + n Dodecane	(Seyer and Todd, 1931)
SO <sub>2</sub> + n Tetra decane	(Seyer and Todd, 1931)
SO <sub>2</sub> + n Dotria contane	(Seyer and Todd, 1931)
SO <sub>2</sub> + Caprylene	(Seyer and Hodnett, 1936)
SO <sub>2</sub> + Decalin (cis and trans Deca hydronaphthalene)	(Seyer and Cornett, 1937)
SO <sub>2</sub> + Styrene	(Marvel and Glavis, 1938)
SO <sub>2</sub> + 10-Hendecenoic Acid	(Marvel and Glavis, 1938)
SO <sub>2</sub> + 1-Pentane	(Marvel and Glavis, 1938)
SO <sub>2</sub> + Vinyle chloride	(Marvel and Glavis, 1938)
SO <sub>2</sub> + Camphor	(Bellucci and Grassi, 1913)
SO <sub>2</sub> + Toluene	(DeCarli, 1926, 1926a)
SO <sub>2</sub> + Tetraline	(DeCarli, 1926, 1926a)
SO <sub>2</sub> + Phenol	(Nikitin and Kovalskaya, 1952)
SO <sub>2</sub> + Formamide	(Terres and Doerges, 1956)
SO <sub>2</sub> + Dimethyl Formamide	(Terres and Doerges, 1956)
SO <sub>2</sub> + Ethyl Acetate	(Terres and Doerges, 1956)
SO <sub>2</sub> + n-Propyl Acetate	(Terres and Doerges, 1956)
SO <sub>2</sub> + 2, 3 Lutidine	(Hoffman and Van der Werf, 1948)
SO <sub>2</sub> + 2, 4 Lutidine	(Hoffman and Van der Werf, 1948)
SO <sub>2</sub> + 2, 6 Lutidine	(Hoffman and Van der Werf, 1948)
SO <sub>2</sub> + n-Hexane	(Seyer and Gill, 1924)
SO <sub>2</sub> + Cetane	(Seyer and Hugget, 1924)
SO <sub>2</sub> + many aromatic compounds	(Terres and Doerges, 1956)

Data for the solubility of sulfur dioxide in liquid magnesium are given by Schneider and Each, 1940.

SULFUR TRIOXIDE SO<sub>3</sub>

(Also see H<sub>2</sub>SO<sub>4</sub>.)

Data for equilibrium in the system SO<sub>3</sub> + H<sub>2</sub>O + H<sub>2</sub>SO<sub>4</sub>, determined by the freezing-point method, are given by Moles and Carlota, 1936.

Data for the solubility of SO<sub>3</sub> in H<sub>2</sub>SO<sub>4</sub> - HNO<sub>3</sub> mixtures are given by Gel'fman, 1950 and Revallier, 1955.

Freezing points in the system SO<sub>3</sub> - D<sub>2</sub>O and in solutions containing NaDSO<sub>4</sub>, KDSO<sub>4</sub>, etc., are given by Flowers, Gillespie, Oubridge and Solomons, 1958.

## Sb STIBIUM

## Sb ANTIMONY

Fusion-point data are given for:

Sb + I	(Jaeger and Dornbosch, 1912)
Sb + I + As	(Quercigh, 1912)
Sb + S	(Jaeger and Dornbosch, 1912)
Sb + Zn + Pb	(Tammann and Schaftmeister, 1924)
Sb + Zn + Bi	(Tammann and Schaftmeister, 1924)
Sb + Al + Pb	(Tammann and Schaftmeister, 1924)

## Br ANTIMONY TRIBROMIDE $SbBr_3$

SOLUBILITY IN BENZENE DETERMINED BY "SYNTHETIC METHOD"  
(Menschutkin, 1910)

Gms. $SbBr_3$ per 100 Gms.			Gms. $SbBr_3$ per 100 Gms.		
t°	Sat.	Sol.	Solid Phase	t°	Solid Phase
5.6 <sup>m</sup>	0		$C_6H_6$	90	$2SbBr_3 \cdot C_6H_6$
4.5 <sup>e</sup>	8.3		$C_6H_6 + 2SbBr_3 \cdot C_6H_6$	92.5 <sup>m</sup>	"
15	12.5		$2SbBr_3 \cdot C_6H_6$	91.5	"
35	23		"	90	"
55	39		"	85 <sup>e</sup>	$2SbBr_3 \cdot C_6H_6 + SbBr_3$
75	60.5		"	90	$SbBr_3$
85	74.3		"	94	"

RECIPROCAL SOLUBILITIES OF ANTIMONY TRIBROMIDE AND VARIOUS ORGANIC  
COMPOUNDS, DETERMINED BY THE "SYNTHETIC METHOD"  
(Menschutkin, 1910)

$SbBr_3$ + Brombenzene			$SbBr_3$ + Chlorbenzene			$SbBr_3$ + Iodobenzene			$SbBr_3$ + Fluorbenzene		
Gms. $SbBr_3$ per 100 Gms.			Gms. $SbBr_3$ per 100 Gms.			Gms. $SbBr_3$ per 100 Gms.			Gms. $SbBr_3$ per 100 Gms.		
t°	Sat.	Sol.	t°	Sat.	Sol.	t°	Sat.	Sol.	t°	Sat.	Sol.
-31 <sup>m</sup>	0		-45.2 <sup>m</sup>	0		-28.6 <sup>m</sup>	0		-39.2 <sup>m</sup>	0	
-32	5.7		-47 <sup>e</sup>	5.2		-30.3	7.0		-39.5 <sup>e</sup>	1.3	
-25 <sup>e</sup>	9.5		-40	6.8		-32 <sup>e</sup>	14.3		-25	4.3	
-15	15		-30	9.6		-20	21.6		-15	6.7	
- 5	20.8		-20	12.6		-10	27.5		+ 5	12.6	
+ 5	26.8		-10	16		0	33.4		25	21.8	
15	33		0	20		+10	39.3		45	35.3	
25	39.6		20	30		20	45.2		55	45.5	
45	54.6		40	45.4		40	57.6		65	60.8	
65	71.9		60	65.8		60	71.1		75	81.8	
85	90.7		80	86.3		80	86.3		85	93.5	
94	100		94	100		94	100		94	100	

m = melting point e = eutectic

## RECIPROCAL SOLUBILITIES OF ANTIMONY TRIBROMIDE AND VARIOUS ORGANIC COMPOUNDS, DETERMINED BY THE "SYNTHETIC METHOD"--Cont.

SbBr <sub>3</sub> + p Dibrombenzene			SbBr <sub>3</sub> + p Dichlorbenzene			SbBr <sub>3</sub> + Nitrobenzene			SbBr <sub>3</sub> + m Dinitrobenzene		
Gms. SbBr <sub>3</sub> per 100 Gms.			Gms. SbBr <sub>3</sub> per 100 Gms.			Gms. SbBr <sub>3</sub> per 100 Gms.			Gms. SbBr <sub>3</sub> per 100 Gms.		
t°	Sat.	Sol.	t°	Sat.	Sol.	t°	Sat.	Sol.	t°	Sat.	Sol.
88m	0		54.5m	0		6m	0		90m	0	
85	10		51.5	14		1	22		80	29.1	
80	25.2		48.5e	26.5	- 4		37.4		70	50	
75	39.2		55	35.9	- 9		48.4		60	63	
70	52		60	43.1	-14.5e		55.3		50	70.8	
65e	62.2		65	50.7	- 5		58.3		47.5e	72	
70	68.7		70	58.8	+ 5		61.5		50	73.4	
75	75.3		75	67.2	25		68.6		60	78.2	
80	81.8		80	75.8	45		76.6		70	84	
85	88.3		85	84.5	65		85.3		80	90.4	
90	94.3		90	93.4	85		94.7		90	96.8	
94	100		94	100	94		100		94	100	

Br

Molecular compounds are not formed in the above systems. The diagram in each case consists of two arms meeting at the eutectic.

SbBr <sub>3</sub> + Ethylbenzene				SbBr <sub>3</sub> + Propylbenzene				SbBr <sub>3</sub> + p Cymene			
Gms. SbBr <sub>3</sub> per 100 Gms.				Gms. SbBr <sub>3</sub> per 100 Gms.				Gms. SbBr <sub>3</sub> per 100 Gms.			
t°	Sat.	Sol.	Solid Phase	t°	Sat.	Sol.	Solid Phase	t°	Sat.	Sol.	Solid Phase
-93m	0		C <sub>6</sub> H <sub>5</sub> ·C <sub>2</sub> H <sub>5</sub>	-80	1.3	1.1		-75m	0		
-93.2e	0.4		" + 1.1	-60	3.7	"		-77e	2		
-70	1		1.1	-40	9.4	"		-50	6.1		1.1
-50	2.2		"	-20	22.5	"		-30	12.3		"
-30	4.8		"	-10	38.4	"		-10	27		"
-10	12		"	- 5t	49	1.1+SbBr <sub>3</sub>		0	42.3		"
+10	29.2		"	+10	53.3	SbBr <sub>3</sub>		+ 5t	51.5	1.1+SbBr <sub>3</sub>	
20	46.3		"	20	57.1	"		20	56	SbBr <sub>3</sub>	
29t	69.7		1.1+SbBr <sub>3</sub>	40	66.2	"		40	64.1	"	
50	78.2		SbBr <sub>3</sub>	60	77.2	"		60	75	"	
70	87.3		"	80	89.8	"		80	88.5	"	
90	97.7		"	94	100	"		94	100	"	

m = melting point

e = eutectic

t = transition point

1.1 = compound of equimolecular amounts of the two constituents in each case.

# Sb STIBIUM

## RECIPROCAL SOLUBILITIES OF ANTIMONY TRIBROMIDE AND VARIOUS ORGANIC COMPOUNDS, DETERMINED BY THE "SYNTHETIC METHOD" (Menschutkin, 1911)

	SbBr <sub>3</sub> + Acetic Acid		SbBr <sub>3</sub> + Benzoic Acid		SbBr <sub>3</sub> + Benzoyl Chloride		SbBr <sub>3</sub> + Benzene Sulphonic Acid	
	Gms. SbBr <sub>3</sub> per 100 Gms.		Gms. SbBr <sub>3</sub> per 100 Gms.		Gms. SbBr <sub>3</sub> per 100 Gms.		Gms. SbBr <sub>3</sub> per 100 Gms.	
	t°	Sat. Sol.	t°	Sat. Sol.	t°	Sat. Sol.	t°	Sat. Sol.
Br	16.5m	0	120m	0	- 0.5m	0	52.5m	0
	15	12.2	115	20.1	- 3	19.5	50	15.8
	10	41.8	110	36.8	- 6e	32	47.5	26.2
	4e	58.2	105	50	+10	41.2	44e	36.9
	20	64.3	100	61.5	20	47.5	50	39.1
	40	72.5	95	71	30	54	60	45.7
	60	81.9	85	83.1	40	60.8	70	55.2
	70	97.1	79e	87.6	50	67.8	80	68.1
	80	92.4	85	92	60	74.9	85	77.6
	90	97.8	90	96.4	80	89.4	90	90.3
	94	100	94	100	94	100	94	100

m = melting point e = eutectic

Molecular compounds are not formed in the above systems. The diagram in each case consists of two arms meeting at the eutectic.

SbBr <sub>3</sub> + Acetophenone			SbBr <sub>3</sub> + Amylbenzene			SbBr <sub>3</sub> + Anisole		
t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
19.5m	0	C <sub>6</sub> H <sub>5</sub> COCH <sub>3</sub>	-70	4.5	SbBr <sub>3</sub> ·C <sub>6</sub> H <sub>5</sub> ·C <sub>9</sub> H <sub>11</sub>	-34m	0	C <sub>6</sub> H <sub>5</sub> OCH <sub>3</sub>
15	22.7	"	-50	8.3	"	-35	2.5	" + 1:1
1.5m	48.6	" + 1:1	-30	16.6	"	-20	11.7	1:1
20	56.8	1:1	-25	21	"	0	26.5	"
30	63.3	"	-17	32.5	" + SbBr <sub>3</sub>	10	37.1	"
37.5m	75	"	-10	33.5	SbBr <sub>3</sub>	20	50.5	"
31e	83.2	1:1 + SbBr <sub>3</sub>	0	35.6	"	25	59	"
40	84.6	SbBr <sub>3</sub>	20	41.6	"	30.5m	77	"
60	88.4	"	40	51.3	"	30e	77.9	" + SbBr <sub>3</sub>
80	94.1	"	60	65	"	40	80.6	SbBr <sub>3</sub>
94	100	"	80	84	"	60	86.4	"
						80	93.6	"

m = melting point e = eutectic t = transition point

SbBr <sub>3</sub> + Benzaldehyde			SbBr <sub>3</sub> + Benzonitrile			SbBr <sub>3</sub> + Benzophenone		
t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
-20	38.4	1:1	-13.2m	0.0	C <sub>6</sub> H <sub>5</sub> CN	48m	0	C <sub>6</sub> H <sub>5</sub> CO·C <sub>6</sub> H <sub>5</sub>
0	45.5	"	-16	19.2	"	40	24	"
20	54.3	"	-18e	28.7	" + 1:1	29e	41.2	" + 1:1
35	64.1	"	0	43	1:1	40	50	1:1
40	70.3	"	20	59	"	45	56.3	"
41.5m	77.2	"	30	67	"	48.5e	66.4	"
37.8e	84.4	1:1 + SbBr <sub>3</sub>	38m	77.8	"	45	76	"
55	88	SbBr <sub>3</sub>	39e	82.5	1:1 + SbBr <sub>3</sub>	40	80	1:1 + SbBr <sub>3</sub>
75	93.1	"	55	87.5	SbBr <sub>3</sub>	50	82.6	SbBr <sub>3</sub>
85	96.1	"	75	93.3	"	70	88.7	"
90	98.2	"	85	96.5	"	80	92.4	"
94	100	"	90	98.3	"	90	97.3	"
			94	100	"	94	100	"

m = melting point e = eutectic

1:1 = compound of equimolecular amounts of the two constituents in each case.

RECIPROCAL SOLUBILITIES OF ANTIMONY TRIBROMIDE AND VARIOUS ORGANIC COMPOUNDS, DETERMINED BY THE "SYNTHETIC METHOD"  
(Menschutkin, 1911)

SbBr<sub>3</sub> + Cyclohexane

t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
6.4m	0	C <sub>6</sub> H <sub>12</sub>
6e	0.3	C <sub>6</sub> H <sub>12</sub> + SbBr <sub>3</sub>
20	1.4	SbBr <sub>3</sub>
40	3.7	"
60	7.1	"
80	12.5	"
	liquid layers formed	
92.5	17.4	97.6
110	25.8	96.5
130	36.4	95
150	47.8	92.7
170	62.3	86.3
175t	74.0	

SbBr<sub>3</sub> + Pseudo Cymene

t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
-37.2m	0	C <sub>8</sub> H <sub>8</sub> (CH <sub>3</sub> ) <sub>1,2,4</sub>
-58.8e	9.7	" + 1.1
-50	11	1.1
-30	16.2	"
-10	31	"
0	47.6	"
7e	63.5	1.1 + 2.1
15	67.4	2.1
25	73	"
33e	79.1	2.1 + SbBr <sub>3</sub>
50	82.8	SbBr <sub>3</sub>
70	88.4	"
90	97.4	"

SbBr<sub>3</sub> + Mesitylene

t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
-54.4m	0	C <sub>6</sub> H <sub>3</sub> CH <sub>3</sub> ) <sub>1,3,5</sub>
-55.2e	2.1	" + 1.1
-30	3.6	1.1
-10	9	"
+10	25.4	"
20	35.5	"
29t	46.5	1.1 + 2.1
40	54.2	2.1
50	61.7	"
60	70.2	"
69.5m	85.8	"
69e	87.7	2.1 + SbBr <sub>3</sub>
80	92.7	SbBr <sub>3</sub>

Br

SbBr<sub>3</sub> + Diphenylacethane

t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
26m	0	CH <sub>3</sub> (C <sub>6</sub> H <sub>5</sub> ) <sub>2</sub>
22.5e	12.8	" + 2.1
40	22.8	2.1
50	29.5	"
60	37.5	"
70	47.8	"
80	60.2	"
90m	81.1	"
85	89.6	"
82e	92.2	2.1 + SbBr <sub>3</sub>
90	96.2	SbBr <sub>3</sub>
94	100	"

SbBr<sub>3</sub> + Naphthalene

t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
79.4m	0	C <sub>10</sub> H <sub>8</sub>
75	23.7	"
70	37.4	"
65	48.6	"
57	61.2	" + 2.1
60	68	2.1
65	81.3	"
66m	84.9	"
65e	86.7	2.1 + SbBr <sub>3</sub>
75	90.1	SbBr <sub>3</sub>
85	94.9	"
90	97.7	"

SbBr<sub>3</sub> + α Nitronaphthalene

t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
57m	0.0	αC <sub>10</sub> H <sub>7</sub> HO <sub>2</sub>
50	23.2	"
40	42.6	"
35	50.5	" + 1.1
37.5	62.6	1.1**
38.2m	67.6	"
38e	68	1.1 + SbBr <sub>3</sub>
50	73.4	SbBr <sub>3</sub>
70	83.8	"
90	96.4	"

SbBr<sub>3</sub> + Diphenyl

t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
70.5m	0	C <sub>6</sub> H <sub>5</sub> C <sub>6</sub> H <sub>5</sub>
60	35.7	"
50	54.3	"
47e	57.4	" + 2.1
55	68.5	2.1
60.5m	82.7	"
70	86.5	SbBr <sub>3</sub>
80	91.5	"
90	97.3	"
94	100	"

SbBr<sub>3</sub> + Phenol

t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
41m	0	C <sub>6</sub> H <sub>5</sub> OH
35	22.5	"
30	40	"
28.5e	44.6	" + 2.1
40	53	2.1
50	62.5	"
60	75.8	"
65	84.7	"
66.5m	88.5	"
75	91.7	SbBr <sub>3</sub>
85	95.8	"
90	98.1	"

SbBr<sub>3</sub> + Phenetol

t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
-28.6m	0	C <sub>6</sub> H <sub>5</sub> OC <sub>2</sub> H <sub>5</sub>
-29e	1.6	" + 1.1
-10	4.8	1.1
+10	12.9	"
20	19.2	"
30	29.7	"
40	46.2	"
48.8m	74.7	"
47e	77.8	1.1 + SbBr <sub>3</sub>
60	83	SbBr <sub>3</sub>
70	87.3	"
90	97.4	"

m = melting point    e = eutectic    t = critical temperature    \* = transition point

\*\*Not obtained regularly, in such cases, single eutectic at 23° and 61.5 per cent SbBr<sub>3</sub>.

1.1 = compound of equimolecular amounts of the two constituents in each case.

2.1 = compound of 2 molecules of SbBr<sub>3</sub> with one molecule of the other constituent.



# Sb STIBIUM

## RECIPROCAL SOLUBILITIES OF ANTIMONY TRIBROMIDE IN VARIOUS ORGANIC COMPOUNDS, DETERMINED BY THE "SYNTHETIC METHOD" (Menschutkin, 1910-11)

SbBr <sub>3</sub> + α Bromonaphthalene		SbBr <sub>3</sub> + α Chloronaphthalene		SbBr <sub>3</sub> + β Chloronaphthalene		SbBr <sub>3</sub> + Tetrahydrobenzene	
t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.
3m	0	-17m	0	56m	0	--	--
0	15.8	-21	17.4	50	26.1	-5	11.7
-3.5e	31.4	-24.5e	22.6	45	38.5	15	15.1
15	38.7	-10	27.3	40	49	35	24.1
35	49.9	+10	35.5	37.5e	53.6	55	41
45	56.9	30	46.7	45	58.8	65	55.1
55	64.7	50	61.6	55	56.8	70	64.5
65	72.9	60	69.9	65	75.2	75	76.2
75	81.8	70	78.6	75	83.8	80	84.4
80	86.3	80	87.5	80	88.1	85	90.7
85	90.8	90	96.6	85	92.4	90	95.8
90	95.4	94	100	90	96.7	94	100

B

SbBr <sub>3</sub> + α Chlorotoluene		SbBr <sub>3</sub> + m Chlorotoluene		SbBr <sub>3</sub> + p Chlorotoluene		SbBr <sub>3</sub> + n Nitrotoluene	
t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.
-36.2m	0	-47.8m	0	6.2m	0	16m	0
-38.5e	10.7	-50e	8.1	2.5e	23.3	10	24.2
-20	15.4	-30	11.7	20	33	5	39
0	22.5	-10	17.5	30	39.3	0	46.6
+20	32.5	+10	25.8	40	47.2	-9e	56.8
30	38.8	30	37.5	50	56.3	+10	62.7
40	46.8	40	45.1	60	66.7	30	69.7
50	56	50	54.4	70	77.8	50	77.5
60	66.5	60	65	80	88.2	60	81.5
70	77.8	70	77	90	97	70	86.3
80	88.2	80	88.2	94	100	80	91.4
90	97	90	97			90	97.2

Molecular compounds are not formed in the above systems. The diagram in each case consists of two arms meeting at the eutectic.

SbBr <sub>3</sub> + Toluene			SbBr <sub>3</sub> + o Nitrotoluene			SbBr <sub>3</sub> + p Nitrotoluene		
t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
-93m	0	C <sub>6</sub> H <sub>5</sub> ·CH <sub>3</sub>	-8.5m	0	NO <sub>2</sub> ·C <sub>6</sub> H <sub>4</sub> ·CH <sub>3</sub>	52.5m	0	p NO <sub>2</sub> ·C <sub>6</sub> H <sub>4</sub> ·CH <sub>3</sub>
-93.5e	1.0	"1-1	-13.5	19.5	"1-1	45	29.8	"
-80	2.4	1-1	30	27.6	1-1	40	42.2	"
-60	6.2	"	10	35.6	"	35	50	"
-40	12.4	"	20	47.5	"	25	61	"
-20	25.7	"	25	55.7	"	16e	67	"SbBr <sub>3</sub>
-1t	53.1	1-1+2-1	31t	70	"SbBr <sub>3</sub>	30	71.6	SbBr <sub>3</sub>
+20	69.4	2-1	40	73.5	SbBr <sub>3</sub>	50	78.9	"
30t	78	2-1+SbBr <sub>3</sub>	50	77.5	"	60	82.9	"
40	80.6	SbBr <sub>3</sub>	60	81.7	"	70	87.2	"
60	86.6	"	80	91.4	"	80	92	"
80	93.8	"	90	97.2	"	90	97.5	"
94	100	"						

SbBr <sub>3</sub> + Triphenylmethane		SbBr <sub>3</sub> + o Xylene		SbBr <sub>3</sub> + m Xylene		SbBr <sub>3</sub> + p Xylene	
t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.	t°	Gms. SbBr <sub>3</sub> per 100 Gms. Sat. Sol.
92m	0	-29m	0	-57m	0	14m	0
85	18	-33e	10.5	-59.2e	5.5	12	16.6
80	30.1	-20	17	-45	10	10e	28
70	47	-10	24.6	-35	14.2	20	36
60	58.2	0	34.5	-25	20	3-	44.6
48e	67.1	20	65.8	-5	38.8	40	53.8
60	73.3	24m	77.2	+5	56.6	50	63.5
70	79.5	22.5e	78.6	12.5t	75.4	60	71
80	86.4	30	80	25	77.6	67.5m	87.3
90	95.2	50	84.7	45	82.3	66.5e	88.3
94	100	70	90.1	65	87.9	75	91.4
		90	97.7	87	95.3	85	95.7

In the case of each of the above xylenes the compound existing between the first and second eutectic consists of equimolecular amounts of SbBr<sub>3</sub> and xylene.

1-1 = compound of equimolecular amounts of the two constituents in each case.

2-1 = compound of 2 molecules of SbBr<sub>3</sub> with 1 molecule of the other constituent.

m = melting point

e = eutectic

t = transition point

THE SYSTEM  $\text{SbBr}_3 - \text{Br}_2$   
(Pusin and Makur, 1938)

Read from the graph drawn by the authors.

t°	Mole % $\text{SbBr}_3$	Solid Phase	t°	Mole % $\text{SbBr}_3$	Solid Phase
-15.5	10	$\text{SbBr}_3 + \text{Br}_2$	50	32	$\text{SbBr}_3$
0	12	$\text{SbBr}_3$	60	41	"
10	14	"	70	52	"
20	17	"	80	77	"
30	21	"	90	85	"
40	26	"			

Freezing-point data are given for:

Br

$\text{SbBr}_3 + \text{SbCl}_3$	(Bernadis, 1912)
$\text{SbBr}_3 + \text{SnBr}_4$	(Pusin and Makur, 1938)
$\text{SbBr}_3 + \text{Br}$	(Pusin and Makur, 1938)
$\text{SbBr}_3 + \text{AsBr}_3$	(Pusin and Lowy, 1926)
$\text{SbBr}_3 + \text{Azobenzene}$	(Vanstone, 1914)
$\text{SbBr}_3 + \text{Bibenzyl}$	(Vanstone, 1914)
$\text{SbBr}_3 + \text{Stilbene}$	(Vanstone, 1914)
$\text{SbBr}_3 + m\text{-Nitrophenol}$	(Pushin, 1948a)
$\text{SbBr}_3 + \text{trinitrotoluene}$	(Pushin, Nikolic, et al., 1947)
$\text{SbBr}_3 + \text{TiBr}_4$	(Eingorn, 1950)
$\text{SbBr}_3 + \text{Bromoacetic acid}$	(Sumarokova and Khakhlova, 1956)
$\text{SbBr}_3 + \text{Benzanilide}$	(Vanstone, 1925)
$\text{SbBr}_3 + \text{Erythrite}$	(Rusin and Dezelic)
$\text{SbBr}_3 + \text{Aniline}$	(Kurakov, 1932)
$\text{SbBr}_3 + \text{Zenzophenone}$	(Kurakov, Krotkov and Oksman, 1915)
$\text{SbBr}_3 + \text{Toluene}$	(Kurakov, Krotkov and Oksman, 1915)
$\text{SbBr}_3 + \text{Triphenylmethane}$	(Kurakov, Krotkov and Oksman, 1915)

## ANTIMONY OLEATE

CH

## PALMITATE

## STEARATE

SOLUBILITY IN TRANSFORMER OIL  
(Nikitina and Maksimova, 1949)

Gms. soap per 100 gms. oil at

	12°	30°	70°
Antimony Oleate	0.96	6.2	-
Antimony Palmitate	0.32	0.52	0.86
Antimony Stearate	0.10	0.32	-

ANTIMONY NITROSO  $\beta$  PHENYL HYDROXYLAMINE (Cupferronate)  $\text{Sb}[\text{C}_6\text{H}_5 \cdot \text{N}(\text{NO}) \cdot \text{O}]_3$ 

One liter sat. solution of the salt in water contains 0.000045 gm. atom (=0.0055 gm.)  $\text{Sb C}_6\text{H}_5 \cdot \text{N}(\text{NO}) \cdot \text{O}$ , at 18°. (Pinkus and Martin, 1927.)

# Sb STIBIUM

## ANTIMONY TRIPHENYL $\text{Sb}(\text{C}_6\text{H}_5)_3$

Freezing-point data are given for mixtures of antimony triphenyl and mercury diphenyl and for antimony triphenyl and tin tetraphenyl. (Cambì, 1912.)

## Cl ANTIMONY TRICHLORIDE $\text{SbCl}_3$

### SOLUBILITY IN WATER (Meerberg, 1903a)

#### Solid Phase $\text{SbCl}_3$

t°	Mols. $\text{SbCl}_3$ per 100 Mols. $\text{H}_2\text{O}$	Gms. $\text{SbCl}_3$ per 100 g. $\text{H}_2\text{O}$	t°	Mols. $\text{SbCl}_3$ per 100 Mols. $\text{H}_2\text{O}$	Gms. $\text{SbCl}_3$ per 100 g. $\text{H}_2\text{O}$
0	47.9	601.6	35	91.6	1152.0
15	64.9	815.8	40	108.8	1368.0
20	{ 72.4	910.1	50	152.5	1917.0
	{ 74.1	931.5	60	360.4	4531.0
25	78.6	988.1	72	$\infty$	$\infty$
30	84.9	1068.0			

### SOLUBILITY OF ANTIMONY TRICHLORIDE IN AQUEOUS HYDROCHLORIC ACID AT 20° (Meerberg, 1903a)

Mols. per 100 Mols. $\text{H}_2\text{O}$		Gms. per 100 g. $\text{H}_2\text{O}$		Mols. per 100 Mols. $\text{H}_2\text{O}$		Gms. per 100 g. $\text{H}_2\text{O}$	
HCl	$\text{SbCl}_3$	HCl	$\text{SbCl}_3$	HCl	$\text{SbCl}_3$	HCl	$\text{SbCl}_3$
0	72.4	0.0	910.1	9.1	68.9	18.41	866.4
2.4	71.2	4.86	895.4	11.7	68.1	23.68	856.3
6.1	69.9	12.34	879.0	28.7	62.8	58.08	789.8
8.3	68.2	16.80	857.6				

100 gms. sat. sol. of  $\text{SbCl}_3$  in  $\text{H}_2\text{O}$  contain 90.90 gms.  $\text{SbCl}_3$  at 25°.  
100 gms. sat. sol. of  $\text{SbCl}_3$  in 10.55% HCl contain 90.07 gms.  $\text{SbCl}_3$  at 25°. (Miyake, 1924, 1925.)

Data for the system  $\text{SbCl}_3 + \text{KCl} + \text{H}_2\text{O}$  are given. The double salts  $2\text{KClSbCl}_3$  and  $7\text{KCl}_3\text{SbCl}_3$  were found but no mixed crystals as mentioned by Jordis, 1903.

Data for the extraction of  $\text{SbCl}_3$  from aqueous HCl solutions containing  $\text{NH}_4\text{SCN}$  are given by Bock, 1951.

DISTRIBUTION OF  $\text{SbCl}_3$  BETWEEN AQUEOUS  $\text{HCl}$  AND ETHER  
(Mylius, 1911)

1 gm. Sb as  $\text{SbCl}_3$ , dissolved in 100 cc. aqueous  $\text{HCl}$ , was shaken with 100 cc ethyl ether at room temperature.

% of Conc. of $\text{HCl}$	% of Total Sb in Ether Layer
20	6
15	13
10	22
5	8
1	0.3

RECIPROCAL SOLUBILITIES OF ANTIMONY TRICHLORIDE AND VARIOUS ORGANIC COMPOUNDS, DETERMINED BY THE "SYNTHETIC METHOD"  
(Menschutkin, 1911)

Cl

 $\text{SbCl}_3$  + Acetic Acid

t*	Gms. $\text{SbCl}_3$ per 100 Gms. Sat. Sol.	Solid Phase
16.5m	0	$\text{CH}_3\text{COOH}$
10	22.7	"
0	42.5	"
-5	48.5	"
-9	52.7	" + 1.1
0	59	1.1
10	67.3	"
19m	79.1	"
25	81.5	$\text{SbCl}_3$
45	87.4	"
65	95.3	"
73	100	"

 $\text{SbCl}_3$  + Acetophenone

t*	Gms. $\text{SbCl}_3$ per 100 Gms. Sat. Sol.	Solid Phase
19.5m	0	$\text{C}_6\text{H}_5\text{COCH}_3$
15	14.3	"
5	28.5	"
1e	31.8	" + 1.1
15	35.4	1.1
35	41.6	"
55	55.2	"
60.5m	65.4	"
45	79.3	"
32e	84	1.1 + $\text{SbCl}_3$
50	89.3	$\text{SbCl}_3$
70	98.2	"

 $\text{SbCl}_3$  + Anisole

t*	Gms. $\text{SbCl}_3$ per 100 Gms. Sat. Sol.	Solid Phase
-34.m	0	$\text{C}_6\text{H}_5\text{OCH}_3$
-36.5e	11.8	" + 1.1
-30	16	1.1
-10	28.3	"
+10	43	"
20	52.8	"
25t	63.6	1.1 + 2.1
35	70	2.1
41.5m	80.9	"
40e	84.5	" + $\text{SbCl}_3$
60	92	$\text{SbCl}_3$
70	98	"

 $\text{SbCl}_3$  + Aniline

t*	Gms. $\text{SbCl}_3$ per 100 Gms. Sat. Sol.	Solid Phase
-7.2e	1	$\text{C}_6\text{H}_5\text{NH}_2$ + 1.4
+20	7	1.4
60	18.7	"
77t	29.6	1.4 + 1.3
88m	44.8	1.3
87e	46.3	1.3 + 1.2
94.5	54.9	1.2
89.5e	61.7	1.2 + 1.1
100.5m	71	1.1
70	82.2	"
31e	88	1.1 + $\text{SbCl}_3$
60	94.9	$\text{SbCl}_3$

 $\text{SbCl}_3$  + Benzaldehyde

t*	Gms. $\text{SbCl}_3$ per 100 Gms. Sat. Sol.	Solid Phase
10	43.5	1.1
20	47.5	"
30	52.4	"
40	60.2	"
43.5m	68.1	"
40	74.2	"
30	80.6	"
25e	83	1.1 + $\text{SbCl}_3$
35	85	$\text{SbCl}_3$
45	87.5	"
65	95.2	"
73	100	"

 $\text{SbCl}_3$  + Benzophenone

t*	Gms. $\text{SbCl}_3$ per 100 Gms. Sat. Sol.	Solid Phase
48m	0	$\text{C}_6\text{H}_5\text{COC}_6\text{H}_5$
40	16.3	"
35e	21.6	" + 1.1
45	26.2	1.1
55	31.4	"
65	37.5	"
76m	55.4	"
65	71.6	"
45	80.6	"
39e	82.7	" + $\text{SbCl}_3$
50	87	$\text{SbCl}_3$
70	97.7	"

1-1 = compound of equimolecular amounts of the two constituents in each case.  
 2-1 = compound of 2 molecules of  $\text{SbCl}_3$  with 1 molecule of the other constituent.  
 1-2, 1-3 and 1-4 = compounds of 1 molecule of  $\text{SbCl}_3$  with 2, 3 and 4 molecules of aniline.

m = melting point

e = eutectic

t = transition point

# Sb STIBIUM

## RECIPROCAL SOLUBILITIES OF ANTIMONY TRICHLORIDE AND VARIOUS ORGANIC COMPOUNDS, DETERMINED BY THE "SYNTHETIC METHOD"--Cont.

SbCl <sub>3</sub> + Benzoic Acid			SbCl <sub>3</sub> + Benzoyl Chloride			SbCl <sub>3</sub> + Benzene Sulphonic Acid			SbCl <sub>3</sub> + Tetrahydrobenzene		
t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.		t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.		t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.		t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	
120	0		-5	17.8		52.5m	0		-25	19.1	
110	23		-15	36.8		45	18		-15	24	
100	38.8		-23e	45		25	43.7		-5	30	
90	50		-5	50.7		5	56.1		+5	37.1	
80	59		+15	58.2		-5e	60.8		15	45.1	
70	66		25	62.9		+5	49.8		25	54.3	
60	71.6		35	68.4		25	56.7		35	64.5	
46e	78		45	74.9		45	69.2		45	74	
60	89.2		55	82.4		65	90.2		55	83.6	
70	97.5		70	96.5		73	100		65	92.8	

Cl

Molecular compounds are not formed in the above systems. The diagram in each case consists of two arms meeting at the eutectic.

SbCl <sub>3</sub> + Benzene				SbCl <sub>3</sub> + Bromobenzene				SbCl <sub>3</sub> + Chlorobenzene			
t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase		t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase		t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	
4m	7.3	C <sub>6</sub> H <sub>6</sub>	"	-31e	0	C <sub>6</sub> H <sub>5</sub> Br	"	-45.2e	0	C <sub>6</sub> H <sub>5</sub> Cl	"
1	19.4	" + 2.1		-32.5m	4.8	" + 1.1		-47m	4.3	" + 1.1	
10	24.6	2.1		-30	6.8	"		-40	7	"	
20	30.5	"		-20	14.8	"		-30	11.1	"	
40	44.1	"		-10	23.9	"		-15	20.5	"	
60	60.6	"		0	34.3	"		-5	32.5	"	
75	76.8	"	+ 3t	40.3	1.1 + SbCl <sub>3</sub>			0t	44.2	"	
79e	85.3	"	20	52	SbCl <sub>3</sub>			20	56	"	
70	93.5	"	40	68	"			40	72.1	"	
62	96	2.1 + SbCl <sub>3</sub>	60	85.8	"			60	88.2	"	
67.5	97.9	SbCl <sub>3</sub>	73	100	"			73	100	"	

SbCl <sub>3</sub> + Fluorobenzene				SbCl <sub>3</sub> + Iodobenzene				SbCl <sub>3</sub> + Nitrobenzene			
t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase		t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase		t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	
-39.2m	0	C <sub>6</sub> H <sub>5</sub> F	"	-28.6m	0	C <sub>6</sub> H <sub>5</sub> I	"	6m	0	C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>	"
-40.5e	2.4	" + 1.1		-35	12.8	"		-2	20.4	"	
-25	11	1.1		-45e	29.8	" + 1.1		-10	32	"	
-15	17.3	"		-34.5	11.7	1.1 unstable		-16.5e	38	" + 1.1	
-10	21.4	"		-15	26.4	"		-10.5	44	1.1	
-5	26.4	"		-3	49.1	"		-7.5	50	"	
0	34.1	"		-35	32.5	1.1 + SbCl <sub>3</sub>		-6m	64.8	"	
+ 5.5t	45.8	1.1 + SbCl <sub>3</sub>		-15	38.9	SbCl <sub>3</sub>		-6.5e	67.5	1.1 + SbCl <sub>3</sub>	
15	53.6	SbCl <sub>3</sub>	+ 5	46.4	"	"		+ 5	69.6	SbCl <sub>3</sub>	
25	61.6	"	25	56	"	"		35	78.7	"	
45	77.7	"	45	69.6	"	"		55	87.4	"	
65	93.8	"	65	88.8	"	"		70	96.6	"	

m = melting point

e = eutectic

t = transition point

1.1 = compound of equimolecular amounts of the two constituents in each case.

2.1 = compound of 2 molecules of SbCl<sub>3</sub> with 1 molecule of the other constituent.

## C 1

C 1C 1

C 1

C 1

## Sb STIBIUM

## RECIPROCAL SOLUBILITIES OF ANTIMONY TRICHLORIDE AND VARIOUS ORGANIC COMPOUNDS, DETERMINED BY THE "SYNTHETIC METHOD"--Cont.

SbCl <sub>3</sub> + p Cymene			SbCl <sub>3</sub> + Pseudocymene			SbCl <sub>3</sub> + Diphenyl		
t°	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
-75m	0	p C <sub>6</sub> H <sub>4</sub> CH <sub>3</sub> C <sub>3</sub> H <sub>7</sub>	-57.4m	0	C <sub>6</sub> H <sub>3</sub> (CH <sub>3</sub> ) <sub>3</sub> 1,2,4	70.5m	0	C <sub>6</sub> H <sub>5</sub> -C <sub>6</sub> H <sub>5</sub>
-76.5e	2	" + 1:1	-60e	18.6	" + 1:1	65	14	"
-50	7	1:1	-45	23.6	1:1	55	33.4	"
-30	15	"	-25	33.3	"	50e	40	" + 2:1
-10	30	"	-10	45	"	55	45.2	2:1
-3.5t	41	1:1 + 2:1	-5	50.7	" + 2:1	60	51.4	"
10	46.1	2:1	+15	55.8	2:1	70	70.7	"
30	60	"	35	62.2	"	71m	74.6	"
40t	76.4	2:1 + SbCl <sub>3</sub>	50	69.7	"	65	85.5	"
50	81.2	"	56m	79.2	"	57e	88.9	2:1 + SbCl <sub>3</sub>
60	87	"	51e	87.5	2:1 + SbCl <sub>3</sub>	65	93.1	SbCl <sub>3</sub>
70	95.6	"	65	93.9	SbCl <sub>3</sub>	70	97	"

SbCl <sub>3</sub> + Mesitylene			SbCl <sub>3</sub> + Diphenyl Methane			SbCl <sub>3</sub> + Triphenyl Methane		
t°	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
-54.4m	0	C <sub>6</sub> H <sub>3</sub> (CH <sub>3</sub> ) <sub>3</sub> 1,3,5	26m	0	CH <sub>2</sub> (C <sub>6</sub> H <sub>5</sub> ) <sub>2</sub>	92m	0	CH(C <sub>6</sub> H <sub>5</sub> ) <sub>3</sub>
-55.6	1.5	" + 1:1	22.5e	7.9	" + 2:1	85	11.8	"
-40	3	1:1	40	15.1	2:1	80	19.3	"
-20	7	"	60	26	"	70	32	"
0	14.2	"	70	33	"	60	42.4	"
10	20.3	"	80	41.6	"	50	49.6	"
30	39.3	"	90	52.7	"	49t	50	" + 1:1
38t	51.4	" + 2:1	95	59.8	"	45	62.8	1:1
65	65.4	2:1	100m	72.9	"	40	68.3	"
75.5m	70.2	"	95	82.2	"	35e	72	1:1 + SbCl <sub>3</sub>
70	87	"	90	86.7	"	45	76.6	SbCl <sub>3</sub>
58.5	92.4	2:1 + SbCl <sub>3</sub>	80	91.5	"	35	82.4	"
63	94	SbCl <sub>3</sub>	67e	95.7	2:1 + SbCl <sub>3</sub>	65	90.6	"
70	98	"	70	97	SbCl <sub>3</sub>	70	96.1	"

SbCl <sub>3</sub> + Naphthalene			SbCl <sub>3</sub> + α Chloronaphthalene			SbCl <sub>3</sub> + β Chloronaphthalene		
t°	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
79.4m	0	C <sub>10</sub> H <sub>8</sub>	-17m	0	α C <sub>10</sub> H <sub>7</sub> Cl	56	0	β C <sub>10</sub> H <sub>7</sub> Cl
75	15.2	"	-21e	8.1	" + 2:1	50	16.6	"
65	35	"	0	14.4	2:1	45	27.2	"
59e	42.8	" + 2:1	10	18.7	"	40	35.4	"
65	48.4	2:1	20	24.6	"	30	47.3	"
75	58.8	"	30	33.5	"	25e	52.3	" + 1:1
80	65	"	40	47.7	"	29.5m	58.2	1:1
86m	79	"	45	61.5	"	28e	64	1:1 + SbCl <sub>3</sub>
80	88.7	"	46m	73.6	"	35	68.3	SbCl <sub>3</sub>
70	93	"	45.5e	75	2:1 + SbCl <sub>3</sub>	45	75.3	"
65e	94	2:1 + SbCl <sub>3</sub>	55	82.2	SbCl <sub>3</sub>	60	87.5	"
70	97.2	SbCl <sub>3</sub>	70	96.5	"	73	100	"

m = melting point

e = eutectic

t = transition point

1:1 = compound of equimolecular amounts of the two constituents in each case.  
 2:1 = compound of 2 molecules of SbCl<sub>3</sub> with 1 molecule of the other constituent.

## RECIPROCAL SOLUBILITIES OF ANTIMONY TRICHLORIDE AND VARIOUS ORGANIC COMPOUNDS, DETERMINED BY THE "SYNTHETIC METHOD"--Cont.

SbCl <sub>3</sub> + <i>o</i> Bromonaphthalene			SbCl <sub>3</sub> + <i>α</i> Nitronaphthalene		
t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
3m	0	<i>α</i> -C <sub>10</sub> H <sub>7</sub> Br	57m	0	<i>α</i> -C <sub>10</sub> H <sub>7</sub> NO <sub>2</sub>
-1e	8.3	" <sup>1.1</sup>	50	13.6	"
10	12.8	" <sup>1.1</sup>	40	27.3	"
25	24	"	30e	35.8	" <sup>1.1</sup>
33	38.5	"	35	43.2	" <sup>1.1</sup>
34.5m	52.4	"	37.5	49.3	"
33	62.1	"	39m	56.7	"
31.5e	64.7	"	37.5	64.9	"
40	69.7	1.1 + SbCl <sub>3</sub>	34.5e	72.8	1.1 + SbCl <sub>3</sub>
50	76.2	SbCl <sub>3</sub>	45	78	SbCl <sub>3</sub>
60	84.5	"	60	87.4	"
70	94.8	"	70	96.6	"

SbCl <sub>3</sub> + Phenol			SbCl <sub>3</sub> + Phenetol			SbCl <sub>3</sub> + Toluene		
t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
41a	0	C <sub>6</sub> H <sub>5</sub> OH	-28.6m	0	C <sub>6</sub> H <sub>5</sub> OC <sub>2</sub> H <sub>5</sub>	-93m	0	C <sub>6</sub> H <sub>5</sub> ·CH <sub>3</sub>
35	16.2	"	-29e	1.4	" <sup>1.1</sup>	-94e	1.1	" <sup>1.1</sup>
30	25.6	"	-20	4.5	"	-70	3.1	" <sup>1.1</sup>
20	38.7	"	-10	8.1	"	-30	15.8	"
10	48	"	+10	18.2	"	0	41.5	"
5e	52	" <sup>2.1</sup>	20	27.4	"	11t	57.8	" <sup>2.1</sup>
15	58.6	2.1	30	39.4	"	20	62.8	2.1
30	70.6	"	40	58	"	40	78	"
37m	83	"	42.2m	65	"	42.5m	83.1	"
36.5e	83.7	2.1 + SbCl <sub>3</sub>	35e	77.8	"	40e	85.8	2.1 + SbCl <sub>3</sub>
55	90.6	SbCl <sub>3</sub>	50	86.8	"	50	89	SbCl <sub>3</sub>
70	98.2	"	70	97.1	"	70	97.8	"

SbCl <sub>3</sub> + <i>o</i> Chlorotoluene			SbCl <sub>3</sub> + <i>m</i> Chlorotoluene			SbCl <sub>3</sub> + <i>p</i> Chlorotoluene		
t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase
-36.2m	0	<i>o</i> -ClC <sub>6</sub> H <sub>4</sub> CH <sub>3</sub>	-47.8m	0	<i>m</i> -ClC <sub>6</sub> H <sub>4</sub> CH <sub>3</sub>	6.2m	0	<i>p</i> -ClC <sub>6</sub> H <sub>4</sub> CH <sub>3</sub>
-37.5e	6.9	" <sup>1.1</sup>	-49e	6.9	" <sup>1.1</sup>	3	12.7	"
-20	18.3	" <sup>1.1</sup>	-40	12.3	" <sup>1.1</sup>	0	23.5	"
-10	29.2	"	-30	20.1	"	-3	32.8	"
-5	37.1	"	-20	31	"	-7.5e	43.8	" <sup>1.1</sup>
-0.5t	47.9	1.1 + SbCl <sub>3</sub>	-14t	40	1.1 + SbCl <sub>3</sub>	0	47.2	SbCl <sub>3</sub>
+10	53.1	SbCl <sub>3</sub>	0	46.1	SbCl <sub>3</sub>	10	52.2	"
20	58.2	"	10	51.6	"	30	64.8	"
30	64.6	"	20	57.4	"	40	72.3	"
40	71.8	"	40	72.8	"	50	80.2	"
60	88.4	"	60	89.1	"	60	88.8	"
73	100	"	73	100	"	70	97.4	"

m = melting point

e = eutectic

t = transition point

1.1 = compound of equimolecular amounts of the two constituents in each case.

2.1 = compound of 2 molecules of SbCl<sub>3</sub> with 1 molecule of the other constituent.



## Sb STIBIUM

## RECIPROCAL SOLUBILITIES OF ANTIMONY TRICHLORIDE AND VARIOUS ORGANIC COMPOUNDS, DETERMINED BY THE "SYNTHETIC METHOD"--Cont.

SbCl <sub>3</sub> + o Nitrotoluene				SbCl <sub>3</sub> + m Nitrotoluene				SbCl <sub>3</sub> + p Nitrotoluene			
t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase		t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase		t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	
-8.5m	0	oNO <sub>2</sub> C <sub>6</sub> H <sub>4</sub> CH <sub>3</sub>		16m	0	mNO <sub>2</sub> C <sub>6</sub> H <sub>4</sub> CH <sub>3</sub>		52.5m	0	pNO <sub>2</sub> C <sub>6</sub> H <sub>4</sub> CH <sub>3</sub>	
-13.5	11.3	"		10	15	"		45	18.5	"	
-18.5e	18.5	" + 1:1		0	30.7	"		35	33.6	"	
-10	21.3	1:1		-10	39.2	"		30	38.8	"	
+10	31.1	"		-20	42.8	"		20	46	"	
20	39	"		crystallisation not obtained here				7.5e	52	" + 1:1	
30	50	"						7.5e	62.3	1:1	
34.5m	62.3	"						5	66.1	"	
33	68	"		0	67.2	SbCl <sub>3</sub>		3e	68.5	1:1 + SbCl <sub>3</sub>	
27.5e	74.6	" + SbCl <sub>3</sub>		20	72.5	"		10	70	SbCl <sub>3</sub>	
40	79.1	SbCl <sub>3</sub>		30	76.3	"		30	75.5	"	
50	84.5	"		40	80.8	"		50	85	"	
70	97.5	"		50	86	"		70	97.5	"	
				60	91.6	"					
				73	100	"					

SbCl <sub>3</sub> + o Xylene				SbCl <sub>3</sub> + m Xylene				SbCl <sub>3</sub> + p Xylene			
t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase		t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase		t*	Gms. SbCl <sub>3</sub> per 100 Gms. Sat. Sol.	Solid Phase	
-29	0	C <sub>6</sub> H <sub>4</sub> (CH <sub>3</sub> ) <sub>2</sub>		-57m	0	C <sub>6</sub> H <sub>4</sub> (CH <sub>3</sub> ) <sub>2</sub>		14m	0	C <sub>6</sub> H <sub>4</sub> (CH <sub>3</sub> ) <sub>2</sub>	
-35e	14	" + 1:1		-60.5e	7.5	" + 1:1		11.7e	11.7	" + 1:1	
-30	17.5	"		-45	15.8	1:1		20	17.5	1:1	
-20	24.8	"		-25	29	"		40	37.3	"	
-10	33.4	"		-5	46.2	"		30	52.3	"	
0	43.4	"		-2	49.8	" + 2:1		55t	62.7	" + 2:1	
10	55	"		5	53.1	2:1		60	66.1	2:1	
19.5m	68.1	"		15	58.7	"		70m	81	"	
25	71.3	2:1		25	65.7	"		65	88.1	"	
30	75.7	"		33	73.8	"		58e	92	" + SbCl <sub>3</sub>	
33.5m	81	"		38	81	"		69	97.2	SbCl <sub>3</sub>	
31.5e	82.5	2:1 + SbCl <sub>3</sub>		36.5e	83.7	2:1 + SbCl <sub>3</sub>		-	-	-	
50	88	SbCl <sub>3</sub>		50	87.7	SbCl <sub>3</sub>		10	20.7	C <sub>6</sub> H <sub>4</sub> (CH <sub>3</sub> ) <sub>2</sub> (unstable)	
60	92.4	"		60	91.5	"		7e	32.8	" + 2:1	
71	98.5	"		70	97.2	"		35	50.3	"	
								55	62.7	"	

m = melting point

e = eutectic

t = transition point

1:1 = compound of equimolecular amounts of the two constituents in each case.

2:1 = compound of 2 molecules of SbCl<sub>3</sub> with 1 molecule of the other constituent.

100 gms. absolute acetone dissolve 537.6 gms. SbCl<sub>3</sub> at 18°. d<sub>15</sub> sat. sol. = 2.216. (Naumann, 1904.)

100 gms. ethyl acetate dissolve 5.9 gms. SbCl<sub>3</sub> at 18° d sat. sol. = 1.7968. (Naumann, 1910.)

100 gms. acetylene tetrachloride (C<sub>2</sub>H<sub>2</sub>Cl<sub>4</sub>) dissolve 21.75 gms. SbCl<sub>3</sub> at 25°. (de Pauw, 1922, 1926.)

Fusion-point data are given for:

SbCl <sub>3</sub> + SbCl <sub>5</sub>	(Aten, 1909)	
SbCl <sub>3</sub> + SbI <sub>3</sub>	(Bernadis, 1912)	
SbCl <sub>3</sub> + SbI <sub>3</sub> + SbBr <sub>3</sub>	(Bernadis, 1912)	
SbCl <sub>3</sub> + SbCl <sub>2</sub>	(Kendall, Crittenden and Muller, 1923)	
SbCl <sub>3</sub> + SnCl <sub>4</sub>	(Kendall, Crittenden and Muller, 1923)	
SbCl <sub>3</sub> + Benzene	(Kurnakov, Krotkov and Oksman, 1915)	
SbCl <sub>3</sub> + Naphthalene	(Kurnakov, Krotkov and Oksman, 1915)	
SbCl <sub>3</sub> + Diphenyl Methane	(Kurnakov, Krotkov and Oksman, 1915)	
SbCl <sub>3</sub> + Triphenyl Methane	(Kurnakov, Krotkov and Oksman, 1915)	
SbCl <sub>3</sub> + p(cyanotoluene	(Pushin, Ristic, Parchomenko, and Ubovic, 1942)	
SbCl <sub>3</sub> + TiCl <sub>4</sub>	(Eingorn, 1950a)	
SbCl <sub>3</sub> + Azobenzene	(Vanstone, 1914)	
SbCl <sub>3</sub> + Benzil	(Vanstone, 1914)	
SbCl <sub>3</sub> + s diphenyl ethane	(Vanstone, 1914)	Cl
SbCl <sub>3</sub> + Stilbene	(Vanstone, 1914)	
SbCl <sub>3</sub> + Benzaniline	(Vanstone, 1925)	
SbCl <sub>3</sub> + β Chlor Naphthalene	(Vasiliev, 1917)	
SbCl <sub>3</sub> + α Nitro Naphthalene	(Vasiliev, 1917)	
SbCl <sub>3</sub> + Trinitrotoluene	(Pushin, Nikolic, et al., 1947)	
SbCl <sub>3</sub> + Chloroacetic Acid	(Usanovich and Sumarokova, 1951)	
SbCl <sub>3</sub> + Trichloro Acetic Acid	(Sumarokova and Usanovich, 1951)	

#### ANTIMONY PENTACHLORIDE SbCl<sub>5</sub>

Cl

##### DISTRIBUTION BETWEEN AQUEOUS HCl AND ETHYL ETHER (Mylius, 1911)

1 gm. Sb as SbCl<sub>5</sub>, dissolved in 100 cc. aqueous HCl, was shaken with 100 cc. ethyl ether at room temperature.

% Conc. of HCl	% of Total Sb in Ether Layer
20	81
15	22
10	6
5	2.5
1	trace

100 gms. of a sat. solution of antimony pentachloride (SbCl<sub>5</sub>) in selenium oxychloride (SeOCl<sub>2</sub>) contain 38.64 gms. SbCl<sub>5</sub> at 25°. (Wise, 1923.)

1 mole % SbCl<sub>5</sub> dissolves in iodine monochloride (ICl). (Gutmann, 1950.)

Data for the freezing-points of mixtures of antimony pentachloride and antimony pentafluoride are given by Ruff (1909).

ANTIMONY OXYCHLORIDE  $\text{Sb}_4\text{O}_5\text{Cl}_2$ SOLUBILITY IN AQUEOUS SOLUTIONS OF HYDROCHLORIC ACID AT 25°  
(Lea and Wood, 1924)

Hydrated antimonious oxide was added in excess to solutions of pure HCl of varying concentrations and the mixtures kept in a thermostat for two months. They were shaken from time to time by hand. Portions were removed for analysis and after another month other portions were removed for a duplicate analysis. The results agreed satisfactorily, thus indicating that equilibrium had been reached. The results gave a smooth curve, thus showing the absence of a transition point. The solid phase gradually took on a crystalline appearance and on analysis corresponded to  $\text{Sb}_4\text{O}_5\text{Cl}_2$ .

Gm. atoms per liter of sat. sol.		Gm. atoms per liter of sat. sol.		Gm. atoms per liter of sat. sol.	
Cl	Sb	Cl	Sb	Cl	Sb
0.194	0.00012	1.56	0.0116	2.81	0.177
0.402	0.000172	1.74	0.0194	3.36	0.309
0.601	0.000298	1.90	0.0299	3.85	0.440
1.02	0.00124	2.29	0.0755	5.93	1.13
1.32	0.00565	2.54	0.120		

ANTIMONY TRIFLUORIDE  $\text{SbF}_3$ SOLUBILITY IN WATER  
(Rosenheim and Grünbaum, 1909)

t°	Gms. $\text{SbF}_3$ per 100 Gms.	
	Water	Sat. Solution
0	384.7	79.4
20	444.7	81.6
22.5	452.8	81.9
25	492.4	83.1
30	563.6	84.9

SOLUBILITY IN AQUEOUS SOLUTIONS OF SALTS AND OF HYDROFLUORIC ACID AT 0°  
(Rosenheim and Grünbaum, 1909)

Celluloid flasks were used and all measuring apparatus provided with HF resistant coating. The  $\text{SbF}_3$  was prepared in the form of rhombic transparent crystals from  $\text{Sb}_2\text{O}_3$  and HF.

Normality of Aq. Salt Solution	Gms. $\text{SbF}_3$ per 100 Gms. $\text{H}_2\text{O}$ present in Aq. Solutions of:							
	KCl	KBr	$\text{KNO}_3$	$\text{K}_2\text{SO}_4$	$\text{K}_2\text{C}_2\text{O}_4$	$(\text{NH}_4)_2\text{C}_2\text{O}_4$	$\text{K}_2\text{C}_4\text{H}_4\text{O}_6$	HF
1	461.8	448.7	458.2	419.9	465.7	-	461.4	432.5
0.5	448.3	450	451.9	408.5	481.2	431.9	430.5	404
0.25	431.9	455.6	418.3	406.6	451.3	442.3	430.8	-
0.125	407.3	417.2	401.4	-	405.2	433.3	435.2	<sup>a</sup> 479.4

<sup>a</sup>(2  $\frac{1}{2}$  HF)

Data for the distribution of  $\text{Sb}^{+++}$  between aqueous HF solutions and ethyl ether are given by Bock and Herrmann, 1956 and by Kitahara, 1949.

SOLUBILITY OF ANTIMONY TRIFLUORIDE IN ORGANIC SOLVENTS AT 25°  
(Breck, Harvey, and Haendler, 1949)

Solvent	Gms. $\text{SbF}_3$ per 100 ml. Sat. Sol.	Solvent	Gms. $\text{SbF}_3$ per 100 ml. Sat. Sol.
Benzene	$5.5 \times 10^{-4}$	Methanol	133
n-Heptane	$1.6 \times 10^{-3}$	1-Propanol	34.3
1,4 Dioxane	1.11	Methyl Ethyl Ketone	8.0
Di-n-Butyl Ether	$5.0 \times 10^{-2}$	Acetone	55.3
Chlorobenzene	$5.0 \times 10^{-4}$	Nitrobenzene	$5.6 \times 10^{-2}$

STIBINE  $\text{SbH}_3$ 

H

At room temperature 1 volume of water dissolves 1/5 volume of  $\text{SbH}_3$ .

At room temperature 1 volume of alcohol dissolves 15 volumes of  $\text{SbH}_3$ .

At 0° 1 volume of carbon disulfide dissolves at least 250 volumes of  $\text{SbH}_3$ . Stock and Guttman, 1904.

ANTIMONY TRI IODIDE  $\text{SbI}_3$ 

I

THE SYSTEM ANTIMONY TRIIODIDE - AMMONIUM IODIDE - WATER  
(Francois, 1935)

The results are presented only in the form of a diagram from which the following values were read.

Gms. per 100 gms. H <sub>2</sub> O			Solid Phase	Gms. per 100 gms. H <sub>2</sub> O			Solid Phase	Gms. per 100 gms. H <sub>2</sub> O			Solid Phase
SbI <sub>3</sub>	NH <sub>4</sub> I			SbI <sub>3</sub>	NH <sub>4</sub> I			SbI <sub>3</sub>	NH <sub>4</sub> I		
<u>Results at 11°</u>											
0.0	165	NH <sub>4</sub> I		0.0	172	NH <sub>4</sub> I		0.0	185	NH <sub>4</sub> I	
20.0	178	"		40.0	195	"		95.0	234	"	
40.0	188	"		55.0	210	" + 1.4.3		120	227	1.4.3	
55.0	198	" + 1.4.3		100	205	1.4.3		148	243	" + 1.2.2	
65.0	194	1.4.3		136	215	" + ?		105	160	1.2.2	
85.0	192	"		142	212	? + 1.2.2					
110.0	194	" + ?		120	180	1.2.2		1.4.3 = SbI <sub>3</sub> · 4NH <sub>4</sub> I · 3H <sub>2</sub> O			
114.0	185	?		100	130	"		1.2.2 = SbI <sub>3</sub> · 2NH <sub>4</sub> I · 2H <sub>2</sub> O			
118.0	180	" + 1.1.2									
105.0	160	1.2.2									
90.0	130	"									
(Cont.)											

(Cont.)

# Sb STIBIUM

## THE SYSTEM ANTIMONY TRIIODIDE - AMMONIUM IODIDE - WATER--Cont.

Gms. per 100 gms. H <sub>2</sub> O			Solid Phase	Gms. per 100 gms. H <sub>2</sub> O			Solid Phase
SbI <sub>3</sub>	NH <sub>4</sub> I			SbI <sub>3</sub>	NH <sub>4</sub> I		
<u>Results at 50°</u>				<u>Results at 75°</u>			
0.0	200	NH <sub>4</sub> I		0.0	224	NH <sub>4</sub> I	1.4.3 = SbI <sub>3</sub> ·4NH <sub>4</sub> I·3H <sub>2</sub> O
70.0	233	"		70.0	255	"	1.2.2 = SbI <sub>3</sub> ·2NH <sub>4</sub> I·2H <sub>2</sub> O
128	270	" + 1.4.3		143	295	" + 1.2.2	
140	266	1.4.3		120	205	1.2.2	
145	270	" + 1.2.2					
120	200	1.2.2					

## THE SYSTEM ANTIMONY TRIIODIDE - SODIUM IODIDE - WATER (Francois, 1935)

The results are presented only in the form of a diagram from which the following approximate values were read.

Gms. per 100 gms. H <sub>2</sub> O			Solid Phase	Gms. per 100 gms. H <sub>2</sub> O			Solid Phase	Gms. per 100 gms. H <sub>2</sub> O			Solid Phase
SbI <sub>3</sub>	NaI			SbI <sub>3</sub>	NaI			SbI <sub>3</sub>	NaI		
<u>Results at 15°</u>				<u>Results at 35°</u>				<u>Results at 60°</u>			
0.0	174	NaI	0.0	197	NaI	0.0	257	NaI			
10	178	" + 1.2.8	25.0	200	" + 1.2.8	50	263	"			
20	130	1.2.8	40	135	1.2.8	85	270	" + 1.2.8			
50	100	"	70	110	"	75	220	1.2.8			
58	90	" + 1.1.6	95	100	" + 1.1.6	100	155	"			
70	60	1.1.6	105	80	1.1.6	130	140	"			
						165	140	" + 1.1.6			
						170	120	1.1.6			
1.2.8 = SbI <sub>3</sub> ·2NaI·8H <sub>2</sub> O						200	105	" + SbI <sub>3</sub>			
1.1.6 = SbI <sub>3</sub> ·NaI·6H <sub>2</sub> O						150	85	SbI <sub>3</sub>			
						100	50	"			
						55	25	"			

Data for the extraction of SbI<sub>3</sub> from 6.9N HCl with ether are given by Kitahara, 1948.

100 gms. methylene iodide, CH<sub>2</sub>I<sub>2</sub>, dissolve 11.3 gms. SbI<sub>3</sub> at 12° and the density of the solution is 3.453. (Retgers, 1893.)

Melting points are given for:

SbI <sub>3</sub> + AsI <sub>3</sub>	(Vasilev, 1912, 1921; Quercigh, 1912; Jaeger and Dornbosch, 1912)
SbI <sub>3</sub> + P <sub>2</sub> O <sub>3</sub>	(Jaeger and Dornbosch, 1912)
SbI <sub>3</sub> + I	(Quercigh, 1912)
SbI <sub>3</sub> + SnI <sub>3</sub>	(Vasilev, 1921)
SbI <sub>3</sub> + C <sub>6</sub> H <sub>5</sub> CN	(Pushin, Ristic, Parchomenko, and Ubovic, 1942)
SbI <sub>3</sub> + Naphthalene	(Pushin, 1948a)
SbI <sub>3</sub> + Nitrobenzene	(Pushin, 1948a)

ANTIMONY TRIOXIDE  $\text{Sb}_2\text{O}_3$ 

0

## SOLUBILITY IN WATER

t°	Moles $\text{Sb}_2\text{O}_3$ per 1000 Gms. $\text{H}_2\text{O}$	Reference
15	0.000055	Schulze, 1883
25	0.000029	Gayer and Garrett, 1952
100	0.00034	Schulze, 1883

SOLUBILITY OF ANTIMONY TRIOXIDE IN AQUEOUS NaOH AND HCl SOLUTIONS AT 25°  
(Gayer and Garrett, 1952)

The rhombic modification was used.

Initial moles NaOH per 1000 gms. $\text{H}_2\text{O}$	Gm. atom of Sb per 1000 gms. $\text{H}_2\text{O}$	Initial moles HCl per 1000 gms. $\text{H}_2\text{O}$	Gm. atom of Sb per 1000 gms. $\text{H}_2\text{O}$
0.000	0.000058	0.005	0.000021
0.00505	0.000098	0.010	0.000026
0.0101	0.000148	0.020	0.000034
0.0202	0.000238	0.030	0.000045
0.0404	0.000428	0.050	0.000061
0.0400	0.000378	0.075	0.000082
0.0749	0.000758	0.100	0.000102
0.0998	0.000998		

At 15° 0.000055 gm. mole  $\text{Sb}_2\text{O}_3$ .

For data on the solubility of  $\text{Sb}_2\text{O}_3$  in tartaric acid and in sodium and potassium tartarate solutions see Nanda and Pani, 1953 and Samantora, Rao and Pani, 1955. Results in partially neutralized gluconic acid solutions are given by Patra and Pani, 1955.

ANTIMONY TETRAOXIDE  $\text{Sb}_2\text{O}_4$ 

0

SOLUBILITY IN VARIOUS SOLUTIONS  
(Konopik and Zwiauer, 1952)

Solvent	t°	Gms. $\text{Sb}_2\text{O}_4$ per liter	Solvent	t°	Gms. $\text{Sb}_2\text{O}_4$ per liter
$\text{H}_2\text{O}$	room	< 0.000038	2 N $\text{HNO}_3$	100	< 0.00031
	100	0.00034	conc. $\text{HNO}_3$	100	< 0.00015
conc. HCl	room	0.065	8 N NaOH	100	< 0.00038
	100	2.344	0.01 M tartaric acid + 0.01 M potassium tartarate	room	0.0014
conc. $\text{H}_2\text{SO}_4$	B.pt.	11.1			

Melting points in the system  $\text{Sb}_2\text{O}_3$  -  $\text{Sb}_2\text{S}_3$  are given by Quercigh, 1912, and by Koster and Braumann, 1951.

## Sb STIBIUM

### ANTIMONY TRISULFIDE $Sb_2S_3$

Kapustinsky (1940) calculated the solubility product at 25° on the basis of thermochemical data to be  $2.9 \times 10^{-59}$ . The calculated solubility in aqueous solutions is thus:

pH:	3	5	7	9	11
Moles $Sb_2S_3$ per liter:	$3.3 \times 10^{-2}$	$1.3 \times 10^{-4}$	$8.2 \times 10^{-7}$	$3.5 \times 10^{-8}$	$2.2 \times 10^{-9}$

1000 cc water dissolve 0.00175 gm.  $Sb_2S_3$  at 18°. (Weigel, 1907.)

#### SOLUBILITY OF ANTIMONY TRI SULFIDE IN AQUEOUS SOLUTIONS OF AMMONIA (Epik, 1932)

The determinations were made by warming mixtures of sulfide and aqueous ammonia of different concentrations for five minutes over a Bunsen burner. The solutions thus obtained were analyzed for antimony and residual ammonia.

Percent concentration of $NH_3$ in solvent		Gms. $Sb_2S_3$ dissolved per 100 cc solvent
at beginning	at end	
1.0	0.88	0.127
2.0	1.7	0.206
5.0	4.0	0.420
10.0	7.4	0.730
15.0	9.2	0.870
25.0	13.4	1.280

The effect of time of heating and variation in excess of sulfide were studied. The gms. of sulfide per 100 cc of solvent was found to increase from 0.58 to 0.73 when the amount of sulfide per 1 gm. of  $NH_3$  in the original solution varied from 0.05 to 0.15.

Fusion-point data are given for:

$Sb_2S_3 + CuS$	(Parravano and Cesaris, 1912)
$Sb_2S_3 + SnS$	(Parravano and Cesaris, 1912)
$Sb_2S_3 + Ag_2S$	(Jaeger and Van Klooster, 1912; Kuroso, 1919;
$Sb_2S_3 + PbS$	Pelabon, 1913; Jitsuka, 1919)
$Sb_2S_3 + BiS$	(Takahashi, 1919)

ANTIMONY PENTASULFIDE  $\text{Sb}_2\text{S}_5$ 

S

SOLUBILITY IN AQUEOUS HYDROCHLORIC ACID SOLUTIONS  
(Sorum and Wolf, 1950)n = normality of HCl      S = mg.  $\text{Sb}_2\text{S}_5$  per 100 ml. sat. sol.

At 26°		At 40°		At 60°	
n	S	n	S	n	S
0.00	0.7	0.00	0.2	0.48	0.7
0.53	0.0	0.47	0.1	0.99	0.0
1.01	0.0	0.97	0.4	2.03	0.2
2.00	0.7	2.02	0.4	3.01	6.4
2.82	2.1	2.89	1.2	3.55	13.0
3.72	6.7	3.60	9.8	4.05	21.0
4.03	15.8	3.98	14.4	5.52	131.8
5.59	111.0	5.40	104.0	6.35	328.2
		6.24	244.0	6.42	378.6
				6.66	538.2

ANTIMONY TRIPHENYL SULFIDE  $\text{Sb}(\text{C}_6\text{H}_5)_3\text{S}$ 

S

Fusion-point data are given by Pascal, 1923, for:

$\text{Sb}(\text{C}_6\text{H}_5)_3\text{S} + \text{PO}(\text{C}_6\text{H}_5)_3$	(Tri phenyl phosphine oxide)
$\text{Sb}(\text{C}_6\text{H}_5)_3\text{S} + \text{PS}(\text{C}_6\text{H}_5)_3$	(Tri phenyl phosphine sulfide)
$\text{Sb}(\text{C}_6\text{H}_5)_3\text{S} + \text{AsS}(\text{C}_6\text{H}_5)_3$	(Tri phenyl arsine sulfide)
$\text{Sb}(\text{C}_6\text{H}_5)_3\text{S} + \text{AsO}(\text{C}_6\text{H}_5)_3$	(Tri phenyl arsine oxide)

ANTIMONY SELENIDES  $\text{SbSe}$ ,  $\text{Sb}_2\text{Se}$ 

Se

Fusion-point data are given by Pelabon, 1908, for:

 $\text{SbS} + \text{Ag}_2\text{Se}$  and  $\text{Sb}_2\text{S}_3 + \text{Ag}_2\text{S}$ .

## SCANDIUM 8-HYDROXY QUINOLATE

Sc

Data for the extraction from aqueous solutions by benzene are given by Umland, 1957.



# Sc SCANDIUM

## CO SCANDIUM OXALATE $\text{Sc}_2(\text{C}_2\text{O}_4)_3 \cdot 5\text{H}_2\text{O}$

### SOLUBILITY IN AQUEOUS SOLUTIONS OF AMMONIUM OXALATE AND OF HYDROCHLORIC ACID

In Aqueous Ammonia Oxalate at 25°  
(Wirth, 1914)

Gms. per 100 Gms. Sat. Sol.		Solid Phase
$\text{C}_2\text{O}_3$	$\text{Sc}_2\text{O}_3$	
1.624	0.3019	$\text{Sc}_2(\text{C}_2\text{O}_4)_3 \cdot 5\text{H}_2\text{O}$
2.4	0.4012	"
4.478	0.7108	" + $(\text{NH}_4)_2\text{C}_2\text{O}_4$

In Aqueous Hydrochloric Acid at 25° and at 50°  
(Meyer, 1914)

Normality of Aqueous HCl	Gms. $\text{Sc}_2(\text{C}_2\text{O}_4)_3$ per 100 Gms. Sat. Sol.	
	At 25°	At 50°
0.1	0.0299	0.0420
0.5	0.0650	0.0870
1	0.1020	0.1435
2	0.1716	0.2556
5	0.4170	0.6533

### SOLUBILITY IN AQUEOUS SOLUTIONS OF SULFURIC ACID

Results at 25° (Wirth, 1914)

Normality of Aq. $\text{H}_2\text{SO}_4$	Gms. $\text{Sc}_2(\text{C}_2\text{O}_4)_3$ per 100 Gms. Sat. Sol.	Solid Phase
1	0.1148	$\text{Sc}_2(\text{C}_2\text{O}_4)_3 \cdot 5\text{H}_2\text{O}$
2.1	0.2573	"
2.43	0.2904	"
3.57	0.4204	"
4.86	0.5834	"

Results at 25° and at 50° (Meyer, 1914)

Normality of Aq. $\text{H}_2\text{SO}_4$	Gms. $\text{Sc}_2(\text{C}_2\text{O}_4)_3$ per 100 Gms. Sat. Sol.	
	At 25°	At 50°
0.1	0.0385	0.0562
0.5	0.0997	0.1481
1	0.1663	0.2493
2	0.3176	0.4429
5	0.7761	1.1280

100 gms. sat. solution of scandium oxalate in 2.43  $\text{N}$   $\text{H}_2\text{SO}_4$  + 0.5  $\text{N}$  oxalic acid contain 0.0284 gm.  $\text{Sc}_2\text{O}_3$  at 25°. (Wirth, 1914.)

SCANDIUM CHLORIDE  $\text{ScCl}_3$ 

Cl

SOLUBILITY OF SCANDIUM CHLORIDE IN HYDROCHLORIC ACID SOLUTIONS AT 0°  
(Fischer and Buhler, 1956)

Sat. Sol. Wt. %			Sat. Sol. Wt. %			Sat. Sol. Wt. %		
HCl	$\text{ScCl}_3$	Solid Phase	HCl	$\text{ScCl}_3$	Solid Phase	HCl	$\text{ScCl}_3$	Solid Phase
0	43.2	6m	18.2	22.0	6m	28.3	14.8	6
0.3	41.3	6m	19.7	18.9	9	30.2	18.5	6
2.1	39.9	6m	22.5	18.0	6	28.8	23.8	6
4.8	32.1	9	23.4	17.2	6	28.3	24.3	6
8.2	32.7	6m	24.6	16.1	6	28.0	24.3	6
12.2	28.3	6m	24.9	16.4	6	27.6	24.7	6
14.2	23.2	9	25.5	15.7	6	25.8	27.7	6

m = metastable

Data for the extraction of scandium from aqueous HCl and  $\text{HNO}_3$  solutions by tributyl phosphate are given by Peppard, Mason and Maier, 1956. Extraction data for the nitrate by ether are given by Bock and Bock, 1949, 1950.

SCANDIUM HYDROXIDE  $\text{Sc(OH)}_3$ 

OH

Oka, 1940 found the solubility of scandium hydroxide in water to be  $1.3 \times 10^{-8}$  moles per liter.

SCANDIUM SULFATE  $\text{Sc}_2(\text{SO}_4)_3$ 

SO

SOLUBILITY IN WATER AND IN AQUEOUS SULFURIC ACID AT 25°  
(Wirth, 1914)

Solvent	Gms. $\text{Sc}_2(\text{SO}_4)_3$ per 100		Solid Phase
	Gms. Sat. Sol.		
Water	28.52		$\text{Sc}_2(\text{SO}_4)_3 \cdot 5\text{H}_2\text{O}$
0.5 $\bar{n}$ $\text{H}_2\text{SO}_4$	29.29		"
1 $\bar{n}$ $\text{H}_2\text{SO}_4$	19.87		"
4.86 $\bar{n}$ $\text{H}_2\text{SO}_4$	8.363		"
9.73 $\bar{n}$ $\text{H}_2\text{SO}_4$	1.315		"
22.35 $\bar{n}$ $\text{H}_2\text{SO}_4$	0.484		$\text{Sc}_2(\text{SO}_4)_3 \cdot 3\text{H}_2\text{O}$

Scandium sulfuric acid double sulfate,  $\text{Sc}_2(\text{SO}_4)_3 \cdot 3\text{H}_2\text{SO}_4$ : 100 gms. sat. sol. in conc.  $\text{H}_2\text{SO}_4$  of  $\bar{d} = 1.6$  contain 0.8616 gm. of the double salt. (Wirth, 1914.)

Se SELENIUM

Se SELENIUM

SOLUBILITY IN ALKALIS

(Calcagni, 1923)

100 cc. of aq. 66% KOH solution dissolve 9.19 gms. Se. This corresponds to an atomic ratio of 39.15 gm. atoms K:14.91 gms. atoms Se, which shows that not all of the selenium is in the form of selenide.

100 cc. of aq. 66% NaOH solution dissolve 2.45 gms. Se.

100 cc. of sat. aq. Ba(OH)<sub>2</sub> solution dissolve 2.65 gms. Se after being kept several days at 80°.

SOLUBILITY OF SELENIUM IN CARBON DISULFIDE

(Moles and Jimeno, 1915)

(Also see the earlier data of Marc, 1906, 1907, below.)

Carefully prepared amorphous red selenium was used. The saturated solutions were analyzed by evaporating at ordinary temperature and weighing the residue after heating to 110°. The solubility of selenium varies with the time which elapses after its preparation and with the time of exposure to light. Amorphous selenium in contact with carbon disulfide is transformed to crystalline selenium. The variations in solubility are probably due to this transformation. It is necessary to admit the existence of many varieties of red crystalline selenium with different solubilities. These varieties owe their origin to the action of the solvent or of light and may be identical with the two monoclinic modifications studied by Muthmann. Some of the solubility results obtained by the authors are as follows:

t°	Gms. Se per 100 gms. Se+CS <sub>2</sub>	Conditions of the determination
?	0.0573	Solubility 1 hour after preparation of sample
?	0.0475	Solubility 24 hours after preparation of sample
?	0.0190	Solubility 1436 hours after preparation of sample
3	0.00191	Solution prepared in the dark: 3 hours
12	0.00247	Solution prepared in the dark: 3 hours
12	0.00662	Solution prepared in the dark: 72 hours
9	0.0251	Same solution after 48 hours exposure to sunlight
44	0.1586	Solution in boiling CS <sub>2</sub>
0	0.0184	The above solution cooled for 20 hours

100 gms. selenium monochloride saturated with selenium by shaking in a thermostat at 25° for a very long time contain 9.73 gms. Se. (Lenher and Kao, 1926.)

SOLUBILITY IN CARBON DISULFIDE  
(Marc, 1906)

C

100 cc. CS<sub>2</sub> dissolve 0.065 gm. amorphous Se at room temperature. Se which is heated to 180° for 6 - 7 hours is insoluble in CS<sub>2</sub>. Se crystallized from the melt at 200° is insoluble in CS<sub>2</sub>. Se heated once quickly to 140° is very slightly soluble in CS<sub>2</sub>.

100 cc. CS<sub>2</sub> dissolve at the boiling-point 3 - 3.4 mgs. Se which has been heated to 140° for 1 hr.

100 cc. CS<sub>2</sub> dissolve at the boiling-point 2 mgs. Se which has been heated to 195° for 2 days. (Marc, 1907.)

The surface tension and density of solutions of selenium and sulfur in carbon disulfide were accurately determined by Kapustinsky and Golutvin, 1947.

SOLUBILITY OF MIXED CRYSTALS OF SELENIUM AND SULFUR IN  
CARBON DISULFIDE AT 25°  
(Ringer, 1902)

Mols. per 100 Mols. Solution			Mol. % Se in Crystals	Mols. per 100 Mols. Solution			Mol. % Se in Crystals
CS <sub>2</sub>	Se	S		CS <sub>2</sub>	Se	S	
43.1	0	56.9	0	58.24	2.35	39.41	55.67
45.1	0.93	53.97	3.54	64.66	1.58	33.76	68.38
44.98	1.03	53.99	3.81	81.11	2.4	16.49	58.7
47.84	2.07	50.59	8.69	88.41	2.17	9.42	61.5
49.54	2.19	48.27	16.4(a)	91.38	1.68	6.94	65
47.62	2.16	50.22	14.2(a)	99.51	0.49	0	100(b)
46.12	1.485	52.39	29.35(a)	99.14	0.86	0	100(c)

(a) Mix crystals homogeneous in all except these solutions.

(b) Solubility of hexagonal selenium.

(c) Solubility of amorphous selenium.

100 gms. methylene iodide (CH<sub>2</sub>I<sub>2</sub>) dissolve 1.3 gms. Se at 12°. (Retgers, 1893.)

Freezing-point data for mixtures of Se + S, Se + Te and Se + S + Te are given by Losana, 1923.

Fusion-point curves for mixtures of selenium and other metals are given by Pelabon (1909). Results for Se + Te are given by Pellini and Vio (1906), and by Hahn and Klinger, 1949.

## Se SELENIUM

### 8r DIPHENYL SELENIUM BROMIDE $(C_6H_5)_2SeBr_2$

THE SYSTEM DIPHENYL SELENIUM BROMIDE - TELLURIUM BROMIDE - WATER AT 25°  
(Pellini, 1906a)

Gms. per 1000 cc. Sat. Sol.		Mol. % $(C_6H_5)_2$ $SeBr_2$ in Cryst. Mixture	Gms. per 100 cc. Sat. Sol.		Mol. % $(C_6H_5)_2$ $SeBr_2$ in Cryst. Mixture
$(C_6H_5)_2TeBr_2$	$(C_6H_5)_2SeBr_2$		$(C_6H_5)_2TeBr_2$	$(C_6H_5)_2SeBr_2$	
18.614	0	0	10.224	14.608	44.89
17.400	1.448	4.91	7.544	19.876	51.18
16.152	4.172	10.51	6.780	18.984	94.25
15.030	6.210	18.21	3.184	17.392	95.82
13.320	8.148	24.98	0	18.984	100
11.940	11.420	34.94			

## F SELENIUM FLUORIDES

Data for the distribution of  $Se^{IV}$  between aqueous HF solutions and ethyl ether are given by Kitahara, 1949 and by Bock and Herrmann, 1956.

### 0 SELENIUM DIOXIDE $SeO_2$

THE SYSTEM  $SeO_2 - H_2O$   
(Manchot and Ortner, 1922)

(Determined by the freezing point method)

t°	Gms. $SeO_2$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $SeO_2$ per 100 gms. sat. sol.	Solid Phase
- 0.2	0.99	Ice	-20	53.60	Ice
- 1.1	4.88	"	-23(e)	57.00	Ice + $SeO_2 \cdot H_2O$
- 5.0	21.83	"	-21	58.0	$SeO_2 \cdot H_2O$
- 8.2	33.00	"	-12.5	61.6	"
- 9.9	37.64	"	- 7.0	63.4	"
-11.3	40.65	"	+ 7.0	68.32	"
-13.0	44.00	"	22.0	72.52	"
-14.9	47.03	"	42.0	77.50	"
-16.5	49.10	"	65.0	82.50	"

Results for the system  $SeO_2 + HBr$  between 0° and 30° are given by Parker and Robinson, 1931.

SOLUBILITY OF SELENIUM DIOXIDE IN SEVERAL SOLVENTS  
(de Coninck, 1906)

Solvent	t°	Gms. SeO <sub>2</sub> per 100 cc. Solvent
Water	11.3 - 15	38.5
Ethyl Alcohol (93%)	14.1	10.2
Methyl Alcohol	11.8	6.66
Acetone	15.3	4.35
Acetic Acid (Glacial)	12.9	1.11

SELENIUM TRIOXIDE SeO<sub>3</sub>

0

THE SYSTEM SeO<sub>3</sub> - H<sub>2</sub>O  
(Dostal, 1955)

S = SeO<sub>3</sub>A = H<sub>2</sub>SeO<sub>4</sub>B = H<sub>4</sub>S<sub>3</sub>O<sub>11</sub>C = H<sub>2</sub>Se<sub>2</sub>O<sub>7</sub>

Wt. % SeO <sub>3</sub>	obs. t° of transition	t° of sat'n. in H <sub>2</sub> O	Solid Phase	Wt. % SeO <sub>3</sub>	obs. t° of transition	t° of sat'n. in H <sub>2</sub> O	Solid Phase
87.10		60.4	A	92.00	17.8	24.4	B
87.30		62.0	A	92.17	17.8	23.7	B
87.42		62.2	A	92.25	17.8	23.1	B
87.50		62.3	A	92.25	12.4	14.9	C (m)
87.57	--	62.4mp	A	92.25	17.8	23.1	B
87.69		61.9	A	92.30	17.8	22.6	B
87.90		60.9	A	92.37	17.8	22.2	B
88.15		59.7	A	92.37	12.5	22.2	B
88.45	12.3	57.8	A	92.45	17.8	22.1	B
88.78	12.4	55.8	A	92.65	17.9	20.7	B
89.25	12.2	52.5	A	92.75	17.8	18.8	B
89.62	12.3	49.3	A	92.8	--	17.8	B+C
89.80	25.3	47.8	A	92.90	17.8	18.2	C
89.80	12.3	47.8	A	93.08	17.8	18.4	C
90.22	25.3	43.5	A	93.15	17.9	18.7	C
90.30	25.3	42.1	A	93.22	17.8	18.7	C
90.51	12.5	39.2	A	93.37	--	18.8mp	C
	25.3		A	93.68		18.6	C
90.55	25.3	37.5	A	93.85		18.4	C
90.63	12.4	37.3	A	94.04	13.2	17.8	C
	25.4		A	94.27	13.4	16.8	C
90.90	25.4	33.0	A	94.50	13.4	15.5	C
90.97	25.4	32.5	A	94.7	--	13.5	C+S
90.97	12.6	32.5	A	94.80	13.4	15.1	S
91.02	25.4	30.9	A	94.93	13.5	20.5	S
91.02	12.5	30.9	A	95.05	13.5	25.9	S
91.13	12.5	29.5	A	95.10	13.5	32.7	S
	25.3		A	95.25	13.6	34.0	S
91.26	25.4	27.7	A	95.37	13.5	43.2	S
91.30	25.4	26.6	A	95.66	13.4	53.0	S
91.37	25.4	25.4mp	B	95.85	13.5	59.6	S
91.4	--	25.4	A+B	95.94	13.3	65.6	S
91.44	12.5	24.3	B	96.51	13.4	79.2	S
91.59		25.1	B	96.72		85.0	S
91.59	12.6	25.1	B	97.50		97.2	S
91.59		19.8	A (m)	98.18		105.6	S
91.65	17.8	25.1	B	98.71		110.6	S
91.80	17.8	24.7	B	99.50		117.3	S
91.80	12.4	15.0	A (m)	99.81		118.8	S
91.9	--	12.4	A+C(m)	100.0		119.8mp	S

(m)=metastable

1447

mp = melting point

## Se SELENIUM

Results of Vuillard, 1957 for the System  $H_2SeO_4 - H_2O$

t°	Wt. % $H_2SeO_4$	Solid Phase
-88	50.3	$H_2SeO_4 \cdot 4H_2O$ + ICE (metastable)
-83.4	49.4	$H_2SeO_4 \cdot 6H_2O$ + ICE (stable)
-68.5	54.8	$H_2SeO_4 \cdot 6H_2O$ + $H_2SeO_4 \cdot 4H_2O$
-58.5	74.1	$H_2SeO_4 \cdot 4H_2O$ + $H_2SeO_4 \cdot H_2O$ (metastable)
-54.5	70.3	$H_2SeO_4 \cdot 4H_2O$ + $H_2SeO_4 \cdot 2H_2O$
-24	77.7	$H_2SeO_4 \cdot 2H_2O$ + $H_2SeO_4 \cdot H_2O$

## Si SILICON

SOLUBILITY IN LEAD, IN ZINC AND IN SILVER  
(Moissan and Siemens, 1904)

In Lead		In Zinc		In Silver	
t°	Gms. Si per 100 Gms. Lead	t°	Gms. Si per 100 Gms. Zinc	t°	Gms. Si per 100 Gms. Silver
1250	0.024	600	0.06	970	9.22 (58.02)
1330	0.070	650	0.15	1150	14.89 (27.66)
1400	0.150	730	0.57	1250	19.26 (19)
1450	0.210	800	0.92	1470	41.46 (16)
1550	0.780	850	1.62		

The silicon which crystallized from the saturated solution in silver was found to be incompletely soluble in HF. The figures in parentheses show the percentage soluble in HF in each case.

Data for the solubility of silicon in liquid gallium between 300°--1420° are given by Keck and Broder, 1953.

## Br SILICON TETRABROMIDE $SiBr_4$

MELTING POINTS OF SILICON TETRABROMIDE - DIOXANE SOLUTIONS  
(Kennard and McCusker, 1948)

Mole % Dioxane	Melting Point	Solid Phase	Mole % Dioxane	Melting Point	Solid Phase	Mole % Dioxane	Melting Point	Solid Phase
0.0	5.4	S	16.3	-5.8	S*	56.4	-4.0	C
0.0	2.3	S*	19.8	-3.9	S	61.2	-2.7	C
4.5	2.9	S	19.8	-7.1	S*	66.9	-1.1	C
8.4	1.2	S	27.0	-6.9	S	70.6	+0.1	C + D
8.4	-2.0	S*	31.1	-8.2	S	75.5	1.7	D
10.0	+0.4	S	31.1	-11.1	S*	80.8	3.6	D
10.0	-3.2	S*	39.5	-11.4	S + C	86.4	6.9	D
12.5	-0.8	S	39	-13.5	S* + C	90.9	7.5	D
12.5	-4.2	S*	44.5	-8.6	C	96.6	10.0	D
16.3	-2.2	S	50.6	-6.0	C	100.0	11.8	D

\* = Metastable

S =  $SiBr_4$

C =  $SiBr_4 \cdot 4(CH_2)_4O_2$

D =  $(CH_2)_4O_2$

Densities, dielectric constants, and polarizabilities of dilute silicon tetrabromide - dioxane solutions and silicon tetrabromide - carbon tetrachloride solutions are also given by Kennard and McCusker, 1948.

Fusion-point data are given for SiBr<sub>4</sub> + SiCl<sub>2</sub> and SiBr<sub>4</sub> + SiI<sub>4</sub> by Raeder, 1933.

SILICON TETRAPHENYL Si(C<sub>6</sub>H<sub>5</sub>)<sub>4</sub>

CH

Freezing-point data for mixtures of silicon tetraphenyl and tin tetraphenyl are given by Pascal (1912).

SILICON TETRACHLORIDE SiCl<sub>4</sub>

Cl

MISCIBILITY OF SiCl<sub>4</sub> WITH ORGANIC SOLVENTS  
(Vol'nov, 1954)

System	t°	Mole % SiCl <sub>4</sub>		
		in original mix	in phase I	in phase II
SiCl <sub>4</sub> -C <sub>2</sub> H <sub>5</sub> OH <sup>a</sup>	-70	25.7	99.9	62.8
	-40	34.8	93.7	64.2
SiCl <sub>4</sub> -C <sub>2</sub> H <sub>7</sub> OH <sup>b</sup>	-70	34.2	88.4	56.8
	-51	46.6	64.7	55.2
SiCl <sub>4</sub> -Ethyl acetoacetate <sup>c</sup>	-70	25.6	98.0	61.8
	-26	32.5	90.1	61.3
	+10	39.0	85.6	61.8
SiCl <sub>4</sub> -Diethyl malonate <sup>d</sup>	-70	27.6	98.1	62.8
	-50	40.0	94.3	67.1
	-36	66.0	89.4	77.7

a, b, c: systems evolved HCl at minimum temperatures of -38°, -48°, +12° respectively.

d: critical point at -32°, 86 mole % SiCl<sub>4</sub>.

FREEZING POINTS IN THE SYSTEM SiCl<sub>4</sub> - SO<sub>2</sub>  
(Bond and Stephens, 1929)

t°	Gms. SiCl <sub>4</sub> per 100 gms. mixture	t°	Gms. SiCl <sub>4</sub> per 100 gms. mixture	t°	Gms. SiCl <sub>4</sub> per 100 gms. mixture
-76.5	1.09	-16.6	19.34	- 6.3	72.07
-77.0	1.97	-12.9	23.18	-12.8	83.12
-79.1	1.97	- 9.2	28.75	-20.1	88.46
-70.2	2.83	- 8.1	30.67	-38.6	94.66
-57.0	4.36	- 6.1	37.44	-46.9	96.03
-46.6	6.33	- 5.1	45.29	-72.4	98.70
-38.4	8.35	- 4.9	52.55	-77.0	98.84
-32.4	10.27	- 4.8	56.71	-79.2	98.84
-27.5	12.37	- 4.8	60.72	-76.5	98.98
-22.0	15.40	- 5.5	68.00	-67.7	100.00



## Si SILICON

Melting point data are given for the following systems:

$\text{SiCl}_4$ + Dioxane	(Kennard and McCusker, 1948)
$\text{SiCl}_4$ + Anisole	(Sisler, et al., 1948; Sisler and Cory, 1947)
$\text{SiCl}_4$ + Phenetole	(Sisler, et al., 1948)
$\text{SiCl}_4$ + Methyl-m-Cresyl Ether	(Sisler, et al., 1948)
$\text{SiCl}_4$ + Diphenyl Ether	(Sisler and Cory, 1947)
$\text{SiCl}_4$ + Diethyl Ether	(Sisler and Mattair, 1948; Sisler, Batey, Pfahler, and Mattier, 1948)
$\text{SiCl}_4$ + Tetrahydrofuran	(Sisler, Batey, Pfahler, and Mattier, 1948)
$\text{SiCl}_4$ + Azobenzene	(Pushin, 1948a)
$\text{SiCl}_4$ + Naphthalene	(Pushin, 1948a)
$\text{SiCl}_4$ + SiI	(Raeder, 1933)
$\text{SiCl}_4$ + $\text{TiCl}_4$	(Nasu, 1933, 1934)
$\text{SiCl}_4$ + $\text{SnCl}_4$	(Sackmann, Schaaf and Arnold, 1958)
Cl $\text{SiCl}_4$ + $\text{TiCl}_4$	(Sackmann, Schaaf and Arnold, 1958)
$\text{SiCl}_4$ + $\text{CCl}_4$	(Sackmann, 1955)

### SILICON METHYL CHLORIDES $\text{SiCl}(\text{CH}_3)_3$ $\text{SiCl}_2(\text{CH}_3)_2$ $\text{SiCl}_3(\text{CH}_3)$

Melting points in the systems  $\text{SiCl}_4$  - diethyl ether,  $\text{SiCl}(\text{CH}_3)_3$  - diethyl ether,  $\text{SiCl}_2(\text{CH}_3)_2$  - diethyl ether and  $\text{SiCl}_3(\text{CH}_3)$  - diethyl ether are given by Sisler and Mattair, 1948.

### TRICHLOROSILANE $\text{SiHCl}_3$

Melting points are given for the systems  $\text{SiHCl}_3$  +  $(\text{C}_2\text{H}_5)_2\text{O}$  and  $\text{SiHCl}_3$  + tetrahydrofuran by Sisler, Schilling and Groves, 1951.

## F SILICON TETRAFLUORIDE $\text{SiF}_4$

SOLUBILITY IN AQUEOUS HYDROFLUORIC ACID SOLUTIONS AT 15°  
(Nikolaev, 1954)

Sat. Sol. Wt. %		Sat. Sol. Wt. %	
HF	$\text{SiF}_4$	HF	$\text{SiF}_4$
71.95	7.95	88.05	1.09
73.18	7.52	91.30	0.42
73.25	7.10	92.05	0.68
78.15	4.55	93.40	0.29
80.00	3.35	95.50	0.15
84.50	1.75	96.00	0.05

## SOLUBILITY IN AQUEOUS HYDROFLUORIC ACID SOLUTIONS AT 15°--Cont.

Results of other authors, quoted by Nikolaev: (17-20°)

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
HF	SiF <sub>4</sub>	Author	HF	SiF <sub>4</sub>	Author
64.75	12.35	M	95.40	0.52	N
63.20	6.45	M	95.60	0.25	N
73.85	8.65	M	96.02	0.08	N
85.00	1.35	N	96.80	0.02	N
87.73	1.89	N	67.00	0.065	N
88.47	0.72	N	97.00	0.052	N
92.20	0.50	M	97.20	0.00	N
93.25	0.70	N	97.50	0.00	N
93.63	0.35	N	98.20	-	N
94.13	0.35	N	98.50	-	N
94.64	0.36	N			

M = Munter, Aepli and Kossatz, 1947

N = Nikolaev and Ivanov, 1936

SOLUBILITY OF SILICON TETRAFLUORIDE IN ORGANIC SOLVENTS AT 27-33° AND A  
TOTAL PRESSURE OF 750 - 760 mm  
(Tarbuton, Egan and Frary, 1930)

Solvent	Gms. SiF <sub>4</sub> per 100	
	cc solvent	gms. sat. sol.
Methyl Alcohol (abs.)	-	32.8
Ethyl Alcohol (96.1 wt. %)	-	39.0
Ethyl Alcohol (abs.)	57.2	36.4
Ethyl Alcohol (96.1 wt. %)	60.8	37.8
Ethyl Alcohol (94.3 wt. %)	61.5	38.1
Ethyl Alcohol (92.6 wt. %)	63.4	38.8
Ethyl Alcohol (91.0 wt. %)	63.9	39.0
Iso propyl alcohol (98%)	39.4	28.2
Amyl Alcohol	20.9	17.3
Glycol	-	26.2
Di ethylene glycol	-	17.6
Glycerol	-	5.7
Acetone (anhydrous)	3.2	3.1
Acetic Acid (glacial)	1.1	1.1
Pyruvic Acid (38 - 45%)	-	4.4

SILICON POTASSIUM HEXAFLUORIDE SiK<sub>2</sub>F<sub>6</sub>

K

(See also potassium fluosilicate)

100 cc. sat. sol. of silicon potassium hexafluoride in water contain 0.00544 gm. SiK<sub>2</sub>F<sub>6</sub> at 17°. (von Hevesy, Christiansen and Berglund, 1925.)

## Si SILICON

### I SILICON IODIDES $\text{Si}_2\text{I}_6$ , $\text{SiI}_4$

SOLUBILITY IN CARBON DISULFIDE  
(Friedel and Lachburg, 1869; Friedel, 1869)

100 gms.  $\text{CS}_2$  dissolve 19 gms.  $\text{Si}_2\text{I}_6$  at 19°.  
100 gms.  $\text{CS}_2$  dissolve 26 gms.  $\text{Si}_2\text{I}_6$  at 27°.  
100 gms.  $\text{CS}_2$  dissolve 2.2 gms.  $\text{SiI}_4$  at 27°.

### O SILICON DIOXIDE $\text{SiO}_2$

#### SOLUBILITY OF AMORPHOUS SILICA IN WATER

The results of various authors are in very good agreement from 0° to 200°. Alexander, Heston and Iler, 1954 plotted their data and those of Struckman (1885), Gardner, Szychalski (1938), Hitchen (1935) Lenher and Merrill (1917), Jephcott and Johnson (1950). The results of Morachevskii and Piryutko (1956) also agree. The degree of hydration and the conditions of preheating affect the rate of attainment of equilibrium. The following values were read from the average plot.

t°	Wt. % $\text{SiO}_2$ in sat. sol.	t°	Wt. % $\text{SiO}_2$ in sat. sol.
0	0.003	100	0.043
25	0.012	125	0.053
50	0.023	150	0.062
75	0.033	175	0.072
		200	0.081

#### SOLUBILITY OF $\text{SiO}_2$ AT VARIOUS pH (Alexander, Heston and Iler, 1954)

(HCl or NaOH added; also see tables following.)

pH	Wt. % $\text{SiO}_2$ in sat. sol.	pH	Wt. % $\text{SiO}_2$ in sat. sol.
1	0.015	7	0.011
2	0.016	8	0.012
3	0.015	9	0.015
4	0.014	10	0.035
6	0.011	11	0.33

#### SOLUBILITY OF SILICA IN AQUEOUS SOLUTIONS OF ACIDS (Lenher and Merrill, 1917)

A platinum bottle and stirrer were used. The silica was prepared by adding silicon tetrachloride to water. The gel thus formed was washed until free of HCl and dried between filter papers. Conductivity water was used and equilibrium was reached within 24 hours. The saturated solution was evaporated to dryness in a platinum dish. The residue was

weighed and the silica volatilized with  $\text{HF}$  +  $\text{H}_2\text{SO}_4$ . The difference was considered to show "the amount of silica which had changed from an un-filterable to a filterable state of division."

<u>Results for Aqueous HCl</u>				<u>Results for Aqueous</u>	
<u>At 25°</u>		<u>At 90°</u>		<u>H<sub>2</sub>SO<sub>4</sub> at 90°</u>	
% HCl	Gm. SiO <sub>2</sub> per 50 cc Sol.	% HCl	Gm. SiO <sub>2</sub> per 50 cc Sol.	% H <sub>2</sub> SO <sub>4</sub>	Gm. SiO <sub>2</sub> per 50 cc Sol.
0	0.0080	0	0.0213	3.9	0.0211
3	0.00665	2	0.0198	7.3	0.0186
6.3	0.00465	3	0.0186	15.6	0.0112
11.1	0.00245	5.4	0.0152	25.4	0.0058
18.9	0.0008	7.6	0.0115	36	0.0034
25.1	0.0006	10	0.0091	46.9	0.0013
34.6	0.0003	13.6	0.0056	55.6	0.0005
		18.6	0.0029	71	0.0004

At 90°, a slow current of  $\text{CO}_2$  through the solutions did not affect the results. Ignited silica reaches equilibrium very slowly as compared with silica gel. The true solubility of ignited silica is probably the same as that of gelatinous silica.

Data for the solubility of  $\text{SiO}_2$  in aqueous  $\text{H}_3\text{PO}_4$  at 50° and 90° are given by Sveshnikova and Danilova, 1957.

#### SOLUBILITY OF SILICA HYDRATE IN 3.0 NORMAL AMMONIA AT 18° (Schwarz, 1916)

The hydrate was prepared by conducting silicon fluoride in water. It was washed with water and dried at 150°. It contained 9.04%  $\text{H}_2\text{O}$ . About 0.12 gm. quantities were shaken with 25 cc. portions of 3.0 n ammonia and allowed to stand. The amount dissolved per 25 cc. increased with the time of shaking from 0.0144 gm. after 4 hours to 0.0522 gm. after 228 hours. The curve drawn from the results showed that the maximum solubility was reached in about 200 hours. The solubility varies with the water content and modification of the silica. No ammonium silicate was formed.

Data for the rate of solubility of silica in aqueous  $\text{NaOH}$  are given by Holt and King, 1955. Rates of solution in aqueous  $\text{Na}_2\text{CO}_3$  and aqueous  $\text{NaHCO}_3$  at 20° are given by Tregan. For other data in aqueous  $\text{NaOH}$ ,  $\text{KOH}$  and quaternary hydroxides see Merrill and Spencer, 1951 and Correns, 1941.

Data for the solubility of  $\text{SiO}_2$  in  $\text{NH}_4\text{F}$  solutions is given by Dixon, 1946.

# Si SILICON

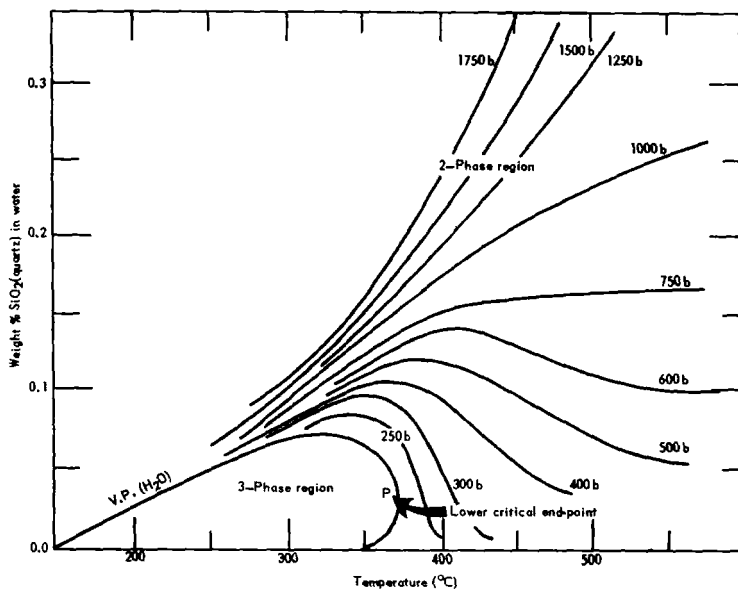
## SOLUBILITY OF SILICA IN WATER AT HIGH TEMPERATURES AND PRESSURES (Kennedy, 1950)

Results in agreement with these are given by Morey and Hesselgesser, 1951, by Wyart and Sabatier, 1955, and by Franke, 1950, Schloemer, 1952.

t°	Gms. SiO <sub>2</sub> per 100 gms. sat. sol.		t°	Gms. SiO <sub>2</sub> per 100 gms. sat. sol.	
	Quartz	Amorphous		Quartz	Amorphous
100	-	0.038	300	0.068	0.168
150	0.003	0.062	350	0.070	0.230
200	0.024	0.090	374	0.023	-
250	0.049	0.126			

## TWO PHASE SOLUBILITY OF QUARTZ IN STEAM

This system has been extensively studied by Kennedy (1950), as shown in the following diagram.



## Results of Khitarov, 1956 at higher pressures:

Pressure, bars	Wt. % SiO <sub>2</sub> in saturated solution in steam			
	400°	450°	500°	600°
1000	-	-	0.19 - 0.26	0.30
2000	0.22 - 0.23	-	-	-
3000	0.26	0.43	-	1.20
4000	0.30	-	-	-

For additional data at high temperatures and pressures see Styrikovich, Khaibullin and Tskhviraashvili, 1955 (up to 180 atm.); Mosebach, 1955 (review and thermodynamics); Wyart and Sabatier, 1954 (up to 400°, 480 bars); Morey, 1953 (400 - 600°, up to 30,000 p.s.i.); Gillingham, 1948; Morey and Hesselgesser, 1951 (up to 500°, 15,000 p.s.i.); Mosebach, 1956; Jasmund 1953. See also Tuttle and England, 1955; Wasserburg, 1958, 1958a, Wood, 1958.

The effect of particle size on the solubility of amorphous SiO<sub>2</sub> was determined by Alexander, 1957. The effect of particle size and formation of polysilicic acid is discussed by Baumann, 1955. Stober, 1956 and Greenberg and Price, 1957 discuss the mechanism of dissolution in terms of polyacids. Holt and King, 1955 discuss leaching of surface layers of SiO<sub>2</sub>.

SOLUBILITY OF QUARTZ IN ALKALINE SOLUTIONS  
(Friedman, 1948) (Tuttle and Friedman, 1948)

Gms. SiO<sub>2</sub> per liter of Aqueous NaOH or Na<sub>2</sub>CO<sub>3</sub> Solution

Solvent % Na <sub>2</sub> O	300°		350°		400°		450°	
	NaOH	Na <sub>2</sub> CO <sub>3</sub>	NaOH	Na <sub>2</sub> CO <sub>3</sub>	NaOH	Na <sub>2</sub> CO <sub>3</sub>	NaOH	Na <sub>2</sub> CO <sub>3</sub>
1	20	5	25	13	35	22	35	24
5	135	28	152	50	155	90	163	124
15	514	43	515	60	560	105	560	285

Weighed amounts of pure quartz and sodium carbonate were added to 10 ml. of water in a pressure bomb and rocked up to 150 hours at each temperature. The data for NaOH are from Tuttle and Friedman.

Additional data by Friedman, 1949 covers NaOH solutions containing 1 - 13% Na<sub>2</sub>O from 250 - 450°.

For data on the system SiO<sub>2</sub> - Na<sub>2</sub>O - H<sub>2</sub>O up to 600°, 2000 bars see Morey, 1953.

SiO<sub>2</sub> solubilities in dilute K<sub>2</sub>CO<sub>3</sub>, Na<sub>2</sub>CO<sub>3</sub>, NaOH, Li<sub>2</sub>CO<sub>3</sub>, KCl and NaCl solutions at 500°, 500 bars are given by Wyart and Sabatier, 1955.

A review of SiO<sub>2</sub> solubilities near the critical point is given by Booth and Bidwell, 1948.

## SI SILICON

### SOLUBILITY OF SILICA IN MELTED CALCIUM CHLORIDE (Arndt and Lowenstein, 1909)

t°	Gms. SiO <sub>2</sub> per 100 Gms. Sat. Solution
800	2.5
850	3.8
900	5.4
950	7.6

## W SILICO TUNGSTIC ACID H<sub>8</sub>SiW<sub>12</sub>O<sub>42</sub>

100 gms. H<sub>2</sub>O dissolve 961.5 crystallized silico tungstic acid at 18°, and the solution has Sp. Gr. 2.843.

## Sm SAMARIUM

### BrO SAMARIUM BROMATE Sm(BrO<sub>3</sub>)<sub>3</sub>

#### SOLUBILITY OF SAMARIUM BROMATE IN WATER (James, Fogg, McIntire, Evans and Donovan, 1927)

t°	Gms. per 100 gms. sat. sol.		t°	Gms. per 100 gms. sat. sol.	
	Sm(BrO <sub>3</sub> ) <sub>3</sub> ·9H <sub>2</sub> O	Sm(BrO <sub>3</sub> ) <sub>3</sub>		Sm(BrO <sub>3</sub> ) <sub>3</sub> ·9H <sub>2</sub> O	Sm(BrO <sub>3</sub> ) <sub>3</sub>
0	33.24	25.50	25	53.97	41.40
5	37.58	28.83	30	57.54	44.14
10	42.02	32.23	35	61.12	46.88
15	46.21	35.45	40	64.67	49.61
20	50.16	38.48	45	68.16	52.28

Solid phase Sm(BrO<sub>3</sub>)<sub>3</sub>·9H<sub>2</sub>O in all cases.

### CH SAMARIUM ACETATE Sm(CH<sub>3</sub>COO)<sub>3</sub>·3H<sub>2</sub>O

100 gms. sat. solution of samarium acetate in water contain 13.05 gm. Sm(CH<sub>3</sub>COO)<sub>3</sub> at 25°. (Meyer and Muller, 1920.)

### SAMARIUM LACTATE Sm(C<sub>3</sub>H<sub>5</sub>O<sub>3</sub>)<sub>3</sub>·1½H<sub>2</sub>O

1000 cc. sat. solution of samarium lactate in water contain 11.47 gms. Sm(C<sub>3</sub>H<sub>5</sub>O<sub>3</sub>)<sub>3</sub>·1½H<sub>2</sub>O at 20°. (Jantsch, 1926.)

**Samarium Glycolate**  $\text{Sm}(\text{C}_2\text{H}_3\text{O}_3)_2$ 

100 gms.  $\text{H}_2\text{O}$  dissolve 0.6373 gm.  $\text{Sm}(\text{C}_2\text{H}_3\text{O}_3)_2$  at  $20^\circ$ . (Jantsch and Grünkraut, 1912-13.)

**Samarium Sulfonates**

## SOLUBILITY IN WATER

Salt and Formula	$t^\circ$	Gm. Anhydrous Salt per 100 Gms. $\text{H}_2\text{O}$	Authority
Samarium m Nitrobenzene Sulfonate $\text{Sm}[\text{C}_6\text{H}_4(\text{NO}_2)\text{SO}_3]_3 \cdot 7\text{H}_2\text{O}$	15	50.9	Holmberg, 1907
Samarium Bromonitrobenzene Sulphonate $\text{Sm}[\text{C}_6\text{H}_3(1)\text{Br}(4)\text{NO}_2(2)\text{SO}_3]_3 \cdot 10\text{H}_2\text{O}$	25	7.84	Katz and James, 1913

**Samarium Acetylacetonate**  $\text{Sm}[\text{CH}(\text{COCH}_3)_2]_3$ SOLUBILITY IN ORGANIC SOLVENTS  
(Erametsa and Hamala, 1958)

Solvent	$t^\circ$	Gms. $\text{Sm}_2\text{O}_3$ per 1000 ml.	Solvent	$t^\circ$	Gms. $\text{Sm}_2\text{O}_3$ per 1000 ml.
carbon tetrachloride	20	0.66	acetylacetonate	20	1.74
chloroform	20	2.9	"	30	2.0
acetone	20	4.2	"	40	2.3
methanol	20	100	"	50	2.5
ethanol	20	5.5	"	60	2.8
butanol	20	5.2	"	75	5.5

**Samarium Sorbate**  $\text{Sm}(\text{C}_5\text{H}_7\text{COO})_3$ 

A sat. sol. contains 0.001432 moles per liter at  $20^\circ$ . (Bergamini, 1949.)

**Samarium Sodium Ethylenediamine Tetraacetate**  $\text{Na}[\text{SmC}_2\text{H}_4\text{N}_2(\text{COO})_4]$ 

At  $25^\circ$  0.066 moles of anhydrous salt are dissolved in 1000 gms. of sat. solu in water. (Moeller, Moss and Marshall, 1955.)



# Si SAMARIUM

## CO SAMARIUM OXALATE $\text{Sm}_2(\text{C}_2\text{O}_4)_3 \cdot 10\text{H}_2\text{O}$

One liter  $\text{H}_2\text{O}$  dissolves 0.00054 gm.  $\text{Sm}(\text{C}_2\text{O}_4)_3$  at  $25^\circ$ , determined by the electrolytic conductivity method. (Rimbach and Schubert, 1909.)

### SOLUBILITY OF SAMARIUM OXALATE IN AQUEOUS SOLUTIONS OF ACIDS AT $25^\circ$ (Sarver and Brinton, 1927)

Composition of aq. solvent in normality	Gms. $\text{Sm}_2(\text{C}_2\text{O}_4)_3$ per 100 gms.		Composition of aq. solvent in normality	Gms. $\text{Sm}_2(\text{C}_2\text{O}_4)_3$ per 100 gms.	
	sat.	sol.		sat.	sol.
0.1008 HCl	0.0052	4.00	HCl + sat. $(\text{COOH})_2$	0.0285	
0.2576 "	0.0181	6.00	" + " "	0.1165	
0.5702 "	0.0267	0.2482	$\text{HNO}_3$	0.0189	
0.978 "	0.0712	1.992	"	0.3408	
1.484 "	0.1452	4.054	"	1.062	
2.000 "	0.2296	2.00	" + 0.1 $(\text{COOH})$	0.0905	
0.978 " + 0.1 $(\text{COOH})_2$	0.0061	3.03	" + 0.1 "	0.2898	
2.000 " + 0.1 "	0.0421	4.00	" + 0.1 "	0.6327	
2.865 " + 0.1 "	0.1228	2.00	" + 0.5 "	0.0134	
3.965 " + 0.1 "	0.3202	3.03	" + 0.5 "	0.0504	
0.978 " + 0.5 "	0.0010	4.00	" + 0.5 "	0.1603	
2.000 " + 0.5 "	0.0061	0.086	$\text{H}_2\text{SO}_4$	0.0090	
2.865 " + 0.5 "	0.0175	0.419	"	0.424	
3.965 " + 0.5 "	0.0594	0.958	"	0.1042	
1.484 " + sat. "	0.0031	1.846	"	0.2189	

### SOLUBILITY OF SAMARIUM OXALATE IN AQUEOUS SOLUTIONS OF NITRIC AND OXALIC ACIDS AT $90^\circ$

Composition of aq. solvent in normality	Gms. $\text{Sm}_2\text{O}_3$ per 100 cc sat. sol.		Composition of aq. solvent in normality	Gms. $\text{Sm}_2\text{O}_3$ per 100 cc sat. sol.	
2.5 $\text{HNO}_3$	1.878		2.5 + 5% $(\text{COOH})_2$	0.5457	
5.0 $\text{HNO}_3$	5.675		5.0 + 5% $(\text{COOH})_2$	4.1520	

### SOLUBILITY OF SAMARIUM OXALATE IN AQUEOUS SOLUTIONS OF SULFURIC ACID AT $25^\circ$ (Wirth, 1912)

Solid Phase  $\text{Sm}_2(\text{C}_2\text{O}_4)_3 \cdot 10\text{H}_2\text{O}$  in all cases.

Normality of Aq. $\text{H}_2\text{SO}_4$	Gm. $\text{Sm}_2(\text{C}_2\text{O}_4)_3$ per 100 Gms. Sat. Sol.		Normality of Aq. $\text{H}_2\text{SO}_4$	Gm. $\text{Sm}_2(\text{C}_2\text{O}_4)_3$ per 100 Gms. Sat. Sol.	
1	0.1015		2.8	0.3886	
1.445	0.1804		4.32	0.7008	
1.93	0.2254		6.175	1.072	

SAMARIUM CHLORIDE  $\text{SmCl}_3 \cdot 6\text{H}_2\text{O}$ 

Cl

SOLUBILITY IN WATER AND IN AQUEOUS HYDROCHLORIC ACID  
(Williams, Fogg and James, 1925)

Saturation was secured by constant rotation for 9 hours or more and approaching equilibrium from above and from below. Approximately 1.0 cc quantities of the saturated solutions were diluted to about 150 cc and precipitated with oxalic acid. The precipitate was filtered and the residue ignited and weighed.

Results for Water			Results for Aq. HCl of d = 1.1051		
t°	Gms. $\text{SmCl}_3$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{SmCl}_3$ per 100 gms. sat. sol.	Solid Phase
10	48.02	$\text{SmCl}_3 \cdot 6\text{H}_2\text{O}$	10	21.84	$\text{SmCl}_3 \cdot 6\text{H}_2\text{O}$
20	48.29	"	20	22.42	"
30	48.60	"	30	23.97	"
40	49.20	"	40	25.52	"
50	49.98	"	50	27.49	"

100 gms. pyridine dissolve 6.38 gms.  $\text{SmCl}_3$  at 15°. (Matignon, 1906, 1909.)

SAMARIUM CHROMATE  $\text{Sm}_2(\text{CrO}_4)_3 \cdot 8\text{H}_2\text{O}$ 

CrO

100 gms. sat. solution of samarium chromate in water contain 0.043 gm.  $\text{Sm}_2(\text{CrO}_4)_3$  at 25°. (Britton, 1924.)

SAMARIUM NITRATE  $\text{Sm}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$ 

NO

SOLUBILITY OF SAMARIUM NITRATE IN AQUEOUS SOLUTIONS OF NITRIC ACID  
(Quill and Robey, 1937)

Results at 25°			Results at 50°			
Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
Sm(NO <sub>3</sub> ) <sub>2</sub>	HNO <sub>3</sub>			Sm(NO <sub>3</sub> ) <sub>3</sub>	HNO <sub>3</sub>	
58.95	0.0	Sm(NO <sub>3</sub> ) <sub>3</sub> ·6H <sub>2</sub> O <sup>a</sup>	1.939	64.81	0.0	Sm(NO <sub>3</sub> ) <sub>3</sub> ·6H <sub>2</sub> O
52.08	6.15	"	1.916	62.97	2.12	"
46.52	11.34	"	1.859	57.57	7.53	"
16.40	44.38	"	-	45.05	22.38	"
14.20	48.40	"	1.648	33.20	36.40	"
13.64	51.58	"	1.664	30.22	47.52	" + Sm(NO <sub>3</sub> ) <sub>3</sub> ·4H <sub>2</sub> O
			1.638	27.89	46.21	Sm(NO <sub>3</sub> ) <sub>3</sub> ·4H <sub>2</sub> O(?)

<sup>a</sup>density of sat. solution = 1.782

## Sm SAMARIUM

### DISTRIBUTION OF SAMARIUM NITRATE BETWEEN WATER AND n-HEXYL ALCOHOL AT 25° (Templeton, 1949)

The salt was prepared from "pure" samarium oxide and probably contained excess nitric acid.

Wt. % $\text{Sm}_2\text{O}_3$ in		Wt. % $\text{Sm}_2\text{O}_3$ in	
Aqueous Phase	Alcohol Phase	Aqueous Phase	Alcohol Phase
30.2	5.88	22.7	0.64
28.0	3.33	20.6	.38
25.1	1.37	18.6	.20

Data for the distribution of  $\text{Sm}(\text{NO}_3)_3$  between aqueous  $\text{HNO}_3$  solutions and tributyl phosphate are given by Knapp, Smutz and Spedding, 1956 and by Weaver, Kappelmann and Topp, 1953.

## NO SAMARIUM DOUBLE NITRATES

SOLUBILITY IN CONCENTRATED  $\text{HNO}_3$  OF  $d_{16} = 1.325$  AT 16°  
(Jantsch, 1912)

	Gms. Hydrated Salt per 100 cc. Sat. Sol.
Samarium Magnesium Nitrate $[\text{Sm}(\text{NO}_3)_6] \cdot \text{Mg}_3 \cdot 24\text{H}_2\text{O}$	24.55
Samarium Nickel Nitrate $[\text{Sm}(\text{NO}_3)_6] \cdot \text{Ni}_3 \cdot 24\text{H}_2\text{O}$	29.11
Samarium Cobalt Nitrate $[\text{Sm}(\text{NO}_3)_6] \cdot \text{Co}_3 \cdot 24\text{H}_2\text{O}$	34.27
Samarium Zinc Nitrate $[\text{Sm}(\text{NO}_3)_6] \cdot \text{Zn}_3 \cdot 24\text{H}_2\text{O}$	36.47
Samarium Manganese Nitrate $[\text{Sm}(\text{NO}_3)_6] \cdot \text{Mn}_3 \cdot 24\text{H}_2\text{O}$	50.04

## OH SAMARIUM HYDROXIDE $\text{Sm}(\text{OH})_3$

The Ksp is  $2 \times 10^{-24}$ . (Korenman, 1955.);  $8.4 \times 10^{-23}$  (Moeller and Fogel, 1951);  $6.8 \times 10^{-22}$  (Moeller and Kremens, 1944) (all at 25°)

## PO SAMARIUM DIMETHYL PHOSPHATE $\text{Sm}_2[(\text{CH}_3)_2\text{PO}_4]_6$

100 gms.  $\text{H}_2\text{O}$  dissolve 35.2 gms.  $\text{Sm}_2(\text{CH}_3)_2\text{PO}_4$  at 25° and about 10.8 gms. at 95°. (Morgan and James, 1914.)

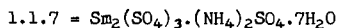
## SO SAMARIUM SULFATE $\text{Sm}_2(\text{SO}_4)_3$

### SOLUBILITY IN WATER

t°	Gms. $\text{Sm}_2(\text{CO}_4)_3 \cdot 8\text{H}_2\text{O}$ per 100 gms. $\text{H}_2\text{O}$	
20	2.67	(Jackson and Reinacker, 1930)
25	1.488	(Spedding and Jaffe, 1954)
40	1.99	(Jackson and Reinacker, 1930)

SOLUBILITY IN AQUEOUS SOLUTIONS OF AMMONIUM SULFATE AT 25°  
(Keyes and James, 1914)

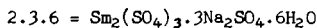
Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Sm <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>		(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Sm <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	
0.03	2.1	Sm <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	32.5	0.9	1.1.7
0.8	2	"	46.3	1	"
1.1	2.8	" + 1.1.7	77.5	1.3	" + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
1.9	1.5	1.1.7	77.3	0.3	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
7.4	0.8	"	76.8	0.6	"
18.8	0.8	"			



50

SOLUBILITY IN AQUEOUS SOLUTIONS OF SODIUM SULFATE AT 25°  
(Keyes and James, 1914)

Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase
Na <sub>2</sub> SO <sub>4</sub>	Sm <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>		Na <sub>2</sub> SO <sub>4</sub>	Sm <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	
-	2.05	Sm <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	10.51	0.012	2.3.6
0.1	2	"	14.71	0.010	"
0.5	0.11	2.3.6	20.02	0.012	"
1.9	0.03	"	23.68	0.018	"
6.44	0.016	"	27.40	0.011	"



100 cc. anhydrous hydrazine dissolve 1 gm. Sm<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> at room temperature. (Welsh and Broderson, 1915.)

SAMARIUM SELENATE Sm<sub>2</sub>(SeO<sub>4</sub>)<sub>3</sub>·8H<sub>2</sub>O

SeO

SOLUBILITY OF SAMARIUM SELENATE IN WATER  
(Friend, 1941)

The solid phase is Sm<sub>2</sub>(SeO<sub>4</sub>)<sub>3</sub>·8H<sub>2</sub>O throughout.

t°	Gms. Sm <sub>2</sub> (SeO <sub>4</sub> ) <sub>3</sub> per 100 gms. Sat. Sol.	t°	Gms. Sm <sub>2</sub> (SeO <sub>4</sub> ) <sub>3</sub> per 100 gms. Sat. Sol.
16.6	33.60	50.0	22.15
25.0	30.21	55.0	21.13
35.2	26.42	64.6	18.62
45.0	23.56	80	14.00

**Sm SAMARIUM**

**WO SAMARIUM TUNGSTATE  $\text{Sm}_2(\text{WO}_4)_3$**

**SOLUBILITY OF SAMARIUM TUNGSTATE IN WATER**  
(Vickery, 1949)

	Gms. $\text{Sm}_2(\text{WO}_4)_3$ per 100 ml.	
	20°	100°
Unignited	0.025	0.032
Ignited	0.003	0.004

**Sn TIN**

**SOLUBILITY OF TIN IN RAW MILK**  
(Quam, 1929)

Highly polished 4 x 7.5 cm. strips of tin were each immersed in 50 cc portions of raw milk and rocked 46 times per minute for 30 minutes. The loss in weight of the Sn strips was determined and the results expressed as Mgs. Sn dissolved per sq. decimeter of surface exposed.

t°	Mg. Sn dissolved per sq. dm. of surface
20-80	None
85	0.378
95	0.516

Melting point data for the system Sn + SnS are given by Anderson and Ridge, 1943. For the systems Sn + SnBr<sub>2</sub> and Sn + SnCl<sub>2</sub> see Corbett and von Winbush, 1955.

**Br STANNOUS BROMIDE  $\text{SnBr}_2$**

**SOLUBILITY IN ETHYL ETHER**  
(Sisler, Schilling and Groves, 1951)

t°	Mole % $\text{SnBr}_2$ in sat. sol.
7	52
20	80
30	100

Fusion-point data are given for  $\text{SnBr}_2 + \text{SnI}_2$  by Karantissis, 1927.

STANNIC BROMIDE  $\text{SnBr}_4$ 

Br

## MELTING POINTS IN SYSTEMS OF STANNIC BROMIDE WITH ORGANIC COMPOUNDS\*\*

(Kurnakov and Woskressenskaya, 1937)

(Kurnakov and Sternin, 1936)

With $(\text{COOCH}_3)_2$			With $(\text{CH}_2\text{COOCH}_3)_2$			With $\text{CH}_3\text{COOC}_2\text{H}_5$		
Mole % $\text{SnBr}_4$	$t^\circ$	Solid Phase	Mole % $\text{SnBr}_4$	$t^\circ$	Solid Phase	Mole % $\text{SnBr}_4$	$t^\circ$	Solid Phase
0	54	A	0	18.4	C	0	-83.6	E
10	50.2	A	5	17.0	C	1.41	-91.5	E + F
20-85	48	A*	9	15.6	C + D	5.00	-75.25	F
95	30.2	A	10	21.8	D	10.00	-54.50	F
97	28.7	A + B	20	32.2	D	20.00	-18.0	F
100	29.5	B	30	35.0	D	29.23	- 8.0	F
			45	36.6	D	31.80	- 7.0	F + G
20	60.1	2L	50	36.8	D	32.00	- 3.0	G
30	72	2L	60	36.3	D	40.00	+ 2.5	G
40	78	2L	70	35.0	D	50.00	5.7	G
50	80	2L	80	32.5	D	57.50	3.8	G
60	78	2L	90	27.7	D	58.50	2.8	G + B
70	72	2L	92	25.5	D + B	75.00	15.2	B
80	60.1	2L	100	29.5	B	100.00	29.9	B

A =  $(\text{COOCH}_3)_2$     B =  $\text{SnBr}_4$     C =  $(\text{CH}_2\text{COOCH}_3)_2$     D =  $\text{SnBr}_4 \cdot (\text{CH}_2\text{COOCH}_3)_2$ E =  $\text{CH}_3\text{COOC}_2\text{H}_5$     F =  $\text{SnBr}_4 \cdot 3\text{CH}_3\text{COOC}_2\text{H}_5$     G =  $\text{SnBr}_4 \cdot \text{CH}_3\text{COOC}_2\text{H}_5$ 

A\*  $(\text{COOCH}_3)_2$  at this temperature the solid phase melts to form two immiscible liquids which have an upper consolute point at  $80^\circ$ . The composition of the conjugate pairs are listed beneath the compositions of solid - liquid equilibrium and are marked "2L".

\*\*The densities, viscosities, and conductivities of these systems were also determined.

THE SYSTEM  $\text{SnBr}_4 - \text{SO}_2$  (LIQUID)

(Bond and Beach, 1926)

The synthetic method was used and a special procedure was devised to prevent contact with moisture.

$t^\circ$	% $\text{SnBr}_4$	Solid Phase	$t^\circ$	% $\text{SnBr}_4$	Solid Phase
29.45	100.00	$\text{SnBr}_4$	28.70	91.65	liquid layer
24.90	98.74	"	34.25	89.81	"
21.15	97.30	"	42.60	85.54	"
18.80	96.24	"	45.75	82.49	"
18.00	95.62	"	47.25	80.31	"
16.60	94.12	"	47.70	78.97	"
16.55Q	94.07	" + liquid layer	48.60	75.14	"
18.33	93.67	liquid layer	48.6ct	71.38	"
23.60	92.75	"	48.50	64.00	"

Q = quad. pt.

(Cont.)

ct = critical temperature

THE SYSTEM  $\text{SnBr}_4 - \text{SO}_2$  (LIQUID)--Cont.

$t^\circ$	% $\text{SnBr}_4$	Solid Phase	$t^\circ$	% $\text{SnBr}_4$	Solid Phase
46.30	52.83	liquid layer	5.45	10.61	$\text{SO}_2$
41.67	43.60	"	3.25	9.45	"
39.75	40.63	liquid layers	2.5	8.93	"
25.00	26.09	"	- 3.5	6.29	"
*18.42	21.67	"	- 5.0	5.37	"
16.3 Q	21.67	" + $\text{SO}_2$	-17.1	2.97	"
*16.6	20.39	"	-21.8	2.41	"
* 8.0	16.55	" + $\text{SO}_2$	-24.0	1.88	"
13.2 }		"	-37.7	0.92	"
* 1.8	14.08	" + $\text{SO}_2$	-45.7	0.58	"
10.7 }		"	-53.05	0.39	"
Br -17.8*	11.88	" + $\text{SO}_2$	*unstable points		
7.1 }		"			

Q = quad. pt.

Bond and Belton, 1945 reinvestigated the system  $\text{SnBr}_4 - \text{SO}_2$  and found the compound  $2\text{SnBr}_4 \cdot \text{SO}_2$ . This is identical in properties and composition with the heavy liquid layer found previously.

The densities and viscosities of solutions of  $\text{SnBr}_4$  in the following solvents at various temperatures were determined by:

(Kurnakov and Sternin, 1936)

Ethyl Formate Methyl Oxalate  
Ethyl Ether Ethyl Malonate  
Methyl Acetate Ethyl Ester of Ethyl Malonic Acid  
Methyl " " " " " "

(Kurnakov and Woskressenskaya, 1937)

$\text{CO}(\text{OCH}_3)_2$   $\text{C}_2\text{H}_5\text{OH}$   
 $\text{CO}(\text{OC}_2\text{H}_5)_2$   $\text{C}_6\text{H}_5\text{OH}$   
 $\text{B}(\text{OCH}_3)_3$   $(\text{C}_2\text{H}_5)_2\text{S}$   
 $\text{B}(\text{OC}_2\text{H}_5)_3$

Melting points have been determined for:

$\text{SnBr}_4 + \text{SnCl}_4$  (Raeder, 1927)  
 $\text{SnBr}_4 + \text{BBr}_3$  (Adamsky and Wheeler, Jr., 1954)  
 $\text{SnBr}_4 + (\text{C}_2\text{H}_5\text{O})_4\text{Si}$  (Bol'nov, 1955)  
 $\text{SnBr}_4 + \text{TiBr}_4$  (Eingorn, 1950)  
 $\text{SnBr}_4 + \text{O}-\text{CH}_2\text{C}_6\text{H}_5\text{CN}$  (Pushin, Ristic, Parchomenko, and Ubovic, 1942)  
 $\text{SnBr}_4 + \text{Trinitrotoluene}$  (Pushin, et al., 1947)  
 $\text{SnBr}_4 + \text{BrCH}_2\text{CO}_2\text{H}$  (Sumarokova and Khakhlova, 1956)  
 $\text{SnBr}_4 + \text{Benzene}$

STANNOUS CUPFERRATE  $\text{Sn}(\text{C}_6\text{H}_5\text{N}(\text{NO}).\text{O})_2$

STAMMIC CUPFERRATE  $\text{Sn}(\text{C}_6\text{H}_5\text{N}(\text{NO}).\text{O})_4$

(Nitroso  $\beta$  Phenyl Hydroxylamine)

CH

One liter  $\text{H}_2\text{O}$  dissolve 0.000035 gm. atom of the SnII compound (=0.0042 gm.) at  $18^\circ$ .

One liter  $\text{H}_2\text{O}$  dissolve 0.000021 gm. atom of the Sn IV compound (=0.0024 gm.) at  $18^\circ$ . (Pinkus and Martin, 1927.)

The solubility product of the Sn IV compound is  $7.5 \times 10^{-35}$  (Pyatnitski, 1946).

TIN TETRAPHENYL (Stannic)  $\text{Sn}(\text{C}_6\text{H}_5)_4$

CH

Freezing-point data for  $\text{Sn}(\text{C}_6\text{H}_5)_4 + \text{Si}(\text{C}_6\text{H}_5)_4$  are given by Pascal (1912).

TIN OXALATE (Stannous)  $\text{Sn}(\text{COO})_2$

CO

100 gms. 95 per cent formic acid dissolve 0.16 gm.  $\text{Sn}(\text{COO})_2$  at  $19^\circ$ . (Aschan, 1913.)

Data for the extraction of  $\text{Sn}^{\text{IV}}$  from aqueous solutions by 8-hydroxy-quinoline are given by Gentry and Sherrington, 1950.

TIN CHLORIDE (Stannous)  $\text{SnCl}_2$

Cl

100 gms.  $\text{H}_2\text{O}$  dissolve 83.9 gms.  $\text{SnCl}_2$  at  $0^\circ$  and 269.8 gms. at  $15^\circ$ . Sp. Gr. of Solutions 1.532 and 1.827 respectively. (Engel, 1889; Michel and Krafft, 1851.)



# Sn TIN

## SOLUBILITY OF STANNOUS CHLORIDE IN AQUEOUS SOLUTIONS OF HYDROCHLORIC ACID AT 0° (Engel)

Milligram Mols. per 10 cc. Solution		Sp.Gr. of Solution	Grams per 100 cc. Solution	
HCl	$\frac{1}{2}\text{SnCl}_2$		HCl	$\text{SnCl}_2$
0	74.0	1.532	0.0	70.26
6.6	66.7	1.489	2.405	63.33
13.54	63.75	1.472	4.935	60.52
24.8	68.4	1.524	9.04	64.95
34.9	81.2	1.625	12.72	77.11
40.0	94.2	1.724	14.58	89.45
44.0	117.6	1.883	16.04	111.7
49.4	147.6	2.114	18.01	138.6
66.0	156.4	2.190	24.05	148.5
78.0	157.0	2.199	28.43	149.0

100 gms. acetone dissolve 55.6 gms.  $\text{SnCl}_2$  at 18°. ( $d_{20} = 1.6.$ )  
(Naumann, 1904.)

100 gms. ether dissolve 11.4 gms.  $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$  at 0°-35.5°.

100 gms. ethyl acetate dissolve 31.2 gms.  $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$  at -2°,  
35.53 gms. at +22° and 73.44 gms. at 82°. (von Laszynski, 1894.)

100 gms. ethyl acetate dissolve 4.46 gms.  $\text{SnCl}_2$  at 18°.  $d_{20}$  of the  
sat. solution = 0.9215. (Naumann, 1910.)

100 gms. 95 per cent formic acid dissolve 4.1 gms.  $\text{SnCl}_2$  at 19°+  
(Aschan, 1913.)

Melting points are given for:

$\text{SnCl}_2 + \text{ZnCl}_2$   
 $\text{SnCl}_2 + \text{SnI}_2$   
 $\text{SnCl}_2 + \text{CsCl}$

(Herrmann, 1911)  
(Karantissis, 1927)  
(Markov and Chernov, 1958a)

## Cl TIN CHLORIDE (Stannic) $\text{SnCl}_4$

### DISTRIBUTION OF STANNIC CHLORIDE BETWEEN WATER AND XYLENE (Smirnoff, 1907)

Very concentrated aqueous stannic chloride solutions were agitated  
with xylene at various temperatures and the amount of  $\text{SnCl}_4$ , in terms of  
Cl, which entered the xylene layer was determined. The amount of Sn and  
Cl in the xylene was found to correspond to  $\text{SnCl}_4$ .

## DISTRIBUTION OF STANNIC CHLORIDE BETWEEN WATER AND XYLENE--Cont.

Results for Xylene +  $\text{SnCl}_4 \cdot 5\text{H}_2\text{O}$ 

t°	Gms. Cl per 100 Gms.		$\frac{c}{c'}$
	Aq.	Xylene	
	Layer, c	Layer, c'	c'
66	40.35	0.08	504.4
80	39.95	0.18	228.5
97.5	40.24	0.33	122.1
111	40.27	0.68	59.3

Results for Xylene +  $\text{SnCl}_4 \cdot 4\text{H}_2\text{O}$ 

t°	Gms. Cl per 100 Gms.		$\frac{c}{c'}$
	Aq.	Xylene	
	Layer, c	Layer, c'	c'
66	41.9	0.92	45.3
80	41.91	1.56	27
100	41.85	2.52	16.7
111	41.68	3.23	12.9

Per cent Cl in  $\text{SnCl}_4 \cdot 5\text{H}_2\text{O}$  = 40.38Per cent Cl in  $\text{SnCl}_4 \cdot 4\text{H}_2\text{O}$  = 42.37

Cl

Results for Xylene +  $\text{SnCl}_4 \cdot 3\text{H}_2\text{O}$ 

t°	Gms. Cl per 100 Gms.		$\frac{c}{c'}$
	Aq.	Xylene	
	Layer, c	Layer, c'	c'
80	43.2	9.93	4.4
94	42.54	9.32	4.6
100	42.64	10.56	4.1
111	42.31	10.03	4.2

Per cent Cl in  $\text{SnCl}_4 \cdot 3\text{H}_2\text{O}$  = 45.12DISTRIBUTION OF TIN BETWEEN AQUEOUS HYDROCHLORIC ACID AND ETHER AT ROOM TEMPERATURE  
(Mylius, 1911)

When 1 gm. of tin as the chloride,  $\text{SnCl}_4$ , is dissolved in 100 cc. of aqueous hydrochloric acid and shaken with 100 cc. of ether, the following per cents of the metal enter the ethereal layers. With 20% HCl, 17 per cent; with 15% HCl, 28 per cent; with 10% HCl, 23 per cent; with 5% HCl, 10 per cent and with 1% HCl, 0.8 per cent of the tin.

Additional data for the distribution of  $\text{SnCl}_4$  between water and ethyl ether at 18° are given by Smyth, 1928.

Data in the form of a diagram for the system  $\text{SnCl}_4$  + HCl are given by Chretien and Varger, 1935.

MELTING POINTS IN SYSTEMS OF STANNIC CHLORIDE AND NITRILES  
 (Pushin, Ristic, Parchomenko, and Ubovic, 1942)

Mole % Propio- nitrile	t°	Mole % Benzo- nitrile	t°	Mole % O-Tolui- nitrile	t°	Mole % m-Tolui- nitrile	t°
0	- 33	0	- 33	0	- 33	0	- 33
11	+ 23	13	+ 54.5	10.5	+ 36	8.5	+ 14
23.5	35	20	66	20	47.5	18	42
34.5	45	31	81	30.5	56	30	62
44	54	40	91.5	41	63	40	75.5
56	66	46.5	98	50.5	67	50	86.5
60	71	53.5	104	60	70	60	94.5
66.6	76.5	66.6	109	66.7	73	66.6	97
70	73.5	76.5	104	69.5	71.5	70	95
74	66	80	100	79.5	54	80	86
83	31	89	80	84	41	88.5	64.5
100	-104	100	- 12.5	100	- 14		

 MELTING POINTS IN SYSTEMS OF STANNIC CHLORIDE WITH ORGANIC COMPOUNDS  
 (Kurnakov and Woskressenskaya, 1937)

With (COOCH <sub>3</sub> ) <sub>2</sub>			With (COOC <sub>2</sub> H <sub>5</sub> ) <sub>2</sub>			With CH <sub>2</sub> (COOC <sub>2</sub> H <sub>5</sub> ) <sub>2</sub>		
Mole % SnCl <sub>4</sub>	t°	Solid Phase	Mole % SnCl <sub>4</sub>	t°	Solid Phase	Mole % SnCl <sub>4</sub>	t°	Solid Phase
0	54.2	A	0	-41	D	0	-49.8	F
10	49.2	A	10	30.2	E	20	- 2	G
20	42.5	A + B	20	58.5	E	30	55.8	G
25	63.2	B	30	69.1	E	40	98	G
30	73.2	B	40	78.6	E	45	112.1	G
40	86.8	B	47	81.9	E	48	115.8	G
50	90.6	B	50	83.6	E	50	116.8	G
52	89.8	B	52	82.6	E	52	110	G*
55-92	88.2	B*	60-97	80.3	E*	60-95	110	G**
95	72	B	100	-30	C	100	-30	C

 With (CH<sub>2</sub>COOC<sub>2</sub>H<sub>5</sub>)<sub>2</sub>

0	-20.8	H	40	71.8	I	75	57	I
10	+ 1.0	I	50	96.4	I	80	49.5	I
25	37.2	I	52	94.2	I	90	36.3	I
30	44.6	I	60	79.7	I	100	-30	
33.3	52.1	I	66.6	68.2	I			

 With CO(OC<sub>2</sub>H<sub>5</sub>)<sub>2</sub>

10	30.1	J	35	46.5	J	50	53.1	K
20	42.0	J	37	42.1	J + K	60	50.0	K
30	47.4	J	40	49.0	K	75	33.5	K
33.3	47.9	J	45	51.5	K	100	-30	C

A = (COOCH<sub>3</sub>)<sub>2</sub>    B = SnCl<sub>4</sub>·(COOCH<sub>3</sub>)<sub>2</sub>    C = SnCl<sub>4</sub>    D = (COOC<sub>2</sub>H<sub>5</sub>)<sub>2</sub>  
 E = SnCl<sub>4</sub>·(COOC<sub>2</sub>H<sub>5</sub>)<sub>2</sub>    E\* = SnCl<sub>4</sub>·(COOC<sub>2</sub>H<sub>5</sub>)<sub>2</sub> + 2 liquids with upper  
 critical temperature = 125°    F = CH<sub>2</sub>(COOC<sub>2</sub>H<sub>5</sub>)<sub>2</sub>    G = SnCl<sub>4</sub>·CH<sub>2</sub>(COOC<sub>2</sub>H<sub>5</sub>)<sub>2</sub>  
 G\* = SnCl<sub>4</sub>·CH<sub>2</sub>(COOC<sub>2</sub>H<sub>5</sub>)<sub>2</sub> + 2 liquids with upper critical temperature =  
 115°    G\*\* = SnCl<sub>4</sub>·CH<sub>2</sub>(COOC<sub>2</sub>H<sub>5</sub>)<sub>2</sub> + 2 liquids with upper critical sol.  
 temp. = 125°    H = (CH<sub>2</sub>COOC<sub>2</sub>H<sub>5</sub>)<sub>2</sub>    I = SnCl<sub>4</sub>·(CH<sub>2</sub>COOC<sub>2</sub>H<sub>5</sub>)<sub>2</sub>    J =  
 SnCl<sub>4</sub>·2CO(OC<sub>2</sub>H<sub>5</sub>)<sub>2</sub>    K = SnCl<sub>4</sub>·CO(OC<sub>2</sub>H<sub>5</sub>)<sub>2</sub>

The densities and viscosities in the systems  $\text{SnCl}_4 - \text{CO}(\text{OC}_2\text{H}_5)_2$ ,  $\text{SnCl}_4 - \text{CO}(\text{OC}_2\text{H}_5)_2$ ,  $\text{SnCl}_4 - \text{B}(\text{OCH}_3)_3$ , and  $\text{SnCl}_4 - \text{B}(\text{OC}_2\text{H}_5)_3$  are given by Kurnakov and Woskressenskaya, 1937a.

THE SYSTEM  $\text{SnCl}_4 - \text{SO}_2$  (LIQUID)  
(Bond and Beach, 1926)

t° of m. pt.	t° of solubility*	% $\text{SnCl}_4$	t° of m. pt.	t° of solubility	% $\text{SnCl}_4$	
-32.7		100.00	-43.8	-45.0	67.47	
-38.7		95.23	-43.8	-45.0	66.06	
-40.6		92.66	-43.9	-45.1	61.54	
-42.6	-52.0	86.16	-44.0	-45.3	58.54	Cl
-43.25	-46.8	82.41	-44.1	-45.9	55.24	
-43.6	-45.7	79.43	-44.3	-46.3	50.76	
-43.6	-45.7	79.05	-44.8	-48.8	44.27	
-43.4	-45.6	76.07	-47.1	-57.5	31.96	
-43.4	-45.4	75.76	-49.8		26.29	
-43.6	-44.9	72.62	-63.0		11.78	
-43.7	-44.9	71.75	-27.7		5.40	

\*The temperature of solubility is that at which metastable liquid layers separate.

100 gms. sat. solution of tin tetra chloride in selenium oxychloride ( $\text{SeOCl}_2$ ) contain 13.74 gms.  $\text{SnCl}_4$  at 25°. (Wise, 1923.)

Melting-point data are given for:

$\text{SnCl}_4 + \text{SnI}_4$	(Raeder, 1927)
$\text{SnCl}_4 + \text{TiCl}_4$	(Nasu, 1933)
$\text{SnCl}_4 + \text{Formic Acid Ethyl Ester}$	(1) (2) (3)
$\text{SnCl}_4 + \text{Formic Acid Methyl Ester}$	(1) (2)
$\text{SnCl}_4 + \text{Benzoic Acid Ethyl Ester}$	(1) (3) (4)
$\text{SnCl}_4 + \text{CCl}_4$	(9)
$\text{SnCl}_4 + \text{C}_7\text{F}_{16}$	(10)
$\text{SnCl}_4 + \text{Diphenylether}$	(5)
$\text{SnCl}_4 + \text{Anisole}$	(5) (6)
$\text{SnCl}_4 + \text{O-Nitroanisole}$	(7)
$\text{SnCl}_4 + \text{Azobenzene}$	(7)
$\text{SnCl}_4 + \text{Trinitrotoluene}$	(8)
$\text{SnCl}_4 + \text{Methyl-m-Cresyl Ether}$	(6)
$\text{SnCl}_4 + \text{Phenetole}$	(6)

(1) Kurnakov, 1916; (2) Kurnakov and Kanov, 1924; (3) Kurnakov, Perelmutter and Kanov, 1915; (4) Kurnakov and Perelmutter, 1924; (5) Sisler and Cory, 1947; (6) Sisler, et al., 1946; (7) Pushin, 1948a (8) Pushin et al., 1948 (9) Sackmann, 1955 (10) Campbell and Hickman, 1953

Data for the extraction of  $\text{SnII}$  from aq. HF solutions by ethyl ether at 20° are given by Bock and Herrmann, 1956.

# Sn TIN

## F ALKYL TIN FLUORIDES

SOLUBILITY OF EACH SEPARATELY IN SEVERAL SOLVENTS  
(Krause, 1918)

Compound and Formula	t°	Gms. compound per 100 gms.			
		CH <sub>3</sub> OH	C <sub>2</sub> H <sub>5</sub> OH	H <sub>2</sub> O	C <sub>6</sub> H <sub>6</sub>
Trimethyl Tin Fluoride (CH <sub>3</sub> ) <sub>3</sub> SnF	31.3	2.45	1.08	0.846	0.005
Triethyl Tin Fluoride (C <sub>2</sub> H <sub>5</sub> ) <sub>3</sub> SnF	32.3	4.39	2.20	0.182	0.034
Tri n propyl " (nC <sub>3</sub> H <sub>7</sub> ) <sub>3</sub> SnF	31.3	4.26	2.73	0.020	0.118
Tri isobutyl " (iC <sub>4</sub> H <sub>9</sub> ) <sub>3</sub> SnF	31.6	0.614	0.414	0.012	0.100
Tri isoamyl " (iC <sub>5</sub> H <sub>11</sub> ) <sub>3</sub> SnF	31.3	1.22	1.03	0.003	0.967
Diethyl n propyl Tin Fluoride (C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> (nC <sub>3</sub> H <sub>7</sub> )SnF	31.0	6.93	3.78	0.12	0.005
Dimethyl Tin Difluoride (CH <sub>3</sub> ) <sub>2</sub> SnF <sub>2</sub>	30.7	0.33	0.081	4.66	-
Diethyl " (C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> SnF <sub>2</sub>	30.8	2.64	0.45	2.03	0.047
Di n propyl " (nC <sub>3</sub> H <sub>7</sub> ) <sub>2</sub> SnF <sub>2</sub>	32.0	1.91	0.93	0.22	-

## I STANNOUS IODIDE SnI<sub>2</sub>

SOLUBILITY IN WATER AND IN AQUEOUS HYDRIODIC ACID  
(Young, 1897)

t°	Gms. SnI <sub>2</sub> per 100 Gms. Aqueous HI Solutions of:							
	0% = H <sub>2</sub> O	5.83%	9.60%	15.2%	20.44%	24.8%	30.4%	36.82%
20	0.98	0.20	0.23	0.60	1.81	4.20	10.86	25.31
30	1.16	0.23	0.23	0.64	1.81	4.06	10.28	23.46
40	1.40	0.33	0.28	0.71	1.90	4.12	10.06	23.15
50	1.69	0.46	0.38	0.82	2.12	4.34	10.35	23.76
60	2.07	0.66	0.55	1.11	2.51	4.78	11.03	24.64
70	2.48	0.91	0.80	1.37	2.92	5.43	11.97	25.72
80	2.95	1.23	1.13	1.83	3.70	6.38	13.30	27.23
90	3.46	1.65	1.52	2.40	4.58	7.82	15.52	29.84
100	4.03	2.23	2.04	3.63	5.82	9.60	-	34.05

Data for the extraction of SnI<sub>2</sub> from 6.9N HCl solution by ether are given by Kitahara, 1948.

SOLUBILITY IN ORGANIC SOLVENTS  
(Dorfman and Hildebrand, 1927; also see Negisi, 1940)

Solvent	Wt. % SnI <sub>4</sub> in sat. sol.						
	10°	20.2°	22.4°	25°	28°	40°	50°
Heptane <sup>b</sup>	2.02	-	-	3.36	-	5.24	-
Ethyl Ether	3.64	-	-	4.80	-	6.36	-
CCl <sub>4</sub>	3.56	-	5.25(1) <sup>c</sup>	5.69	-	9.04	12.50(1) <sup>e</sup>
Chloroform	4.94	-	-	8.28	8.21(1) <sup>d</sup>	12.91	-
Benzene	9.76	12.65(1)	-	15.17	-	23.02	-
Toluene	9.99	-	-	14.89	-	21.93	-
m Xylene	8.62	-	-	13.42	-	20.00	-
Ethylene bromide	9.11	-	-	14.16	-	20.91	-
Methylene iodide	18.65 <sup>a</sup> (2)	-	-	-	-	-	-
(C <sub>6</sub> F <sub>5</sub> ) <sub>2</sub> N(3)	-	-	-	0.00102	-	0.0020(35°)	0.00394(45°)
C <sub>6</sub> F <sub>10</sub> O(3)	-	-	-	0.00220	-	0.0036(35°)	0.0074(45°)

<sup>a</sup>sp. gr. = 3.481

<sup>b</sup>see also table following

<sup>c</sup>sp. gr. = 1.59

<sup>d</sup>sp. gr. = 1.50

<sup>e</sup>sp. gr. = 1.63

(1) McDermott, 1911

(2) Retgers, 1893

(3) McLaughlin and Scott, 1954

SOLUBILITY OF STANNIC IODIDE IN SEVERAL LIQUID PARAFFINS  
(Dice and Hildebrand, 1928)

<u>n</u> Octane		<u>n</u> Heptane		<u>n</u> Hexane		iso Octane	
Mol.		Mol.		Mol.		Mol.	
fraction		fraction		fraction		fraction	
SnI <sub>4</sub> in		SnI <sub>4</sub> in		SnI <sub>4</sub> in		SnI <sub>4</sub> in	
t°	sat. sol.	t°	sat. sol.	t°	sat. sol.	t°	sat. sol.
127.3	0.3602	127.6	0.2836	138.1	0.2531	183.4	0.3029
129.4	0.3824	130.9	0.3220	143.4	0.2887	191.6	0.3692
131.1	0.4454	134.8	0.3720	146.4	0.3225	194.9	0.4592
131.2	0.4541	136.4	0.4340	148.8	0.3714	195.3*	0.50
132.0*	0.52	136.8	0.48	149.4*	0.42	195.4	0.5193
132.3	0.5418	136.7	0.4861	148.7	0.4526	194.9	0.5380
131.5	0.5832	135.4	0.5606	145.4	0.5344	193.6	0.5920
130.2	0.6297	131.5	0.6105	138.2	0.5916	181.5	0.6922
129.4	0.6430	127.2	0.6818				

\*Critical solution temperature; iso Octane = 2.2.4 Tri methyl pentane.

SOLUBILITY OF STANNIC IODIDE IN CARBON DISULFIDE

Sneider, 1866; Arctowski, 1895-1896; Dorfman and Hildebrand, 1927;  
See also Doane and Drickamer, 1955.

t°	Wt. % SnI <sub>4</sub> in sat. sol.		t°	Wt. % SnI <sub>4</sub> in sat. sol.	
-114.5	9.41	(A.)	10	49.01	(D.H.)
- 94	10.65	(A.)	25	58.53	(D.H.)
- 89	9.68	(A.)	room	59.2	(S.)
- 84	10.22	(A.)	40	67.56	(D.H.)
- 58	16.27	(A.)			

# Sn TIN

## SOLUBILITY OF STANNIC IODIDE IN SILICON TETRACHLORIDE (Hildebrand and Negishi, 1937)

t°	Mol. fraction SnI <sub>4</sub> in sat. sol.		t°	Mol. fraction SnI <sub>4</sub> in sat. sol.	
0.2	0.155	Solid	139.4	32.53	Liquid
25.0	0.381	Solid	139.8	37.62	Liquid
40.0	0.639	Solid	139.9C	39.00	Liquid
81.3	2.36	Solid	139.7	43.16	Liquid
112.1	6.43	Solid	139.5	43.54	Liquid
115.6	7.40	Solid	139.1	45.06	Liquid
131.0	65.36	Solid	138.8	46.95	Liquid
130.9	21.56	Liquid	135.7	51.21	Liquid
133.4	24.21	Liquid	135.8	51.62	Liquid
138.2	29.58	Liquid	132.4	55.12	Liquid

C = critical solution temperature

## SOLUBILITY OF STANNIC IODIDE IN:

### Tetrahydrofuran

### Tetrahydropyran

(Sisler, Schilling and Groves, 1951)

t°	Mole % SnI <sub>4</sub> in sat. sol.	Solid Phase	t°	Mole % SnI <sub>4</sub> in sat. sol.	Solid Phase
0	6	SnI <sub>4</sub>	0	4	SnI <sub>4</sub>
40	11	"	40	12	"
80	26	"	80	27	"
120	64	"	120	65	"
145	100	"	145	100	"

## SOLUBILITY OF SnI<sub>4</sub> IN MOLTEN SULFUR (Dorfman and Hildebrand, 1927)

t°: 104 130

sat. sol.  
wt. % SnI<sub>4</sub>: 76.2 90.8

Melting points are given for the system SnI<sub>4</sub> + BBr<sub>3</sub> by Adamsky and Wheeler, Jr., 1954.

## I TRIMETHYL TIN IODIDE SnI(CH<sub>3</sub>)<sub>3</sub>

Fusion-point data for the system SnI(CH<sub>3</sub>)<sub>3</sub> + C<sub>6</sub>H<sub>5</sub>NH<sub>2</sub> are given by Baume and Perrot, 1914.

## STANNOUS OXIDE SnO

SOLUBILITY OF STANNOUS OXIDE IN HYDROCHLORIC ACID AND SODIUM  
HYDROXIDE SOLUTIONS AT 25°  
(Garrett and Heiks, 1941)

Results in NaOH Solutions				Results in HCl Solutions	
Initial Moles NaOH per 1000 gms. H <sub>2</sub> O	Moles SnO per 1000 gms. H <sub>2</sub> O	Initial Moles NaOH per 1000 gms. H <sub>2</sub> O	Moles SnO per 1000 gms. H <sub>2</sub> O	Initial Moles HCl per 1000 gms. H <sub>2</sub> O	Moles SnO per 1000 gms. H <sub>2</sub> O
0.005	0.00065	0.060	0.00732	0.000	*0.0000050
.010	.00128	.070	.00843	.005	.00175
.015	.00193	.080	.00948	.010	.00390
.020	.00256	.085	.00998	.015	.00600
.025	.00319	.100	.01200	.020	.00815
.030	.00381	.200	.0236	.030	.01245
.035	.00442	.300	.0346	.040	.01680
.040	.00502	.400	.0443		
.050	.00618				

\*Goldschmidt and Eckhardt, 1906 report 0.0000135 moles per liter at 25°. Oka, 1940 reports  $2.0 \times 10^{-9}$  moles per liter.

Earlier Data in Aqueous NaOH at 25°

(Goldschmidt and Eckhardt, 1906)

The authors desired to ascertain whether the mono,  $\text{NaHSnO}_2$ , or the disodium salt,  $\text{Na}_2\text{SnO}_2$ , predominates in alkaline tin hydroxide solutions. Given amounts of carefully prepared tin chloride, made from tin and HCl, and sodium hydroxide solutions were mixed in vessels containing hydrogen. The mixtures were shaken at 25° and the clear supernatant solutions in contact with the precipitated  $\text{Sn(OH)}_2$ , analyzed. (See also Rubenbauer, 1902.)

Gm. Mols. per Liter			Gm. Mols. per Liter		
Total Na	$\text{NaHSnO}_2$	NaOH	Total Na	$\text{NaHSnO}_2$	NaOH
0.00451	0.0009345	0.003525	0.02250	0.00838	0.01412
0.00680	0.00218	0.00462	0.02788	0.01038	0.01755
0.01149	0.003495	0.007995	0.02940	0.00874	0.02066
0.02143	0.006935	0.014495	0.03012	0.00865	0.02147
0.02143	0.00660	0.01483	0.03036	0.01082	0.01954
0.02186	0.00628	0.015575	0.03044	0.009405	0.021035



## Sn TIM

### SOLUBILITY OF STANNOUS OXIDE IN PERCHLORIC ACID SOLUTIONS AT 25° (Gorman and Leighton, 1942)

The results are nearly identical with those of Garrett and Heiks (above) and indicate that tin does not form complex ions with  $\text{Cl}^-$ , and that the increased solubility is a function of  $\text{H}^+$  only.

Initial Moles $\text{HClO}_4$ per liter	Moles $\text{SnO}$ per liter	Initial Moles $\text{HClO}_4$ per liter	Moles $\text{SnO}$ per liter	Initial Moles $\text{HClO}_4$ per liter	Moles $\text{SnO}$ per liter
0.0113	0.00318	0.0433	0.0179	0.0866	0.0353
.0186	.00890	.0449	.0176	.0870	.0379
.0254	.0124	.0590	.0257	.1125	.0475
.0311	.0126	.0665	.0277		
.0343	.0149	.0823	.0353		

## 3 STANNOUS SULFIDE $\text{SnS}$

Kapustinsky, 1940 calculated the solubility product of stannous sulfide from thermochemical data to be  $1.0 \times 10^{-27}$ . The calculated solubility in various solutions are:

pH	3	5	7	9	11
Moles per liter	$9.6 \times 10^{-7}$	$9.7 \times 10^{-9}$	$1.4 \times 10^{-10}$	$1.0 \times 10^{-11}$	$1.0 \times 10^{-12}$

## 3 STANNIC SULFIDE $\text{SnS}_2$

### SOLUBILITY OF STANNIC SULFIDE IN AQUEOUS SOLUTIONS OF AMMONIA (Epik, 1932)

The determinations were made by boiling mixtures of sulfide and aqueous ammonia of various concentrations for 5 minutes over a Bunsen burner. The solutions thus obtained were analyzed for tin and the residual ammonia.

% concentration of $\text{NH}_3$ in solvent		Gms. $\text{SnS}_2$ dissolved per 100 cc sat. sol.
at beginning	at end	
1.0	0.8	0.13
3.0	2.3	0.33
6.0	3.8	0.49
12.0	7.0	0.85
25.0	12.0	1.26

The effect of variation in time of heating and of the ratio of sulfide to ammonia was also studied.

SOLUBILITY OF STANNIC SULFIDE IN AQUEOUS HYDROCHLORIC ACID SOLUTIONS  
(Sorum and Wolf, 1950)

n = normality of HCl

c = milligrams  $\text{SnS}_2$  per 100 ml. of solution

26°		40°		60°	
n	c	n	c	n	c
0.00	2.4	0.00	4.6	0.00	26.9
0.51	1.9	0.48	4.1	0.49	30.0
0.93	2.8	0.98	0.0	0.92	80.0
1.98	15.7	1.68	37.0	1.86	77.3
2.91	36.4	2.88	112.0	3.12	251.0
3.72	83.6	3.25	198.4	3.22	291.0
3.96	173.0	4.20	290.8	4.59	507.0
				5.78	791.0
				6.52	862.0
				6.55	1062.0

S

STANNOUS SULFATE  $\text{SnSO}_4$

SO

THE SYSTEM STANNOUS OXIDE - SULFUR TRIOXIDE - WATER  
(Denham and King, 1935)

Results at 25°				Results at 50°			
d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	SnO	SO <sub>3</sub>			SnO	SO <sub>3</sub>	
1.004	0.30	0.20	1.2.4	1.018	1.04	0.68	1.2.2
1.030	2.21	1.36	"	1.037	2.53	1.53	" + 1.1
1.040	3.07	1.87	"	1.058	3.80	2.17	1.1
1.065	4.56	2.76	"	1.145	9.33	5.64	"
1.090	6.30	3.72	" + 1.1	1.230	14.00	8.30	"
1.120	8.02	4.85	1.1	1.245	14.81	8.74	" + $\text{SnSO}_4$
1.185	11.68	6.79	"	1.220	8.74	14.12	$\text{SnSO}_4$
1.250	15.15	8.87	"	1.263	7.42	19.66	"
1.270	16.30	9.50	"	1.326	5.06	28.43	"
1.300	17.56	10.27	" + $\text{SnSO}_4$				
1.265	14.64	10.52	$\text{SnSO}_4$				
1.240	11.83	10.64	"	1.2.4	$= \text{SnSO}_4 \cdot 2\text{SnO} \cdot 4\text{H}_2\text{O}$		
1.220	9.43	12.85	"	1.2.2	$= \text{SnSO}_4 \cdot 2\text{SnO} \cdot 2\text{H}_2\text{O}$		
1.210	6.39	15.92	"	1.1	$= \text{SnSO}_4 \cdot \text{SnO}$		
1.239	2.98	23.60	"				
1.307	1.50	31.30	"				
1.404	0.60	40.90	"				
1.508	0.36	49.63	"				

100 gms.  $\text{H}_2\text{O}$  dissolve 18.8 gms.  $\text{SnSO}_4$  at 19° and 18.1 gms. at 100°.  
(Marignac.)

## Sr STRONTIUM

## Sr STRONTIUM

Melting point diagrams are drawn for the systems Sr -  $\text{SrBr}_2$  and Sr -  $\text{SrI}_2$  by Cubicciotti and Thurmond, 1949, and by Eastman, Cubicciotti and Thurmond, 1950. About 20 - 25% of the metal dissolves in each salt, and there is a large liquid immiscibility gap in each system above 750°.

Data for the system  $\text{Sr} + \text{CaCl}_2 \rightleftharpoons \text{SrCl}_2 + \text{Ca}$  at 1000° are given by Ostertag, 1956.

## AsO STRONTIUM ARSENITES

THE SYSTEM  $\text{SrO} - \text{As}_2\text{O}_3 - \text{H}_2\text{O}$   
(Masson and Guerin, 1958)

	At 20°		At 60°	
	Sat. Sol. Wt. %		Sat. Sol. Wt. %	
	SrO	$\text{As}_2\text{O}_3$	SrO	$\text{As}_2\text{O}_3$
$\text{SrO} \cdot \text{As}_2\text{O}_3 \cdot n\text{H}_2\text{O}^a$	0.18	2	0.32	5.6
	0.14-0.15	0.21-0.22	0.15-0.16	0.20-0.21
$2\text{SrO} \cdot \text{As}_2\text{O}_3 \cdot n\text{H}_2\text{O}^b$	0.65	trace	3.01	trace

<sup>a</sup>Solubility in water at 20°, 0.38; at 60° 0.39 wt. %  $\text{SrO} \cdot \text{As}_2\text{O}_3$  +

<sup>b</sup>Solubility in water at 20°, 0.25; at 60° 0.32 wt. %  $2\text{SrO} \cdot \text{As}_2\text{O}_3$ .

## AsO STRONTIUM ARSENATES $\text{Sr}_2\text{H}_2(\text{AsO}_4)_2$ $\text{Sr}_3(\text{AsO}_4)_2$

SOLUBILITY OF EACH IN WATER AT 17°  
(Guerin and Michel, 1942)

0.45 gms. of  $\text{Sr}_2\text{H}_2(\text{AsO}_4)_2$  are dissolved in 100 gms. of saturated solution. The solid phase is either the di- or trihydrate.

0.027 gms. of  $\text{Sr}_3(\text{AsO}_4)_2$  are dissolved in 100 gms. of saturated solution. The solid phase is  $\text{Sr}(\text{AsO}_4) \cdot 1.17\text{H}_2\text{O}$ .

Chukhlantsev, 1956 gives the  $K_{sp} [\text{Sr}^{++}]^3 [\text{AsO}_4^{=}]^2 = 8.1 \times 10^{-19}$ .

STRONTIUM Sr

THE SYSTEM STRONTIUM OXIDE - ARSENIC PENTOXIDE - WATER AT 25°  
(Tartar, Rice and Sweo, 1931)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	
	As <sub>2</sub> O <sub>5</sub>	SrO			As <sub>2</sub> O <sub>5</sub>	SrO		
1.001	0.18	0.14	SrHAsO <sub>4</sub>	1.489	33.59	5.98	Sr(H <sub>2</sub> AsO <sub>4</sub> ) <sub>2</sub>	
1.010	1.01	0.48	"	1.542	37.59	5.69	"	
1.042	3.33	1.56	"	1.555	39.71	5.01	"	
1.080	5.41	2.43	"	1.605	42.94	4.44	"	
1.126	8.33	3.84	"	1.805	55.20	2.23	"	
1.199	12.29	5.72	"	1.851	57.97	1.32	"	
1.273	17.31	7.30	" + Sr(H <sub>2</sub> AsO <sub>4</sub> ) <sub>2</sub>	1.999	64.75	0.43	"	
1.339	23.38	6.81	Sr(H <sub>2</sub> AsO <sub>4</sub> ) <sub>2</sub>	2.236	71.71	0.09	"	AsO
1.362	26.08	6.24	"					

SOLUBILITY OF STRONTIUM ARSENATE IN AQUEOUS SALT SOLUTIONS AT 17°  
(Guerin, 1941b)

Added salt	Gms. added salt per 100 cc solu.	Gms. SrHAsO <sub>4</sub> per 100 cc
NH <sub>4</sub> Cl	0.53 (0.1 N)	0.58
	5.3 (1.0 N)	1.27
	10.7 (2 N)	1.85
	21.4 (4 N)	2.25
NH <sub>4</sub> NO <sub>3</sub>	16.0 (2 N)	1.43
NH <sub>4</sub> C <sub>2</sub> H <sub>3</sub> O <sub>2</sub>	15.4 (2 N)	1.50
		Gms. Sr <sub>3</sub> (AsO <sub>4</sub> ) <sub>2</sub> per 100 cc
NH <sub>4</sub> Cl	0.53 (0.1 N)	0.33
	10.7 (2 N)	1.60

STRONTIUM CACODYLATE Sr[(CH<sub>3</sub>)<sub>2</sub>AsO<sub>2</sub>]<sub>2</sub>·12H<sub>2</sub>O

SOLUBILITY OF STRONTIUM CACODYLATE IN WATER  
(Tiollais, 1936)

	Gms. Sr[(CH <sub>2</sub> ) <sub>3</sub> AsO <sub>2</sub> ] <sub>2</sub> per 100 gms. sat. sol.	Solid Phase
0	44.11	Sr[(CH <sub>3</sub> ) <sub>2</sub> AsO <sub>2</sub> ] <sub>2</sub> ·13H <sub>2</sub> O
8.5	46.71	"
17.0	50.34	"
19	52.60	"
22.5	54.90	"
27.0 m.pt.	60.70	"
31	62.01	Sr[(CH <sub>3</sub> ) <sub>2</sub> AsO <sub>2</sub> ] <sub>2</sub> ·3H <sub>2</sub> O
40.5	65.05	"

(Cont.)

## Sr STRONTIUM

### SOLUBILITY OF STRONTIUM CACODYLATE IN WATER--Cont.

	Gms. Sr[(CH <sub>2</sub> ) <sub>3</sub> AsO <sub>2</sub> ] <sub>2</sub> per 100 gms. sat. sol.	Solid Phase
45	66.25	Sr[(CH <sub>3</sub> ) <sub>2</sub> AsO <sub>2</sub> ] <sub>2</sub> ·3H <sub>2</sub> O
50	67.52	"
52	67.94	"
57	68.42	Sr[(CH <sub>3</sub> ) <sub>2</sub> AsO <sub>2</sub> ] <sub>2</sub> ·H <sub>2</sub> O
60	69.01	"
62	69.25	"
67	69.50	"
72.5	69.97	"
79	70.75	"
83	71.50	"
AsO 84	72.50	"
94	73.14	"
99	74.34	"

### SOLUBILITY OF STRONTIUM CACODYLATE IN ALCOHOLS (Tiollais, 1936)

Solvent	t°	Gms. Sr[(CH <sub>3</sub> ) <sub>2</sub> AsO <sub>2</sub> ] <sub>2</sub> per 100 gms. sat. sol.	Solid Phase
Methyl Alcohol	12	56.08	Sr[(CH <sub>3</sub> ) <sub>2</sub> AsO <sub>2</sub> ] <sub>2</sub> ·3H <sub>2</sub> O
Ethyl Alcohol (95%)	15	38.40	"
Ethyl Alcohol (abs.)	15	38.60	"

## BO STRONTIUM BORATES

An diagram of the system SrO - B<sub>2</sub>O<sub>3</sub> - Na<sub>2</sub>O is given by Gode and Simane, 1950.

The data of Constable and Tugtepe, 1952 on strontium borates do not seem to have been obtained with a pure solid phase.

## BO STRONTIUM TETRAMETHOXY BOROHYDRIDE Sr(BOCH<sub>3</sub>)<sub>2</sub>

The solubility in tetrahydrofuran, benzene and cyclohexane is 500 - 800 mg/100 ml at 19°. (Wiberg and Hartwimmer, 1955.)

STRONTIUM BROMIDE  $\text{SrBr}_2 \cdot 6\text{H}_2\text{O}$ 

Br

## SOLUBILITY IN WATER

(Average curve from results of Kremers, 1858; and Etard, 1894)

t°	Gms. $\text{SrBr}_2$ per 100 Gms.		t	Gms. $\text{SrBr}_2$ per 100 Gms.	
	Solution	Water		Solution	Water
0	46	85.2	40	55.2	123.2
10	48.3	93	50	57.6	135.8
20	50.6	102.4	60	60	150
25	51.7	107	80	64.5	181.8
30	52.8	111.9	100	69	222.5

Sp. Gr. of sat. solution at 20° approximately 1.70.

SOLUBILITY OF STRONTIUM BROMIDE IN WATER ABOVE 100°  
(Benrath, 1941)

t°	Gms. $\text{SrBr}_2$ per 100			t°	Gms. $\text{SrBr}_2$ per 100			t°	Gms. $\text{SrBr}_2$ per 100		
	Sat.	Sol.	Solid Phase		Sat.	Sol.	Solid Phase		Sat.	Sol.	Solid Phase
104	69.4		A	262	78.7		A	338	91.0		A
154	71.9		A	291	81.6		A	342	92.0		A
176	73.0		A	303	82.7		A	345	92.4		A + B
212	75.1		A	319	84.4		A	366	93.3		B
224	76.2		A	331	89.0		A	383	94.0		B
249	78.2		A	335	90.0		A				

A =  $\text{SrBr}_2 \cdot \text{H}_2\text{O}$ B =  $\text{SrBr}_2$ FREEZING-POINTS OF AQUEOUS SOLUTIONS OF STRONTIUM BROMIDE  
(Milikan, 1917)

t°	Gms. $\text{SrBr}_2$ per 100		Solid Phase	t°	Gms. $\text{SrBr}_2$ per 100		Solid Phase
	gms.	sat. sol.			gms.	sat. sol.	
-1.7	6.9		Ice	-19.0	34.8		Ice
-4.2	13.9		"	-28.0e	41.7		" + $\text{SrBr}_2 \cdot 6\text{H}_2\text{O}$
-8.4	23.2		"	0	46.8		$\text{SrBr}_2 \cdot 6\text{H}_2\text{O}$
-13.5	29.8		"				(Kremers)

e = eutectic

# Sr STRONTIUM

## SOLUBILITY OF STRONTIUM BROMIDE IN AQUEOUS SOLUTIONS OF HYDROBROMIC ACID AT 25° (Scott and Durham, 1930)

Gms. per 100 gms. sat. sol.		Solid Phase
HBr	SrBr <sub>2</sub>	
0.0	49.93	SrBr <sub>2</sub> ·6H <sub>2</sub> O
3.77	45.18	"
9.39	38.21	"
17.50	28.36	"

Br

## THE SYSTEM STRONTIUM BROMIDE - STRONTIUM OXIDE - WATER AT 25° (Millikan, 1917)

Additional data at 25° are given by Milikau (1916).

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
SrBr <sub>2</sub>	SrO		SrBr <sub>2</sub>	SrO	
49.79	0.0	SrBr <sub>2</sub> ·6H <sub>2</sub> O	40.66	0.84	SrBr <sub>2</sub> ·SrO·9H <sub>2</sub> O+SrO·9H <sub>2</sub> O
49.78	0.21	"4SrBr <sub>2</sub> ·SrO·9H <sub>2</sub> O	38.68	0.79	SrO·9H <sub>2</sub> O
48.06	0.25	SrBr <sub>2</sub> ·SrO·9H <sub>2</sub> O	35.83	0.73	"
47.65	0.28	"	27.33	0.66	"
44.24	0.47	"	21.46	0.65	"
42.76	0.61	"	16.27	0.66	"
41.78	0.64	"	0.0	0.85	"

## SOLUBILITY OF STRONTIUM BROMIDE IN AQUEOUS SOLUTIONS OF STRONTIUM NITRATE AT 25° (Harkins and Pearce, 1916)

Mols. per 1000 Gms. H <sub>2</sub> O		Gms. SrBr <sub>2</sub> per 1000 Gms. H <sub>2</sub> O	d <sub>24</sub> of Sat. Sol.	Mols. per 1000 Gms. H <sub>2</sub> O		Gms. SrBr <sub>2</sub> per 1000 Gms. H <sub>2</sub> O	d <sub>24</sub> of Sat. Sol.
Sr(NO <sub>3</sub> ) <sub>2</sub>	SrBr <sub>2</sub>			Sr(NO <sub>3</sub> ) <sub>2</sub>	SrBr <sub>2</sub>		
0	4.3080	1.066.1	1.7002	0.30663	4.3180	1068.8	1.73766
0.036	4.3105	1066.95	-	0.61124	4.3190	1069.17	1.74866
0.07216	4.3125	1067.42	1.70325	1.8610	4.3390	1073.97	1.77368
0.14568	4.3170	1068.54	1.72844				

## THE SYSTEM STRONTIUM BROMIDE - TERTIARY BUTYL ALCOHOL - WATER AT 25° (Ginnings, Herring and Webb, 1933)

The composition of the homogeneous mixture (Plait Point) of the system was found to be 20.4 gms. SrBr<sub>2</sub> + 29.8 gms. ter. (CH<sub>3</sub>)<sub>3</sub>COH + 49.8 gms. H<sub>2</sub>O.

The original results for the remaining points on the binodal curve are not given but only the values of a series of constants calculated by means of empirical equations.

THE SYSTEM STRONTIUM BROMIDE - UREA - WATER AT 11°  
(de Cari, 1932)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
SrBr <sub>2</sub>	CO(NH <sub>2</sub> ) <sub>2</sub>	Solid Phase	SrBr <sub>2</sub>	CO(NH <sub>2</sub> ) <sub>2</sub>	Solid Phase
47.20	0.0	SrBr <sub>2</sub> ·6H <sub>2</sub> O	35.23	29.90	1.4.2
47.20	3.71	"	28.20	36.50	"
46.50	15.20	"	25.78	40.12	CO(NH <sub>2</sub> ) <sub>2</sub>
46.18	19.50	" + 1.4.2	21.50	40.45	"
42.52	22.56	1.4.2	14.27	40.90	"
			-	40.84	"

1.4.2 = SrBr<sub>2</sub>·4CO(NH<sub>2</sub>)<sub>2</sub>·2H<sub>2</sub>O

Br

SOLUBILITY OF STRONTIUM BROMIDE IN PURE METHYL ALCOHOL AND IN PURE  
ETHYL ALCOHOL

(Lloyd, Brown, Glynwyn, Bonnel and Jones, 1928)

t°	Gms. SrBr <sub>2</sub> per 100 gms. CH <sub>3</sub> OH	Solid Phase	t°	Gms. SrBr <sub>2</sub> per 100 gms. C <sub>2</sub> H <sub>5</sub> OH	Solid Phase
10	115.0	SrBr <sub>2</sub> ·1 <sup>1</sup> / <sub>2</sub> CH <sub>3</sub> OH	10	63.6	SrBr <sub>2</sub> · <sup>1</sup> / <sub>2</sub> C <sub>2</sub> H <sub>5</sub> OH
20	119.4	"	20	63.9	"
30	123.4	"	30	64.9	"
40	125.5	"	40	73.5	"
50	129.6	SrBr <sub>2</sub> · <sup>1</sup> / <sub>2</sub> CH <sub>3</sub> OH	50	75.2	SrBr <sub>2</sub>
60	136.1	"	60	75.5	"
70	144.6	"	80	75.8	"

100 gms. abs. alcohol dissolve 64.5 gms. SrBr<sub>2</sub> at 0°. Sp. Gr. of solution = 1.21. (Fonzes-Diacon, 1895.)

100 cc iso-Amyl alcohol (d = 0.805) dissolve 30.5 gms. SrBr<sub>2</sub> at 25°. (Yagoda, 1930.)

SOLUBILITY OF STRONTIUM BROMIDE IN ABSOLUTE ACETONE

(Bell, Rowlands, Hamford, Thomas and Jones, 1930)

Gms. SrBr <sub>2</sub> per 100 gms. (CH <sub>3</sub> ) <sub>2</sub> CO	Solid Phase	Gms. SrBr <sub>2</sub> per 100 gms. (CH <sub>3</sub> ) <sub>2</sub> CO	Solid Phase
0° 0.869	SrBr <sub>2</sub> ·1 <sup>1</sup> / <sub>2</sub> C <sub>3</sub> H <sub>6</sub> O	28.5° 0.429	SrBr <sub>2</sub> ·1 <sup>1</sup> / <sub>2</sub> C <sub>3</sub> H <sub>6</sub> O
10° 0.753	"	35° 0.359	SrBr <sub>2</sub> ·C <sub>3</sub> H <sub>5</sub> O
20° 0.599	"	40° 0.323	"
27° 0.454	"	50° 0.274	"

Results of Altaba, 1951 at 20°

Salt      Gms. salt per 100 gms. acetone

SrBr <sub>2</sub>	0.621	+	.003
SrBr <sub>2</sub> ·2H <sub>2</sub> O	1.946	+	.004
SrBr <sub>2</sub> ·6H <sub>2</sub> O	1.031	+	.009



## Sr STRONTIUM

100 gms. liquid ammonia ( $\text{NH}_3$ ) dissolve 0.008 gm.  $\text{SrBr}_2$  at  $0^\circ$ .  
(Linhard and Stephens, 1934.)

100 gms. liquid  $\text{SO}_2$  dissolve 0.02 gms.  $\text{SrBr}_2$  at  $25^\circ$ . (Watt,  
Jenkins and Robertson, 1950.)

## BrO STRONTIUM BROMATE $\text{Sr}(\text{BrO}_3)_2$

### THE SYSTEM $\text{Sr}(\text{BrO}_3)_2 - \text{H}_2\text{O}$ (Linke, 1953)

$t^\circ$	Wt. % $\text{Sr}(\text{BrO}_3)_2$ in		Solid Phase	$t^\circ$	Wt. % $\text{Sr}(\text{BrO}_3)_2$ in		Solid Phase
	sat. sol.	den- sity			sat. sol.	den- sity	
-1.14	9.38	-	Ice	65	37.57	1.422	$\text{Sr}(\text{BrO}_3)_2 \cdot \text{H}_2\text{O}$
-1.84	14.94	-	"	72	39.15	-	"
-2.03	16.15	-	"	75	39.75	1.458	"
-2.10	16.85	-	"	75.5	39.9	1.458	" + $\text{Sr}(\text{BrO}_3)_2$
-2.28m	18.48	-	"	76	39.9	-	$\text{Sr}(\text{BrO}_3)_2$
-2.18	17.50	1.165	" + $\text{Sr}(\text{BrO}_3)_2 \cdot \text{H}_2\text{O}$	77	39.9	1.457	"
0	18.32	1.177	$\text{Sr}(\text{BrO}_3)_2 \cdot \text{H}_2\text{O}$	79	40.1	-	"
4.4	20.11	1.199	"	80	40.1	1.461	"
15	23.97	1.241	"	82	40.37	-	"
25	27.25	1.285	"	85	40.60	1.462	"
35	30.03	1.320	"	90	40.75	1.465	"
45	32.69	1.356	"	95	40.89	1.465	"
55	35.15	1.384	"	104	41.0	1.470	"

## CH STRONTIUM FORMATE $\text{Sr}(\text{HCOO})_2$

### SOLUBILITY OF STRONTIUM FORMATE IN WATER (Ashton, Houston and Saylor, 1933)

The results of Stanley, 1904 are apparently in error.

Gms. $\text{Sr}(\text{HCOO})_2$ per 100 gms. $\text{H}_2\text{O}$		Solid Phase	Gms. $\text{Sr}(\text{HCOO})_2$ per 100 gms. $\text{H}_2\text{O}$		Solid Phase
$0^\circ$	9.1	$\text{Sr}(\text{HCOO})_2 \cdot 2\text{H}_2\text{O}$	$60^\circ$	25.0	$\text{Sr}(\text{HCOO})_2 \cdot 2\text{H}_2\text{O}$
$10^\circ$	10.6	"	$70^\circ$	30.0	"
$20^\circ$	12.7	"	$72^\circ$	31.2	"
$30^\circ$	15.2	"	$80^\circ$	31.9	$\text{Sr}(\text{HCOO})_2$
$40^\circ$	17.8	"	$90^\circ$	32.9	"
$50^\circ$	21.0	"	$100^\circ$	34.4	"

THE SYSTEM STRONTIUM FORMATE - FORMIC ACID - WATER AT 25°  
(Dunn and Philip, 1934)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
HCOOH	Sr(HCOO) <sub>2</sub>	Solid Phase	HCOOH	Sr(HCOO) <sub>2</sub>	Solid Phase
0.0	12.52	Sr(HCOO) <sub>2</sub> ·2H <sub>2</sub> O	61.5	20.51	Sr(HCOO) <sub>2</sub>
18.01	13.30	"	63.3	20.74	"
34.24	14.17	"	64.7	20.94	"
41.5	15.28	"	68.7	21.3	" + 2Sr(HCOO) <sub>2</sub> ·HCOOH
48.0	16.40	"	70.5	22.04	2Sr(HCOO) <sub>2</sub> ·HCOOH
53.4	18.27	"	72.3	22.54	"
57.3	20.07	"	74.3	23.07	"

STRONTIUM METHIONATE SrCH<sub>2</sub>(SO<sub>3</sub>)<sub>2</sub>

CH

100 gms. H<sub>2</sub>O dissolve 2.14 gm. SrCH<sub>2</sub>(SO<sub>3</sub>)<sub>2</sub> at 25°. (Backer and Terpetra, 1929.)

100 gms. H<sub>2</sub>O dissolve 2.450 gms. SrCH<sub>2</sub>(SO<sub>3</sub>)<sub>2</sub>·2H<sub>2</sub>O at 25°. (Valeri and Baumrucker, 1949.)

STRONTIUM ACETATE Sr(CH<sub>3</sub>COO)<sub>2</sub>

SOLUBILITY IN WATER  
(Osaka and Abe, 1911)

Gms. Sr(CH <sub>3</sub> COO) <sub>2</sub> per 100			Gms. Sr(CH <sub>3</sub> COO) <sub>2</sub> per 100		
t°	Gms. H <sub>2</sub> O	Solid Phase	t°	Gms. H <sub>2</sub> O	Solid Phase
0.05	36.93	Sr(CH <sub>3</sub> COO) <sub>2</sub> ·4H <sub>2</sub> O	25	40.19	Sr(CH <sub>3</sub> COO) <sub>2</sub> · <sup>1</sup> / <sub>2</sub> H <sub>2</sub> O
5	39.91	"	35.03	38.82	"
10	43.61	"	50	37.35	"
8.4t	43.1	" + Sr(CH <sub>3</sub> COO) <sub>2</sub> · <sup>1</sup> / <sub>2</sub> H <sub>2</sub> O	70	36.24	"
8	43.5	Sr(CH <sub>3</sub> COO) <sub>2</sub> · <sup>1</sup> / <sub>2</sub> H <sub>2</sub> O	80	36.10	"
10	42.95	"	90	36.24	"
15	41.90	"	97	36.36	"

t = transition point

# Sr STRONTIUM

## THE SYSTEM STRONTIUM ACETATE - ACETIC ACID - WATER AT 25° (Dunn and Philip, 1934)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
CH <sub>3</sub> COOH	Sr(CH <sub>3</sub> COO) <sub>2</sub>		CH <sub>3</sub> COOH	Sr(CH <sub>3</sub> COO) <sub>2</sub>	
0.0	28.79	2Sr(CH <sub>3</sub> COO) <sub>2</sub> ·H <sub>2</sub> O	50.4	15.21	5.5.9
2.75	28.20	"	57.3	15.25	1.2.2
11.62	22.09	"	65.2	14.32	"
22.63	18.27	5.5.9	71.9	14.42	"
33.10	16.49	"	76.1	16.90	"
41.6	15.56	"			

CH 5.5.9 = 5Sr(CH<sub>3</sub>COO)<sub>2</sub>·5CH<sub>3</sub>COOH·9H<sub>2</sub>O      1.2.2 = Sr(CH<sub>3</sub>COO)<sub>2</sub>·2CH<sub>3</sub>COOH·2H<sub>2</sub>O

100 gms. pure methyl alcohol sat. with anhydrous strontium acetate contain 0.26 gm. Sr(CH<sub>3</sub>COO)<sub>2</sub> at 15° and 0.18 gm. at 66° (b.pt.). (Henstock, 1934.)

## SOLUBILITY OF STRONTIUM ACETATE IN ANHYDROUS ACETIC ACID (Davidson and Chappell, 1933)

Gm. Mol. % Sr(CH <sub>3</sub> COO) <sub>2</sub> in			Gm. Mol. % Sr(CH <sub>3</sub> COO) <sub>2</sub> in		
t°	sat. sol.	Solid Phase	t°	sat. sol.	Solid Phase
16.6	0.0	CH <sub>3</sub> COOH	66.5	5.89	Sr(CH <sub>3</sub> COO) <sub>2</sub> ·CH <sub>3</sub> COOH
15.5	2.08	"	77.5	6.52	"
14.5	4.31	"	86.0	7.12	"
13.69	5.73*	"	101.1	8.57	"
13.02	7.15*	"	108.8	9.52	"
17.0	4.76	Sr(CH <sub>3</sub> COO) <sub>2</sub> ·CH <sub>3</sub> COOH	111.5	9.95	"
29.7	4.85	"	118.5	10.45	Sr(CH <sub>3</sub> COO) <sub>2</sub> (?)
50.0	5.2	"	121.8	10.76	"

## STRONTIUM TARTRATE SrC<sub>4</sub>H<sub>4</sub>O<sub>6</sub>·3H<sub>2</sub>O

### SOLUBILITY IN WATER (Cantoni and Zachoder, 1905)

Gms.		Gms.		Gms.	
t°	SrC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> ·3H <sub>2</sub> O per 100 cc. Solution	t°	SrC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> ·3H <sub>2</sub> O per 100 cc. Solution	t°	SrC <sub>4</sub> H <sub>4</sub> O <sub>6</sub> ·3H <sub>2</sub> O per 100 cc. Solution
0	0.112	25	0.224	60	0.486
10	0.149	30	0.252	70	0.580
15	0.174	40	0.328	80	0.688
20	0.200	50	0.407	85	0.755

# STRONTIUM Sr

## SOLUBILITY OF ACTIVE AND OF RACEMIC STRONTIUM TARTRATE, EACH SEPARATELY, IN WATER (Deboux and Cattat, 1921)

Saturation was secured by continuous agitation in a thermostat for 7 to 10 hours. The strontium was determined as carbonate and as sulfate.

### Results for the Active salt

t°	Gms. $C_4H_4O_6Sr$ per 100 gms. sat. sol.	Solid Phase
0.0	0.0942	$SrC_4H_4O_6 \cdot 4H_2O$
12.5	0.1285	"
25.0	0.1765	"
37.5	0.2395	"

### Results for the Racemic salt

t°	Gms. $C_4H_4O_6Sr$ per 100 gms. sat. sol.	Solid Phase
0.0	0.0107	$Sr_2C_8H_8O_{12} \cdot 8H_2O$
12.5	0.0202	"
25.0	0.0297	"
37.5	0.0392	"

CH

## SOLUBILITY OF STRONTIUM TARTRATE IN AQUEOUS SOLUTIONS OF ACETIC ACID AT 25°-27° (Herz and Muhs, 1903)

Normality of Acetic Acid	Gms. per 100 cc. Sol.		Normality of Acetic Acid	Gms. per 100 cc. Sol.	
	$CH_3COOH$	$SrC_4H_4O_6 \cdot 3H_2O$		$CH_3COOH$	$SrC_4H_4O_6 \cdot 3H_2O$
0	0	0.227	3.77	21.85	1.051
0.565	3.39	0.678	5.65	33.90	0.982
1.452	8.15	0.864	16.89	101.34	0.184
2.85	17.10	0.996			

## STRONTIUM MALATE $SrC_4H_4O_5$

### SOLUBILITY IN WATER (Cantoni and Basadonna, 1906)

t°	Gms. per 100 cc. Solution	t°	Gms. per 100 cc. Solution	t°	Gms. per 100 cc. Solution
20	0.448	40	1.385	55	2.460
25	0.550	45	1.743	60	2.821
30	0.752	50	2.098	65	3.148
35	1.036			70	3.360

# STRONTIUM Sr

## SOLUBILITY OF ACTIVE AND OF RACEMIC STRONTIUM MALATE, EACH SEPARATELY, IN WATER (Duboux and Cuttat, 1921)

Saturation was secured by continuous rotation in a thermostat for 7 to 10 hours. The strontium was determined as carbonate and as sulfate.

<u>Results for the Active Salt</u>			<u>Results for the Racemic Salt</u>		
t°	Gms. C <sub>4</sub> H <sub>4</sub> O <sub>5</sub> Sr per 100 gms. sat. sol.	Solid Phase	t°	Gms. C <sub>8</sub> H <sub>8</sub> O <sub>10</sub> Sr <sub>2</sub> per 100 gms. sat. sol.	Solid Phase
0.0	0.193	SrC <sub>4</sub> H <sub>4</sub> O <sub>5</sub> ·4H <sub>2</sub> O	0.0	0.290	Sr <sub>2</sub> C <sub>8</sub> H <sub>8</sub> O <sub>10</sub> ·5H <sub>2</sub> O
12.5	0.332	"	12.5	0.325	"
25.0	0.490	"	25.0	0.422	"
37.5	0.781	"	37.5	0.550	"

CH

## SOLUBILITY OF STRONTIUM MALATE IN AQUEOUS SOLUTIONS OF STRONTIUM CHLORIDE AT 25° (Walker, 1925)

Constant agitation in a thermostat was employed for obtaining saturation. The results are expressed in terms of gram molecules of the saturating salt per 1000 gms. H<sub>2</sub>O "corresponding to the weight molar concentration of the added salt."

Gram mols. per 1000 gms. H <sub>2</sub> O		Gram mols. per 1000 gms. H <sub>2</sub> O	
Sr malate	SrCl <sub>2</sub>	Sr malate	SrCl <sub>2</sub>
0.03050	0.0000	0.02349	0.03103
0.02523	0.01828	0.02019	0.06149

## STRONTIUM MALONATE CH<sub>2</sub>(COO)<sub>2</sub>Sr

## SOLUBILITY IN WATER (Cantoni and Diotalevi, 1905)

t°	Gms. per 100 cc. Solution	t°	Gms. per 100 cc. Solution	t°	Gms. per 100 cc. Solution
0	0.541	25	0.521	40	0.464
10	0.540	39	0.499	45	0.453
20	0.532	35	0.478	50	0.443

SOLUBILITY OF STRONTIUM MALONATE IN AQUEOUS SOLUTIONS OF  
STRONTIUM CHLORIDE AT 25°  
(Walker, 1925)

Gms. per liter sat. sol.		Solid Phase
SrCl <sub>2</sub>	SrCH <sub>2</sub> (COO) <sub>2</sub>	
0.0	5.783	SrCH <sub>2</sub> (COO) <sub>2</sub> (?)
2.898	4.784	"
4.919	4.454	"
5.747	3.828	"

STRONTIUM FUMARATE SrC<sub>4</sub>H<sub>2</sub>O<sub>4</sub>

CH

100 gms. H<sub>2</sub>O dissolve 0.29 gm. SrC<sub>4</sub>H<sub>2</sub>O<sub>4</sub> at 30°. (Weiss and Downs, 1923.)

SOLUBILITY OF STRONTIUM SUCCINATE IN WATER  
(Cantoni and Diotallevi, 1905)

t°	Gms. C <sub>4</sub> H <sub>4</sub> O <sub>4</sub> Sr per 100 cc. Sat. Sol.	t°	Gms. C <sub>4</sub> H <sub>4</sub> O <sub>4</sub> Sr per 100 cc. Sat. Sol.	t°	Gms. C <sub>4</sub> H <sub>4</sub> O <sub>4</sub> Sr per 100 cc. Sat. Sol.
0	0.052	20	0.270	40	0.375
5	0.076	25	0.382	45	0.380
10	0.111	30	0.451	50	0.424
15	0.177	35	0.413		

100 gms. sat. solution in water contain 0.439 gms. C<sub>4</sub>H<sub>4</sub>O<sub>4</sub>Sr at 15° and 0.215 gm. at 100°. (Tarugi and Checchi, 1901.)

SOLUBILITY OF STRONTIUM SUCCINATE IN AQUEOUS SOLUTIONS OF SODIUM  
SUCCINATE AT 25°  
(Walker, 1925)

Constant agitation in a thermostat was employed for obtaining saturation. The results are expressed in terms of gram molecules of the saturating salt per 1000 gms. H<sub>2</sub>O "corresponding to the weight molar concentration of the added salt."

Gm. mols. per 1000 gms. H <sub>2</sub> O		Gm. mols. per 1000 gms. H <sub>2</sub> O	
C <sub>4</sub> H <sub>4</sub> O <sub>4</sub> Sr	C <sub>4</sub> H <sub>4</sub> O <sub>4</sub> Na <sub>2</sub>	C <sub>4</sub> H <sub>4</sub> O <sub>4</sub> Sr	C <sub>4</sub> H <sub>4</sub> O <sub>4</sub> Na <sub>2</sub>
0.02013	0.0000	0.01322	0.03751
0.01740	0.00938	0.01221	0.05582
0.01535	0.01875	0.01143	0.07457

## Sr STRONTIUM

### STRONTIUM CITRATE $\text{Sr}(\text{C}_6\text{H}_5\text{O}_7)_2 \cdot 6\text{H}_2\text{O}$ and $\text{Sr}(\text{C}_6\text{H}_5\text{O}_7)_2 \cdot \text{H}_2\text{O}$

SOLUBILITY OF EACH HYDRATE SEPARATELY, IN WATER  
(Chatterjee and Dhar, 1924)

Gms.  $\text{Sr}(\text{C}_6\text{H}_5\text{O}_7)_2$  per liter of Aq. solution sat. with:

	$\text{Sr}(\text{C}_6\text{H}_5\text{O}_7)_2 \cdot 6\text{H}_2\text{O}$	$\text{Sr}(\text{C}_6\text{H}_5\text{O}_7)_2 \cdot \text{H}_2\text{O}$
30°	1.26	2.97
95°	1.57	1.54

### CH STRONTIUM PHENOLATE $(\text{C}_6\text{H}_5\text{O})_2\text{Sr} \cdot 4\text{H}_2\text{O}$

EQUILIBRIUM IN THE SYSTEM STRONTIUM HYDROXIDE, PHENOL AND WATER AT 25°  
(Van Meura, 1916)

Mols. per 100 mols. sat. sol.			Mols. per 100 mols. sat. sol.		
$\text{Sr}(\text{OH})_2$		Solid Phase	$\text{Sr}(\text{OH})_2$		Solid Phase
2	$\text{C}_6\text{H}_5\text{OH}$		2	$\text{C}_6\text{H}_5\text{OH}$	
0.30	0.0	$\text{Sr}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$	6.82	9.67	$(\text{C}_6\text{H}_5)_2\text{Sr} \cdot 4\text{H}_2\text{O}$
0.72	0.49	"	8.87	20.24	"
1.48	1.28	"	9.38	24.84	"
3.83	3.74	"	11.16	47.30	"
4.86	4.80	"	9.62	63.77	" + $\text{C}_6\text{H}_5\text{OH}$
5.58	5.52	"	6.17	65.46	$\text{C}_6\text{H}_5\text{OH}$
6.12	6.04	" + $(\text{C}_6\text{H}_5\text{O})_2\text{Sr} \cdot 4\text{H}_2\text{O}$	3.54	69.91	"

At concentrations of  $\text{Sr}(\text{OH})_2$  less than 0.5 mol. per cent two liquid layers are formed. Analyses of these gave the following results.

Aqueous Layer		Phenol Layer	
Mol. % $\text{Sr}(\text{OH})_2$	Mol. % $\text{C}_6\text{H}_5\text{OH}$	Mol. % $\text{Sr}(\text{OH})_2$	Mol. % $\text{C}_6\text{H}_5\text{OH}$
2		2	
0.12	2.05	0.31	24.41
0.17	2.37	0.43	21.12
0.22	2.72	0.50	18.72
0.34	4.50	0.55	12.95

### STRONTIUM BENZOATE $\text{Sr}(\text{C}_7\text{H}_5\text{O}_2)_2 \cdot \text{H}_2\text{O}$

SOLUBILITY IN WATER  
(Pa-jetta, 1906)

	15.7°	24.7°	31.4°	40.9°
Gms. $\text{Sr}(\text{C}_7\text{H}_5\text{O}_2)_2$ per 100 Gms. Solution	5.31	5.4	5.56	5.77

## SUBSTITUTED STRONTIUM BENZOATES

CH

SOLUBILITY OF SEVERAL STRONTIUM BENZOATES IN WATER AT 20°  
(Ephraim and Pfister, 1925)

Compound	Formula	Gms. anhydrous compd. per 100 cc. sat. sol.
Strontium Benzoate	$(C_6H_5COO)_2Sr \cdot H_2O$	4.953
Strontium -4 Chloro Benzoate	$(C_6H_4ClCOO)_2Sr \cdot 4H_2O$	1.341
Strontium -4 Methoxy Benzoate	$(C_6H_4OCH_3COO)_2Sr \cdot H_2O$	1.6975
Strontium -4 Nitro Benzoate	$(C_6H_4NO_2COO)_2Sr \cdot 8H_2O$	1.340
Strontium -4 Oxy Benzoate	$(C_6H_5OHCOO)_2Sr \cdot H_2O$	11.098

SOLUBILITY OF STRONTIUM HALOGEN BENZOATES IN 94% ACETONE AT ABOUT 20°  
(Bailar, 1931)

Compound	Formula	Gm. mols. compound per liter
Strontium p-Brom Benzoate	$(C_6H_4BrCOO)_2Sr$	0.00028
Strontium p-Chlor Benzoate	$(C_6H_4ClCOO)_2Sr$	0.0010
Strontium p-Iodo Benzoate	$(C_6H_4ICOO)_2Sr$	0.00026

STRONTIUM SALICYLATE  $(C_6H_4OH \cdot COO)_2Sr \cdot 2H_2O$ 

100 gms. sat. solution in water contain 3.04 gms.  $(C_6H_4OHCOO)_2Sr$  at 15° and 20.44 gms. at 100°. (Tarugi and Checchi, 1901.)

SOLUBILITY OF STRONTIUM SALICYLATE IN AQUEOUS ALCOHOL AT 25°  
(Seidell, 1909, 1910)

Wt. % $C_2H_5OH$ in Solvent	$d_{25}$ of Sat. Sol.	Gms. $(C_6H_4OHCOO)_2Sr \cdot 2H_2O$ per 100 Gms. Sat. Sol.	Wt. % $C_2H_5OH$ in Solvent	$d_{25}$ of Sat. Sol.	Gms. $(C_6H_4OHCOO)_2Sr \cdot 2H_2O$ per 100 Gms. Sat. Sol.
0	1.022	5.04	60	0.923	7.15
10	1.006	4.88	70	0.893	5.90
20	0.993	5.22	80	0.859	4.40
30	0.982	6.20	90	0.824	2.56
40	0.966	7.70	92.3	0.815	2.02
50	0.948	8.08	100	0.790	0.44

The solid phase was  $(C_6H_4OH \cdot COO)_2Sr \cdot 2H_2O$  in all cases except the solution in 100 per cent alcohol, in which partial dehydration and conversion of the crystalline salt to an amorphous bulky white powder occurred.

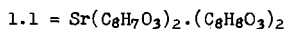


## Sr STRONTIUM

### CH STRONTIUM MANDELATE

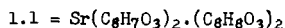
#### THE SYSTEM RACEMIC STRONTIUM MANDELATE - RACEMIC MANDELIC ACID - WATER AT 25° (Ross and Morrison, 1933)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$C_8H_8O_3$	$Sr(C_8H_7O_3)_2$		$C_8H_8O_3$	$Sr(C_8H_7O_3)_2$	
16.9	0.0	$C_8H_8O_3$	3.9	1.0	1.1
17.3	0.5	$C_8H_8O_3 + 1.1$	1.4	2.2	"
14.7	0.6	1.1	1.0	2.9	"
11.6	0.5	"	0.3	3.6	$Sr(C_8H_7O_3)_2$
10.7	0.6	"	0.1	3.7	"
6.8	0.0	"	0.0	3.8	"



#### THE SYSTEM LEVO STRONTIUM MANDELATE - LEVO MANDELIC ACID - WATER AT 25° (Ross and Morrison, 1937)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$C_8H_8O_3$	$Sr(C_8H_7O_3)_2$		$C_8H_8O_3$	$Sr(C_8H_7O_3)_2$	
10.1	0.0	$C_8H_8O_3$	6.0	2.9	1.1
10.3	0.9	"	4.8	3.2	"
10.4	1.8	"	2.0	5.0	"
10.7	2.4	"	1.2	6.1	"
12.7	2.6	1.1	1.3	7.4	"
11.2	2.5	"	1.6	7.7	"
9.8	2.6	"	0.8	7.0	$Sr(C_8H_7O_3)_2$
8.4	2.4	"	0.0	7.4	"
6.4	2.8	"			



### CH STRONTIUM CINNAMATE $(C_6H_5CH:CH.COO)_2Sr \cdot 2H_2O$

100 gms.  $H_2O$  dissolve 1 gm.  $(C_6H_5CH:CH.COO)_2Sr$  at 15°-20°. (Squire and Caines, 1905.)

100 gms. sat. aqueous solution contain 1.18 gm.  $(C_6H_5CH:CH.COO)_2Sr$  at 15°. (Tarugi and Checchi, 1901.)

### STRONTIUM CINNAMATE $C_{18}H_{14}O_4Sr \cdot 4H_2O$

100 cc. sat. solution of strontium cinnamate in water contain 1.4 gms.  $C_{18}H_{14}O_4Sr$  at 20°.

## STRONTIUM SULFONATES

S

SOLUBILITY OF EACH SEPARATELY IN WATER  
(Ephraim and Pfister, 1925a)

Compound and Formula	t°	Gms. anhydrous cmpd. per 100 cc. sat. sol.
Strontium Benzene sulfonate $\text{Sr}(\text{C}_6\text{H}_5\text{SO}_3)_2 \cdot \text{H}_2\text{O}$	20	15.493
Strontium Anthracene-1-sulfonate $\text{Sr}(\text{C}_{14}\text{H}_9\text{SO}_3)_2 \cdot 3\text{H}_2\text{O}$	20	0.1157
Strontium Naphthalene-2-sulfonate $\text{Sr}(\text{C}_{10}\text{H}_6\text{SO}_3)_2 \cdot \text{H}_2\text{O}$	16.5	0.88
Strontium Naphthalene-5-Chlor-1-sulfonate $\text{Sr}(\text{C}_{10}\text{H}_6\text{SO}_3\text{Cl})_2 \cdot 3\text{H}_2\text{O}$	20	0.551
Strontium Naphthalene-6-Oxy-2-sulfonate $\text{Sr}(\text{C}_{10}\text{H}_7\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	20	1.111
Strontium 2,6,8 Naphthylamine disulfonate $\text{Sr}(\text{C}_{10}\text{H}_7 \cdot \text{NH}_2 \cdot \text{SO}_3)_2 \cdot ?\text{H}_2\text{O}$	15	20.80 <sup>a</sup>
Strontium 2,5,7 Naphthylamine disulfonate $\text{Sr}(\text{C}_{10}\text{H}_7 \cdot \text{NH}_2 \cdot \text{SO}_3)_2 \cdot ?\text{H}_2\text{O}$	15	29.48 <sup>a</sup>

<sup>a</sup>Gms. anhydrous salt per 100 gms. of saturated solution.SOLUBILITY OF STRONTIUM BENZENE SULFONATE IN AQUEOUS SOLUTIONS  
OF BENZENE SULFONIC ACID AT 25°  
(Dunn and Philip, 1934)Solid phase  $\text{Sr}(\text{C}_6\text{H}_5\text{SO}_3)_2 \cdot \text{H}_2\text{O}$  throughout.

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
$\text{C}_6\text{H}_5\text{SO}_3\text{H}$	$\text{Sr}(\text{C}_6\text{H}_5\text{SO}_3)_2$	$\text{C}_6\text{H}_5\text{SO}_3\text{H}$	$\text{Sr}(\text{C}_6\text{H}_5\text{SO}_3)_2$
0.0	15.37	28.49	2.39
7.93	8.51	41.8	0.31
10.56	6.43	44.7	0.16
14.12	5.10	49.6	0.07
19.29	3.26		

STRONTIUM 8-QUINOLINOL-5-SULFONIC ACID  $\text{C}_9\text{H}_6\text{OSO}_3\text{Sr}$ Data for the solubility product constant at 25° are given by  
Nasanen and Uusitalo, 1954.

# Sr STRONTIUM

## STRONTIUM CAMPHORATE $\text{dC}_{10}\text{H}_{14}\text{O}_4\text{Sr}\cdot 4\text{H}_2\text{O}$

SOLUBILITY IN AQUEOUS SOLUTIONS OF CAMPHORIC ACID AT 16-17°  
(Jungfleisch and Landrieu, 1914)

Gms. per 100 Gms. Sat. Sol.		Solid Phase
$\text{C}_8\text{H}_{14}(\text{COOH})_2$	$\text{C}_{10}\text{H}_{14}\text{O}_4\text{Sr}$	
1.25	1.413	$\text{C}_8\text{H}_{14}(\text{COOH})_2$
1.03	1.7705	$(\text{C}_{10}\text{H}_{15}\text{O}_4)_2\text{Sr}(\text{C}_{10}\text{H}_{16}\text{O}_4)_2$
1.13	6.525	"
1.20	12.452	"
1.20	17.99	"
0	16.95	$\text{C}_{10}\text{H}_{14}\text{O}_4\text{Sr}\cdot 4\text{H}_2\text{O}$
0	16.56	"
0	12.86	"
	(at 98°)	

## CH 10-CAMPOR SULFONATE $\text{Sr}(\text{C}_{10}\text{H}_{15}\text{OSO}_3)_2$

The solubility in water at room temperature is 28.25% (Pirrone, 1942.)

## STRONTIUM ANTHRAQUINONE SULFONATES

SOLUBILITY OF EACH SEPARATELY IN WATER  
(Flerz-David, Krebsen and Anderau, 1927)

Compound and Formula		t°	Gms. Anhydrous (?) compound per liter
Strontium Anthraquinone:			
1.5 Disulfonate	$\text{Sr}(\text{C}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2\cdot 3\text{H}_2\text{O})$	18	28.0
1.8 Disulfonate	$\text{Sr}(\text{C}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2\cdot 3\frac{1}{2}\text{H}_2\text{O})$	18	0.4
1.8 Disulfonate	$\text{Sr}(\text{C}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2\cdot 3\frac{1}{2}\text{H}_2\text{O})$	100	2.0
-1- Sulfonate	$\text{Sr}(\text{C}_{14}\text{H}_7\text{O}_2\text{SO}_3)_2\cdot 3\text{H}_2\text{O}$	18	1.16
-1- Sulfonate	$\text{Sr}(\text{C}_{14}\text{H}_7\text{O}_2\text{SO}_3)_2\cdot 3\text{H}_2\text{O}$	100	7.05
-2- Sulfonate	$\text{Sr}(\text{C}_{14}\text{H}_7\text{O}_2\text{SO}_3)_2\cdot \text{H}_2\text{O}$	18	0.97
-2- Sulfonate	$\text{Sr}(\text{C}_{14}\text{H}_7\text{O}_2\text{SO}_3)_2\cdot \text{H}_2\text{O}$	100	5.08
2.6 Disulfonate	$\text{SrC}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2$	18	2.35
2.6 Disulfonate	$\text{SrC}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2$	100	3.80
2.7 Disulfonate	$\text{SrC}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2\cdot 2\text{H}_2\text{O}$	18	6.5
2.7 Disulfonate	$\text{SrC}_{14}\text{H}_6\text{O}_2(\text{SO}_3)_2\cdot 2\text{H}_2\text{O}$	100	13.2

STRONTIUM HELIANTHATE  $(C_{14}H_{14}N_3SO_3)_2Sr \cdot 4H_2O$ 

1000 cc.  $H_2O$  dissolve 0.126 gm.  $(C_{14}H_{14}N_3SO_3)_2Sr \cdot 4H_2O$  at 20-25°.  
(Stark and Dehm, 1918.)

STRONTIUM CARBONATE  $SrCO_3$ 

CO

## SOLUBILITY IN WATER

One liter of water dissolves 0.00082 gm. at 8.8° and 0.0109 gm. at 24° by conductivity method. (Holleman, 1893; Kohlrausch and Rose, 1893.)

One liter of water saturated with  $CO_2$  dissolves 1.19 gms.  $Sr(HCO_3)_2$ .

Data for the solubility of strontium carbonate in water containing  $CO_2$  at pressures between 0.05 and 1.1 atmospheres are given by McCoy and Smith (1911). The equilibrium constant is  $k = 1.29 \times 10^{-2}$  with an average deviation from the mean of 1.2 per cent. From this value, the solubility product is calculated to be  $Sr \times CO_2 = k_3 = 1.567 \times 10^{-9}$ .

Using the "polarographic" method (see remarks under barium carbonate) Heyrovsky and Berezicky, 1929, found the solubility of strontium carbonate in water to be 0.00028 gm. equivalents per liter.

SOLUBILITY OF STRONTIUM CARBONATE IN WATER SATURATED WITH CARBON DIOXIDE  
AT PRESSURE OF ONE ATMOSPHERE AND OF THIRTY-FIVE ATMOSPHERES AT 18°  
(Haehnel, 1924)

The limit of solubility at 18° was at 25 atmospheres pressure of  $CO_2$ .

Pressure of Carbon Dioxide	Gms. per 100 gms. sat. sol.	
	Carbonate	Bicarbonate
1.0 atmosphere	0.12	0.17
35.0 atmosphere	0.38	0.57

SOLUBILITY OF STRONTIUM CARBONATE IN AQUEOUS AMMONIUM CHLORIDE  
(Cantoni and Goguelia, 1905)

The mixtures were allowed to stand at 12-18° for 98 days.

Gms. $NH_4Cl$ per 100 Gms. Solution	Gms. $SrCO_3$ per 1000 cc. Sat. Solution
5.35	0.179
10	0.259
20	0.358

## Sr STRONTIUM

### SOLUBILITY OF STRONTIUM CARBONATE IN AQUEOUS SOLUTIONS OF ALKALI CHLORIDES (Townley, Whitney and Felsing, 1937)

		Results at 25°			Results at 40°		
		Gm. Mol. SrCO <sub>3</sub> x 10 <sup>-4</sup> per 1000 gms. H <sub>2</sub> O in aqueous			Gm. Mol. SrCO <sub>2</sub> x 10 <sup>-4</sup> per 1000 gms. H <sub>2</sub> O in aqueous		
Gm. Mol. Alkali Chloride per 1000 gms. H <sub>2</sub> O in each case		LiCl	NaCl	KCl	LiCl	NaCl	KCl
0.0 (= H <sub>2</sub> O alone)		0.5525	0.5525	0.5525	0.7026	0.7026	0.7026
0.02		0.957	0.737	0.672	1.164	0.888	0.975
0.05		1.203	0.965	0.835	1.494	1.140	1.190
CO 0.10		1.455	1.320	1.055	1.845	1.505	1.415
0.20		1.750	1.965	1.375	2.260	2.195	1.690
0.30		1.925	2.485	1.570	2.525	2.780	1.870
0.40		2.040	2.915	1.685	2.717	3.280	1.980
0.50		2.135	3.285	1.756	2.870	3.710	2.055
1.00		2.440	4.415	1.900	3.390	5.145	2.205
3.0		3.405	6.855	2.176	5.060	8.665	2.480

Fusion-point data for SrCO<sub>2</sub> + SrCl<sub>2</sub> are given by Sackur (1911-12.)

### STRONTIUM URANYL CARBONATE Sr<sub>2</sub>[UO<sub>2</sub>(CO<sub>3</sub>)<sub>3</sub>].8H<sub>2</sub>O

A saturated solution in water at 19° contains 1.7 gms. Sr<sub>2</sub>[UO<sub>2</sub>(CO<sub>3</sub>)<sub>3</sub>] per liter. (Bachelet, Cheylan, Douis and Goulette, 1952.)

### CO STRONTIUM OXALATE SrC<sub>2</sub>O<sub>4</sub> .H<sub>2</sub>O

One liter of water dissolves 0.0328 gm. SrC<sub>2</sub>O<sub>4</sub> at 1.35°, 0.0444 gm. at 15.9°, 0.0461 gm. at 18°, 0.0575 gm. at 31.7° and 0.0617 gm. at 37.3°, determined by the conductivity method. (Kohlrausch, 1908.)

One liter of sat. aqueous solution contains 0.057 gm. SrC<sub>2</sub>O<sub>4</sub> at 0° 0.077 gm. at 20° and 0.093 gm. at 40°. (Cantoni and Diotallevi, 1905.)

One liter sat. aq. solution of SrC<sub>2</sub>O<sub>4</sub>·H<sub>2</sub>O contains 0.0589 gm. SrC<sub>2</sub>O<sub>4</sub> at 18°, as determined by conductivity measurements. (Scholder, Gadenne and Niemann, 1927.)

Using the "polarographic" method (see remarks under barium carbonate) Heyrovsky and Berezicky, 1929, found the solubility of strontium oxalate in water to be 0.00056 gm. equivalents per liter.

SOLUBILITY OF STRONTIUM OXALATE IN OXALIC ACID AND KCl SOLUTIONS AT 25°  
(Kurashvili, 1939)

Moles $\text{H}_2\text{C}_2\text{O}_4$ or KCl per liter	Gms. $\text{SrC}_2\text{O}_4$ per liter	
	in aq. $\text{H}_2\text{C}_2\text{O}_4$	in aq. KCl
0.001	0.153	-
0.010	0.218	-
0.100	0.630	0.0575
0.150	0.680	-
0.300	0.083	0.1527
0.500	0.037	0.2767
1.00	-	0.3953

CO

SOLUBILITY OF STRONTIUM OXALATE IN AQUEOUS ACETIC ACID SOLUTIONS  
AT 26°-27°  
(Herz and Muhs, 1903)

Normality of Acetic Acid	Gms. per 100 cc. Solution		Normality of Acetic Acid	Gms. per 100 cc. Solution	
	$\text{CH}_3\text{COOH}$	$\text{SrC}_2\text{O}_4 \cdot \text{H}_2\text{O}$		$\text{CH}_3\text{COOH}$	$\text{SrC}_2\text{O}_4 \cdot \text{H}_2\text{O}$
0	0	0.009	3.86	23.16	0.0598
0.58	3.48	0.0526	5.79	34.74	0.0496
1.45	8.70	0.0622	16.26	97.56	0.0060
2.89	17.34	0.0642			

THE SYSTEM STRONTIUM OXALATE - URANYL OXALATE - WATER  
(Colani, 1934)

Results at 15°

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{UO}_2\text{C}_2\text{O}_4$	$\text{SrC}_2\text{O}_4$	
0.470	0.0	$\text{UO}_2\text{C}_2\text{O}_4 \cdot 3\text{H}_2\text{O}$
0.616	0.093	"
0.771	0.164	$\text{SrUO}_2(\text{C}_2\text{O}_4)_2 \cdot 4\text{H}_2\text{O}$
0.742	0.158	"
0.701	0.160	"
0.549	0.163	"
0.481	0.147	$\text{SrC}_2\text{O}_4 \cdot \text{H}_2\text{O}$
0.266	0.086	"
0.087	0.033	"

Results at 50°

Gms. per 100 gms. sat. sol.		Solid Phase
$\text{UO}_2\text{C}_2\text{O}_4$	$\text{SrC}_2\text{O}_4$	
1.00	0.0	$\text{UO}_2\text{C}_2\text{O}_4 \cdot 3\text{H}_2\text{O}$
1.23	0.121	"
1.75	0.343	"
1.92	0.412	"
2.10	0.521	"
1.99	0.508	$\text{SrUO}_2(\text{C}_2\text{O}_4)_2 \cdot 4\text{H}_2\text{O}$
1.82	0.500	"
1.45	0.477	"
1.32	0.435	$\text{SrC}_2\text{O}_4 \cdot \text{H}_2\text{O}$
0.524	0.189	"
0.349	0.128	"
0.176	0.074	"

# Sr STRONTIUM

## Cl STRONTIUM CHLORIDE $\text{SrCl}_2$

### SOLUBILITY IN WATER

Average curve from the results of Mulder; Etard; see also Tilden, 1884.

Gms. SrCl <sub>2</sub> per 100 Gms.			Solid Phase	Gms. SrCl <sub>2</sub> per 100 Gms.			Solid Phase
t°	Solution	Water		t°	Solution	Water	
-20	26.0	35.1	SrCl <sub>2</sub> ·6H <sub>2</sub> O	60	45.0	81.8	SrCl <sub>2</sub> ·6H <sub>2</sub> O
0	30.3	43.5		"	(46.2)		
10	32.3	47.7	"	70	46.2	85.9	SrCl <sub>2</sub> ·2H <sub>2</sub> O
20	34.6	52.9	"	80	47.5	90.5	
25	35.8	55.8	"	100	50.2	100.8	"
30	37.0	58.7	"		(50.8)		
	(37.0)		120	53.0	112.8	"	
40	39.5	65.3	"	140	55.6	125.2	"
50	42.0	72.4	"	160	58.5	141.0	"
				180	62.0	163.1	"

Transition temperature about 62.5°. Sp. Gr. of sat. solution at 0° = 1.334; at 15° = 1.36. Data in parentheses are those of Assarsson and Balder, 1953.

More recent determinations of the solubility of strontium chloride in water, made by Menzies, 1936, by a modification of the synthetic method which permitted varying at will the amount of solvent in contact with the solute, are as follows.

t°	Gm. Mols. SrCl <sub>2</sub> per 1000 gms. H <sub>2</sub> O		Solid Phase	t°	Gm. Mols. SrCl <sub>2</sub> per 1000 gms. H <sub>2</sub> O		Solid Phase
20	3.33		$\text{SrCl}_2 \cdot 6\text{H}_2\text{O}$	100	6.39		$\text{SrCl}_2 \cdot 2\text{H}_2\text{O}$
25	3.50		"	110	6.74		"
30	3.69		"	120	7.17		"
40	4.10		"	130	7.74		"
50	4.62		"	134.4	8.06		" + $\text{SrCl}_2 \cdot \text{H}_2\text{O}$
60	5.35		"	140	8.20		$\text{SrCl}_2 \cdot \text{H}_2\text{O}$
61.4	5.50		" + $\text{SrCl}_2 \cdot 2\text{H}_2\text{O}$	150	8.60		"
70	5.65		$\text{SrCl}_2 \cdot 2\text{H}_2\text{O}$	160	8.74		"
80	5.86		"	180	9.39		"
90	6.10		"	200	10.29		"

### SOLUBILITY OF STRONTIUM CHLORIDE IN WATER ABOVE 100° (Benrath, 1941)

t°	Gms. SrCl <sub>2</sub> per 100 gms.		Solid Phase	t°	Gms. SrCl <sub>2</sub> per 100 gms.		Solid Phase
	Sat. Sol.				Sat. Sol.		
124	53.9		$\text{SrCl}_2 \cdot 2\text{H}_2\text{O}$	141	55.5		$\text{SrCl}_2 \cdot 2\text{H}_2\text{O}$
131	54.1		"	155	56.9		"
137	55.0		"				

(Cont.)

# STRONTIUM Sr

## SOLUBILITY OF STRONTIUM CHLORIDE IN WATER ABOVE 100°--Cont.

Gms. SrCl <sub>2</sub> per 100 gms.			Gms. SrCl <sub>2</sub> per 100 gms.		
t°	Sat. Sol.	Solid Phase	t°	Sat. Sol.	Solid Phase
166	58.3	SrCl <sub>2</sub> ·2H <sub>2</sub> O	293	73.9	SrCl <sub>2</sub> ·H <sub>2</sub> O
184	60.2	"	312	76.2	"
200	62.3	"	318	78.0	"
230	66.6	SrCl <sub>2</sub> ·2H <sub>2</sub> O+SrCl <sub>2</sub> ·H <sub>2</sub> O	320	78.5	SrCl <sub>2</sub> ·H <sub>2</sub> O+SrCl <sub>2</sub>
233	67.1	SrCl <sub>2</sub> ·H <sub>2</sub> O	340	79.0	SrCl <sub>2</sub>
265	69.7	"	382	80.0	"
			412	81.0	"

Cl

## FREEZING-POINTS OF DILUTE SOLUTIONS OF STRONTIUM CHLORIDE (Klein and Svanberg, 1920)

t° of f. pt.	-0.485	-1.233	-2.584
Normality of aq. SrCl <sub>2</sub> solution	0.10	0.25	0.50

## SOLUBILITY OF STRONTIUM CHLORIDE IN 98.1% DEUTERIUM WATER (Miles and Menzies, 1937)

Gm. Mols. SrCl <sub>2</sub> per 1000 gms. D <sub>2</sub> O			Gm. Mols. SrCl <sub>2</sub> per 1000 gms. D <sub>2</sub> O		
t°		Solid Phase	t°		Solid Phase
0	2.78	SrCl <sub>2</sub> ·6H <sub>2</sub> O	80	5.76	SrCl <sub>2</sub> ·2H <sub>2</sub> O
10	2.91	"	90	6.02	"
20	3.36	"	100	6.34	"
25	3.54	"	110	6.72	"
30	3.73	"	120	7.18	"
40	4.17	"	128.5	7.64	" + SrCl <sub>2</sub> ·H <sub>2</sub> O
50	4.76	"	130	7.63	SrCl <sub>2</sub> ·H <sub>2</sub> O
56.4	5.28	" + SrCl <sub>2</sub> ·2H <sub>2</sub> O	135	7.82	"
60	5.35	SrCl <sub>2</sub> ·2H <sub>2</sub> O	140	7.97	"
70	5.54	"	145	8.14	"

## SOLUBILITY OF STRONTIUM CHLORIDE IN AQUEOUS HYDROCHLORIC ACID SOLUTIONS

### Results at 0°

(Engel, 1888)

Sp. Gr. of Solution	Gms. per 100 cc. Solution		Sp. Gr. of Solution	Gms. per 100 cc. Solution	
	SrCl <sub>2</sub>	HCl		SrCl <sub>2</sub>	HCl
1.334	40.9	0.0	1.220	21.56	8.49
1.304	35.5	2.22	1.201	17.44	10.35
1.269	30.0	4.65	1.167	11.09	13.58
1.133			1.133	3.37	19.23



# Sr STRONTIUM

## Results at 25°

(Harkins and Paine, 1916)

(Milikan, 1918)

Gms. Equiv. HCl per 1000 Gms. H <sub>2</sub> O	d <sub>25</sub> of Sat. Sol.	Gms. SrCl <sub>2</sub> per 100 Gms. Sat. Sol.	Gms. per 100 gms. sat. sol.		Solid Phase
			SrCl <sub>2</sub>	HCl	
0.1551	1.3953	35.17	35.60	0.0	SrCl <sub>2</sub> ·6H <sub>2</sub> O
0.5162	1.3788	33.60	33.97	0.66	"
1.017	1.3563	31.42	27.55	4.57	"
2.165	1.3065	26.33	9.86	16.12	"
9.205	1.1498	3.055	6.68	18.89	"
			2.11	27.14	" + SrCl <sub>2</sub> ·2H <sub>2</sub> O
			1.29	28.23	SrCl <sub>2</sub> ·2H <sub>2</sub> O
			0.13	37.66	"

Cl

## THE SYSTEM STRONTIUM OXIDE - HYDROCHLORIC ACID - WATER AT 25° (Milikan, 1918)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
SrO	HCl		SrO	HCl	
0.08	37.72	SrCl <sub>2</sub> ·2H <sub>2</sub> O	23.27	16.38	SrCl <sub>2</sub> ·6H <sub>2</sub> O
0.10	36.59	"	23.83	16.19	" + SrCl <sub>2</sub> ·SrO·9H <sub>2</sub> O
0.84	28.82	"	24.15	16.40	" "
1.38	28.16	" + SrCl <sub>2</sub> ·6H <sub>2</sub> O	22.88	15.33	SrO·9H <sub>2</sub> O + "
1.46	28.10	SrCl <sub>2</sub> ·6H <sub>2</sub> O	23.06	15.46	" "
4.37	21.96	"	22.94	15.37	" "
6.44	20.66	"	15.19	10.16	SrO·9H <sub>2</sub> O
18.01	17.24	"	9.04	5.76	"
22.20	16.29	"	0.85	0.0	"

## SOLUBILITY OF SrCl<sub>2</sub> IN AQUEOUS HBr SOLUTIONS AT 25° (Harkins and Paine, 1916)

Gms. Equiv. HBr per 1000 Gms. H <sub>2</sub> O	d <sub>25</sub> of Sat. Sol.	Gms. SrCl <sub>2</sub> per 100 Gms. Sat. Sol.
0	1.4015	35.80
0.06817	1.4020	35.47
0.4191	1.4010	33.92
0.9716	1.3992	31.52
1.154	1.3995	20.78

SOLUBILITY OF STRONTIUM CHLORIDE IN AQUEOUS SOLUTIONS OF ACIDS  
AND OF SALTS AT 25°  
(Harkins and Paine, 1916)

Aqueous Solution of	Gms. Equiv. added Salt per 1000 Gms. H <sub>2</sub> O	d <sub>25</sub> of Sol.	Gms. SrCl <sub>2</sub> per 100 Gms. Sol.	Aqueous Solution of	Gms. Equiv. added Salt per 1000 Gms. H <sub>2</sub> O	d <sub>25</sub> of Sol.	Gms. SrCl <sub>2</sub> per 100 Gms. Sol.
CuCl <sub>2</sub>	0.7134	1.4200	34.005	KNO <sub>3</sub>	0.09790	1.4107	35.86
CuCl <sub>2</sub>	2.276	1.4595	30.40	KNO <sub>3</sub>	0.4755	1.4349	35.90
HI	0.1641	1.4058	34.850	HNO <sub>3</sub>	0.1771	1.4038	35.52
HI	0.4462	1.4121	33.28	HNO <sub>3</sub>	0.3521	1.4059	35.40
HI	0.7539	1.4196	31.52	HNO <sub>3</sub>	1.277	1.4175	34.04
KI	0.09199	1.4093	35.45	NaNO <sub>3</sub>	0.3621	1.4216	35.63
KI	0.5401	1.4466	33.79	NaNO <sub>3</sub>	0.5010	1.4588	35.60
KI	0.6015	1.4513	33.60	NaNO <sub>3</sub>	3.553	1.5214	30.88
KI	1.445	1.5154	30.90	NaNO <sub>3</sub>	6.856	1.5581	25.53
KCl	0.0719	1.4032	35.62	Sr(NO <sub>3</sub> ) <sub>2</sub>	0.1372	1.4113	35.42
KCl	0.433	1.4085	34.80	Sr(NO <sub>3</sub> ) <sub>2</sub>	0.5766	1.4336	34.47
KCl	0.8570	1.4152	33.89	Sr(NO <sub>3</sub> ) <sub>2</sub>	1.0988	1.4636	33.30
KCl	1.594	1.4266	32.40	Sr(NO <sub>3</sub> ) <sub>2</sub>	3.318	1.6664	28.97

Cl

THE SYSTEM STRONTIUM CHLORIDE - STRONTIUM OXIDE - WATER  
(Milikan, 1917)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
SrCl <sub>2</sub>	SrO	Solid Phase	SrCl <sub>2</sub>	SrO	Solid Phase
Results at 0°			Results at 40°		
30.68	0.0	SrCl <sub>2</sub> ·6H <sub>2</sub> O	39.62	0.0	SrCl <sub>2</sub> ·6H <sub>2</sub> O
30.55	0.31	" + SrO·9H <sub>2</sub> O	39.26	1.36	" + 1.1.9
29.03	0.30	SrO·9H <sub>2</sub> O	36.62	1.73	1.1.9
23.74	0.29	"	36.08	1.76	"
0.0	0.35	"	34.13	2.03	"
			32.97	2.10	"
			32.07	2.47	" + SrO·9H <sub>2</sub> O
			29.01	1.91	SrO·9H <sub>2</sub> O
35.60	0.0	SrCl <sub>2</sub> ·6H <sub>2</sub> O	28.84	1.90	"
35.65	0.85	" + 1.1.9	18.48	1.42	"
33.41	1.09	1.1.9 + SrO·9H <sub>2</sub> O	0.0	1.48	"
22.09	0.75	SrO·9H <sub>2</sub> O			
12.52	0.86	"			
0.0	0.85	"			
					1.1.9 = SrCl <sub>2</sub> ·SrO·9H <sub>2</sub> O

# **Sr STRONTIUM**

## THE SYSTEM STRONTIUM CHLORIDE-STRONTIUM NITRATE - WATER AT 25° (Ehret, 1932)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	Sr(NO <sub>3</sub> ) <sub>2</sub>	SrCl <sub>2</sub>	
1.476	44.28	0.0	Sr(NO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
1.492	48.69	6.32	"
1.488	38.57	5.54	"
1.508	35.14	10.79	"
1.510	34.29	10.87	"
1.513	33.71	12.11	Sr(NO <sub>3</sub> ) <sub>2</sub>
1.515	30.15	15.10	"
1.523	27.25	18.83	"
1.537	22.75	23.07	"
1.565	19.62	28.45	"
1.568	18.79	28.97	Sr(NO <sub>3</sub> ) <sub>2</sub> + SrCl <sub>2</sub> ·6H <sub>2</sub> O
1.563	18.00	29.23	SrCl <sub>2</sub> ·6H <sub>2</sub> O
1.526	14.10	30.75	"
1.483	9.97	32.51	"
1.403	0.0	35.82	"

## SOLUBILITY OF STRONTIUM CHLORIDE IN AQUEOUS SOLUTIONS OF POTASSIUM PERMANGANATE AT 25° (Herz and Hiebenthal, 1929)

Gm. Mols. per liter		Solid Phase
<sup>1</sup> / <sub>3</sub> KMnO <sub>4</sub>	<sup>1</sup> / <sub>2</sub> SrCl <sub>2</sub>	
0.0	6.24	SrCl <sub>2</sub> ·6H <sub>2</sub> O
0.02	6.22	"
0.41	6.14	"
0.82	6.12	"
+1.36	5.90	"

## SOLUBILITY OF STRONTIUM CHLORIDE IN AQUEOUS ETHANOL

### Results at 18° (Gerardin, 1865)

Sp. Gr. of Aq. Alcohol at 0°	Wt. % Alcohol	Gms. SrCl <sub>2</sub> per 100 Gms. Alcohol	Sp. Gr. of Aq. Alcohol at 0°	Wt. % Alcohol	Gms. SrCl <sub>2</sub> per 100 Gms. Alcohol
0.990	6	49.81	0.939	45	26.8
0.985	10	47.0	0.909	59	19.2
0.973	23	39.6	0.846	86	4.9
0.966	30	35.9	0.832	91	3.2
0.953	38	30.4			

## SOLUBILITY OF STRONTIUM CHLORIDE IN AQUEOUS ETHANOL--Cont.

## Results at 25° (Jankovic, 1958)

Mole % H <sub>2</sub> O in solvent	density	Wt. % SrCl <sub>2</sub> in sat. sol.	Mole % H <sub>2</sub> O in solvent	density	Wt. % SrCl <sub>2</sub> in sat. sol.
96.8	1.348	32.20	55.8	0.960	11.69
94.5	1.312	31.75	50.0	0.934	9.68
89.7	1.252	28.72	43.1	0.906	7.68
84.7	1.194	25.57	35.1	0.874	5.56
79.1	1.134	22.68	26.4	0.845	4.01
69.8	1.052	18.08	17.8	0.820	2.50
64.5	1.018	15.31	6.3	0.801	1.03
59.0	0.983	13.01			

Cl

The composition of the homogeneous mixture (plait point) of the system strontium chloride, tertiary butyl alcohol and water at 25°, was found by Ginnings, Herring and Webb, 1933, to be 6.3 percent SrCl<sub>2</sub>, 33.1 percent ter. (CH<sub>3</sub>)<sub>3</sub>COH and 60.6 percent H<sub>2</sub>O. The original results for the remaining points on the binodal curve are not given but only the values of a series of constants calculated by means of empirical equations.

The binodal curve for the system strontium chloride, allyl alcohol and water at 25° has been determined by Ginning and Dees, 1935, but the authors give only the values of a series of constants calculated from their experimental results by means of an empirical equation.

## SOLUBILITY OF STRONTIUM CHLORIDE IN ANHYDROUS ACETIC ACID

(Davidson and Chappell, 1938)

t°	Gm. Mol. Percent SrCl <sub>2</sub> in sat. sol.	Solid Phase	t°	Gm. Mol. Percent SrCl <sub>2</sub> in sat. sol.	Solid Phase
16.60	0.0	CH <sub>3</sub> COOH	19.0	6.11	SrCl <sub>2</sub>
16.32	0.55	"	30.0	5.12	"
16.05	1.09	"	45.0	4.04	"
15.68	1.81	"	60.0	3.28	"
15.05	3.07	"	83.0	2.22	"
14.00	3.93	"	98.9	1.67	"
13.65	5.11	"			

## SOLUBILITY OF STRONTIUM CHLORIDE IN SEVERAL OTHER SOLVENTS

Solvent	t°	Solubility
Methanol	6	63.3 gms. SrCl <sub>2</sub> ·6H <sub>2</sub> O per 100 gms. solvent (deBruyn, 1892)
Ethanol	6	3.8 gms. SrCl <sub>2</sub> ·6H <sub>2</sub> O per 100 gms. solvent (deBruyn, 1892)
95% formic acid	19	23.8 gms. SrCl <sub>2</sub> per 100 gms. solvent (Aschan, 1913)
Monoethanolamine	25	19.5 gms. SrCl <sub>2</sub> per 100 gms. sat. sol. (Isbin and Kobe, 1945)
Ethylene glycol	25	36.4 gms. SrCl <sub>2</sub> per 100 gms. sat. sol. (Isbin and Kobe, 1945)
Selenium oxychloride	25	5.17 gms. SrCl <sub>2</sub> per 100 gms. sat. sol. (Wise, 1923)
Hydrazine (anhyd.)	room	8 gms. per 100 cc. solvent (Welsh and Broderson, 1915)

# Sr STRONTIUM

Melting point data are given for the following:

$\text{SrCl}_2 + \text{SrF}_2$	(Plato, 1907; Bergman and Bukalova, 1949; Banashek and Bergman, 1954; Bukalova and Bergman, 1952)
$\text{SrCl}_2 + \text{SrO}$	(Sackur, 1911-12)
$\text{SrCl}_2 + \text{SrSO}_4$	(Sackur, 1911-12)
$\text{SrCl}_2 + \text{TiCl}$	(Korring, 1914)
$\text{SrCl}_2 + \text{ZnCl}_2$	(Sandonnini, 1912a, 1914)
$\text{SrCl}_2 + \text{Sr}(\text{NO}_3)_2$	(Gromakov and Gromakova, 1953)
$\text{SrCl}_2 + \text{Li}_2\text{SO}_4 = \text{SrSO}_4 + 2\text{LiCl}$	(Golubeva and Bergman, 1955)
$\text{SrCl}_2 + 2\text{LiNO}_3 = \text{SrCl}_2 + 2\text{LiCl}$	(Tokareva and Bergman, 1956)
$\text{SrCl}_2 + \text{BaF}_2 = \text{SrF}_2 + \text{BaCl}_2$	(Bergman and Bukalova, 1949)

## ClO STRONTIUM CHLORITE $\text{Sr}(\text{ClO}_2)_2$

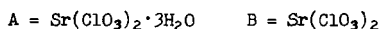
SOLUBILITY IN WATER  
(Levi and Bisi, 1956)

The solid phase is anhydrous.

t°	Wt. % $\text{Sr}(\text{ClO}_2)_2$ in sat. sol.	t°	Wt. % $\text{Sr}(\text{ClO}_2)_2$ in sat. sol.
0	13.05	45	14.92
15	14.00	55	15.32
23	14.25	65	15.72
25	14.3	75	16.10
35	14.51		

## ClO STRONTIUM CHLORATE $\text{Sr}(\text{ClO}_3)_2$

THE SYSTEM STRONTIUM CHLORATE - WATER  
(Linke, 1953)



t°	Gms. $\text{Sr}(\text{ClO}_3)_2$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{Sr}(\text{ClO}_3)_2$ per 100 gms. sat. sol.	density	Solid Phase
- 1.8	9.29	Ice	10	63.4	1.829	A + B
- 4.0	17.92	"	0	63.23m	1.828	B
- 9.4	29.94	"	15	63.55	1.830	B
-14.2	37.46	"	18	(63.6) <sup>a</sup>	(1.839) <sup>a</sup>	B
-22.2	45.11	"	25	63.78	1.831	B
-29.4	49.87	"	35	64.17	1.833	B
-38.1m	55.0	"	45	64.55	1.835	B
-37.0	54.5	Ice+A	50	64.65	1.837	B
-28	57.1	A	55	64.95	1.838	B
-16.7	57.9	A	65	65.32	1.842	B
- 7	59.9	A	75	66.07	1.845	B
0	61.4	A	80	66.07	1.847	B
+ 9	63.47	A	85	66.41	1.849	B
			95	67.08	1.853	B
<sup>a</sup> = Mylius and Funk, 1897			110	67.8	1.861	B
<sup>b</sup> = boiling point			121 <sup>b</sup>	68.7	1.867	B
m = metastable						

STRONTIUM PERCHLORATE  $\text{Sr}(\text{ClO}_4)_2$ 

ClO

SOLUBILITY IN WATER  
(Lilich and Dzhurinskii, 1956)

Willard and Smith, 1930 found that strontium perchlorate crystallized from water at about  $0^\circ$  apparently contained  $4\text{H}_2\text{O}$ . At about  $25^\circ$  a dihydrate,  $2\text{H}_2\text{O}$ , was obtained. Above  $40^\circ$  the crystals corresponded to the formula  $3\text{Sr}(\text{ClO}_4)_2 \cdot 2\text{H}_2\text{O}$ . The transition point between this compound and the dihydrate was at about  $37^\circ$ . Evidence was also obtained of the possible existence of a monohydrate.

t°	Moles $\text{Sr}(\text{ClO}_4)_2$ per 1000 gms. $\text{H}_2\text{O}$	t°	Moles $\text{Sr}(\text{ClO}_4)_2$ per 1000 gms. $\text{H}_2\text{O}$
0	8.16	25	10.54
5	8.57		(10.8) <sup>a</sup>
10	9.03	30	11.43
15	9.49	35	12.02
20	10.18	40	12.70

<sup>a</sup>Willard and Smith, 1923

Freezing point depressions for solutions of  $\text{Sr}(\text{ClO}_4)_2$  up to 1 molal are given by Nicholson and Felsing, 1950.

SOLUBILITY OF ANHYDROUS STRONTIUM PERCHLORATE IN SEVERAL SOLVENTS AT  $25^\circ$   
(Willard and Smith, 1930)

Solvent	$d_{25}^4$ of solvent	$d_{25}^4$ of sat. sol.	Gms. $\text{Sr}(\text{ClO}_4)_2$ per 100 gms.	
			sat. sol.	solvent
Water	0	2.0837	75.59	309.67
Methyl alcohol	0.78705	1.6771	67.95	212.01
Ethyl alcohol	0.78517	1.5539	64.37	180.66
n Propyl alcohol	0.7989	1.4266	58.40	140.38
n Butyl alcohol	0.8059	1.3394	53.16	113.49
iso Butyl alcohol	0.7981	1.2022	43.78	77.87
Acetone	0.7852	1.4984	60.01	150.06
Ethyl acetate	0.89457	1.4717	52.10	136.93

STRONTIUM HEXAANTIPYRINE PERCHLORATE  $[\text{Sr}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6](\text{ClO}_4)_2$ 

CrO

100 cc sat. solution of strontium hexa antipyrine perchlorate in water contain 9.68 gms.  $[\text{Sr}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6](\text{ClO}_4)_2$  at  $20^\circ$ . (Wilke-Dorfurt and Schliephake, 1929.)

## Sr STRONTIUM

### CrO STRONTIUM CHROMATE $\text{SrCrO}_4$

#### SOLUBILITY OF STRONTIUM CHROMATE IN WATER (Davis and Ricci, 1939)

Equilibrium is approached with such extreme slowness that the following results may be subject to slight revision.

t°	Gms. $\text{SrCrO}_4$ per liter
15	0.879 (?)
25	0.91
75	0.62
100	0.43

#### SOLUBILITY OF STRONTIUM CHROMATE IN SEVERAL SOLVENTS AT 15° (Fresenius, 1891)

	Gms. $\text{SrCrO}_4$ per 100 Gms. Solvent		Gms. $\text{SrCrO}_4$ per 100 Gms. Solvent
Water	0.12	Aq. Ethyl Alcohol (29%)	0.0132
Aq. $\text{NH}_4\text{Cl}$ (5%)	0.195	Aq. Ethyl Alcohol (53%)	0.002
Aq. $\text{CH}_3\text{COOH}$ (1%)	1.57		

#### SOLUBILITY OF STRONTIUM CHROMATE IN ETHYL ALCOHOL SOLUTIONS (Davis, 1942)

Solutions rotated with solid strontium chromate did not become saturated for more than a year, and the determinations are complicated by the slow hydration of the solid (to form a mono- or dihydrate). Some reduction of the chromate by alcohol took place upon standing for long periods of time. The lower results of previous authors are probably the result of unsaturation. Results below are in grams  $\text{SrCrO}_4$  per 100 gms. saturated solution.

Wt. % $\text{C}_2\text{H}_5\text{OH}$	(Approx. Volume %)	25°	50°	75°
0.0	0	0.096	0.090	0.080
19.7	25	.011	.012	.008
41.8	50	.004	.009	.003
92.5	95	~ .00005	< .00005	< .00005

## F STRONTIUM FLUORIDE $\text{SrF}_2$

#### SOLUBILITY IN WATER

t°	Gms. per liter	Reference
0.26	0.1135	Kohlrausch, 1908
17.4	0.1173	Kohlrausch, 1908
25	0.1193	Kohlrausch, 1908
	0.39 (?)	Carter, 1928
	0.1208	Talipov and Khadeev, 1950a

SOLUBILITY OF STRONTIUM FLUORIDE AT 25°  
(Talipov and Khadeev, 1950a)

In Aqueous KF Solutions				In Aqueous NaF Solutions	
Moles per liter		Moles per liter		Moles per liter	
KF	SrF <sub>2</sub>	KF	SrF <sub>2</sub>	NaF	SrF <sub>2</sub>
0.0	0.000962	0.004488	0.000164	0.0	0.000962
0.0004987	0.000837	0.004987	0.000144	0.0009974	0.000650
0.0009974	0.000656	0.005487	0.000119	0.001995	0.000451
0.001496	0.000538	0.005985	0.000109	0.003447	0.000253
0.001995	0.000446	0.006485	0.000091	0.003990	0.000200
0.002494	0.000367	0.007982	0.000068	0.004987	0.000140
0.002992	0.000292	0.008480	0.000064	0.005985	0.000119
0.003421	0.000236	0.008948	0.000056	0.006982	0.000093
0.003990	0.000205	0.009877	0.000051	0.007980	0.000066
				0.008982	0.000064
				0.009978	0.000060
				0.01096	0.000050

SOLUBILITY OF STRONTIUM FLUORIDE IN AQUEOUS SOLUTIONS  
OF HYDROCHLORIC ACID AT 25°(?)  
(Tananaev and Tchrelachwilli, 1936)

Normality of aq. HCl	Gm. Mol. SrF <sub>2</sub> dissolved per liter	pH of sat. sol.
0.01	0.0038	2.20
0.10	0.0220	1.03
1.0	0.1240	0.07

0.02 gms. SrF<sub>2</sub> dissolve in 100 gms. liquid SO<sub>2</sub> at 25°. (Watt, Jenkins and Robertson, 1950.)

Melting points in the system SrF<sub>2</sub> - Al<sub>2</sub>O<sub>3</sub> - SiO<sub>2</sub> are given by Ershova, 1957. For the system SrF<sub>2</sub> - SrO - SiO<sub>2</sub> see Ershova and Ol'shanskii, 1957.

STRONTIUM HEXA ANTIPYRINE FLUOBORATE Sr(COC<sub>10</sub>H<sub>12</sub>N<sub>2</sub>)<sub>6</sub>(BF<sub>4</sub>)<sub>2</sub>

100 cc sat. solution of strontium hexa antipyrine boro fluoride in water contain 3.8 gms. Sr(COC<sub>10</sub>H<sub>12</sub>N<sub>2</sub>)<sub>6</sub>(BF<sub>4</sub>)<sub>2</sub> at 20°. (Wilke-Dorfurt and Mureck, 1929.)

STRONTIUM FLUOPHOSPHATE SrPO<sub>3</sub>F.H<sub>2</sub>O

One liter sat. solution of strontium phospho fluoride in water contains 0.055 gm. mols. SrPO<sub>3</sub>F at 20°. (Lange, 1929.)



## Sr STRONTIUM

### STRONTIUM FLUOSILICATE $\text{SrSiF}_6$

At 15° a saturated solution in water contains 3.22%  $\text{SrSiF}_6$ .

100 gms. of a sat. solution of strontium fluosilicate in a solvent composed of 135 cc.  $\text{H}_2\text{O}$  + 9.0 cc. of 1.0 n  $\text{HCl}$  + 1.5 gm.  $(\text{NH}_4)_2\text{SiF}_6$  + 48 cc.  $\text{C}_2\text{H}_5\text{OH}$  contain 1.061 gm.  $\text{SrSiF}_6$  at 18°.5. (Leo, 1923.)

## H STRONTIUM HYDRIDE $\text{SrH}_2$

Phase diagrams for the systems  $\text{SrH}_2 - \text{SrBr}_2$  and  $\text{SrH}_2 - \text{SrI}_2$  are reported by Ehrlich and Gortz (1956) and Ehrlich and Kulke (1956).

## I STRONTIUM IODIDE $\text{SrI}_2$

### SOLUBILITY IN WATER

Average curve from the results of Kremers, 1858; and Etard, 1874.

t°	Gms. $\text{SrI}_2$ per 100 Gms.		Solid Phase	t°	Gms. $\text{SrI}_2$ per 100 Gms.		Solid Phase
	Solution	Water			Solution	Water	
0	62.3	165.3	$\text{SrI}_2 \cdot 6\text{H}_2\text{O}$	90	78.5	365.2	$\text{SrI}_2 \cdot 2\text{H}_2\text{O}$
20	64.0	177.8	"	100	79.3	383.1	"
40	65.7	191.5	"	120	80.7	418.1	"
60	68.5	217.5	"	140	82.5	471.5	"
80	73.0	270.4	"	175	85.6	594.4	"

Transition temperature about 90°. Sp. Gr. of sat. solution at 20° = 2.15.

### THE SYSTEM STRONTIUM IODIDE - STRONTIUM OXIDE - WATER AT 25° (Milikan, 1917)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{SrI}_2$	$\text{SrO}$		$\text{SrI}_2$	$\text{SrO}$	
64.70	0.0	$\text{SrI}_2 \cdot 6\text{H}_2\text{O}$	53.04	0.72	$\text{SrI}_2 \cdot 2\text{SrO} \cdot 9\text{H}_2\text{O}$
64.04	0.16	" + $\text{SrI}_2 \cdot 2\text{SrO} \cdot 9\text{H}_2\text{O}$	49.37	0.74	" + $\text{SrO} \cdot 9\text{H}_2\text{O}$
60.77	0.18	$\text{SrI}_2 \cdot 2\text{SrO} \cdot 9\text{H}_2\text{O}$	39.50	0.55	$\text{SrO} \cdot 9\text{H}_2\text{O}$
55.58	0.46	"	29.98	0.53	"
55.09	0.51	"	22.36	0.57	"
54.16	0.60	"	0.0	0.85	"

Additional data in this system are reported by Milikau, 1916.

SOLUBILITY OF  $\text{SrI}_2$  IN VARIOUS SOLVENTS

Solvent	t°	Solubility
Ethanol	-20	2.6 gms. $\text{SrI}_2$ per 100 gms. sat. sol. (Etard, 1874)
	+ 4	3.1 gms. $\text{SrI}_2$ per 100 gms. sat. sol. (Etard, 1874)
	39	4.3 gms. $\text{SrI}_2$ per 100 gms. sat. sol. (Etard, 1874)
	82	4.7 gms. $\text{SrI}_2$ per 100 gms. sat. sol. (Etard, 1874)
Acetone	20	42.0 gms. $\text{SrI}_2$ per 100 gms. acetone (Altaba, 1951)
liquid $\text{SO}_2$	25	0.14 gms. $\text{SrI}_2$ per 100 gms. sat. sol. (Shatenstein and Viktorov, 1937)
		0.49 <sup>a</sup> gms. $\text{SrI}_2$ per 100 gms. sat. sol. (Watt, Jenkins and Robertson, 1950)
liquid $\text{NH}_3$	0	0.308 gms. $\text{SrI}_2$ per 100 gms. sat. sol. (Linhard and Stephan, 1934)

<sup>a</sup>W. J. and R. used the hemihydrated salt.

STRONTIUM PERIODIDE  $\text{SrI}_4$ 

Data for the formation of strontium periodide in aqueous solution at 25° are given by Herz and Bulla (1911). The experiments were made by adding iodine to aqueous solutions of  $\text{SrI}_2$  and agitating with carbon tetrachloride. From the iodine content of the  $\text{CCl}_4$  layer the amount of iodine in the aqueous layer can be calculated on the basis of the distribution ratio of iodine between water and  $\text{CCl}_4$ . This furnishes the necessary data for calculating the amount of the strontium periodide existing in the aqueous layer.

STRONTIUM IODATE  $\text{Sr}(\text{IO}_3)_2$ 

10

THE SYSTEM  $\text{Sr}(\text{IO}_3)_2 - \text{H}_2\text{O}$   
(Linke, 1953)

The monohydrate is metastable with respect to the other phases at all temperatures.

t°	Wt. % $\text{Sr}(\text{IO}_3)_2$ in sat. sol.		
	Solid Phase $\text{Sr}(\text{IO}_3)_2$	Solid Phase $\text{Sr}(\text{IO}_3)_2 \cdot \text{H}_2\text{O}$	Solid Phase $\text{Sr}(\text{IO}_3)_2 \cdot 6\text{H}_2\text{O}$
0	0.098m	0.1453m	0.0861
6 ± 1 <sup>t</sup>	0.117	-	0.117
7	0.120	0.1763m	0.1230m
11	0.130	-	0.1505m
15	0.138	0.2115m	0.1822m

m = metastable

t = transition temperature

(Cont.)

## Sr STRONTIUM

THE SYSTEM  $\text{Sr}(\text{IO}_3)_2 - \text{H}_2\text{O}$ --Cont.

t°	Wt. % $\text{Sr}(\text{IO}_3)_2$ in sat. sol.		
	Solid Phase $\text{Sr}(\text{IO}_3)_2$	Solid Phase $\text{Sr}(\text{IO}_3)_2 \cdot \text{H}_2\text{O}$	Solid Phase $\text{Sr}(\text{IO}_3)_2 \cdot 6\text{H}_2\text{O}$
18	-	-	0.2135m
20	0.161	0.2369m	0.2302m
20.8 ± 0.5 <sup>t</sup>	-	0.241m	0.241m
25	0.165	0.2606m (0.257) <sup>a</sup>	0.2914m
35	-	0.3116m	-
40	0.203	0.3399m	-
45	-	0.3657m	-
55	0.242	0.4216m	-
65	0.267	0.4769m	-
75	0.296	0.5344m	-
85	0.316	-	-
95	0.340	-	-
100	0.350	0.68m	-

m = metastable

t = transition temperature

a = Monk, 1952

SOLUBILITY OF STRONTIUM IODATE IN SOLUTION OF ELECTROLYTES AT 25°

In aq. NaOH		In aq. $\text{Na}_3\text{P}_3\text{O}_9$		In aq. $\text{Na}_4\text{P}_4\text{O}_{12}$	
(Colman-Porter and Monk, 1952)		(Monk, 1952)		(Monk, 1952)	
Moles per Liter		Moles per Liter		Moles per Liter	
NaOH	$\text{Sr}(\text{IO}_3)_2$	$\text{Na}_3\text{P}_3\text{O}_9$	$\text{Sr}(\text{IO}_3)_2$	$\text{Na}_4\text{P}_4\text{O}_{12}$	$\text{Sr}(\text{IO}_3)_2$
0.0	0.00587	0.0	0.00587	0.00571	0.00933
0.01670	0.00655	0.00546	0.00754	0.00850	0.01087
0.02231	0.00673	0.00675	0.00788	0.01187	0.01291
0.03021	0.00698	0.00824	0.00820		
0.04599	0.00740	0.01061	0.00867		

## MnO STRONTIUM PERMANGANATE $\text{Sr}(\text{MnO}_4)_2$

100 gms. of the sat. solution in water contain about 2.5 gms.  $\text{Sr}(\text{MnO}_4)_2$  at 0°. (Patterson, 1906).

## MoO STRONTIUM MOLYBDATE $\text{SrMoO}_4$

100 gms.  $\text{H}_2\text{O}$  dissolve 0.0104 gm.  $\text{SrMoO}_4$  at 17°. (Smith and Bradbury, 1891.)

The Ksp reported by Rao, 1954 is  $2.58 \times 10^{-7}$ . A sat. sol. in  $\text{H}_2\text{O}$  at 0° contains 1.1 mg. Mo per 100 gms. sat. sol.; at 100°, 1.5 mg. Mo. (Nesmeyanov, Savich, Elkind and Koryazhkin, 1956.)

STRONTIUM NITRIDE  $\text{Sr}(\text{N}_3)_2$ 

N

100 gms. sat. solution of strontium nitride in water contain 31.43 gms.  $\text{Sr}(\text{N}_3)_2$  at 16°. (Curtius and Rissom, 1898.)

STRONTIUM NITRITE  $\text{Sr}(\text{NO}_2)_2$ 

NO

SOLUBILITY OF STRONTIUM NITRITE IN WATER  
(Oswald, 1912, 1914)

t°	Gms. $\text{Sr}(\text{NO}_2)_2$ per 100 Gms.	Solid Phase	t°	Gms. $\text{Sr}(\text{NO}_2)_2$ per 100 Gms.	Solid Phase
	Sat. Sol.			Sat. Sol.	
- 1.3	11.3	Ice	35	43.1	$\text{Sr}(\text{NO}_2)_2 \cdot \text{H}_2\text{O}$
- 3.1	19.6	"	52.5	46.5	"
- 7.7	35.5	"	60.5	49.3	"
- 8.8	32.8	" + $\text{Sr}(\text{NO}_2)_2 \cdot \text{H}_2\text{O}$	65.5	50.7	"
- 2.3	33.4	$\text{Sr}(\text{NO}_2)_2 \cdot \text{H}_2\text{O}$	82.5	54	"
- 0.3	34.5	"	92	56.6	"
+19	39.3a	"	98	58.1	"

<sup>a</sup>d = 1.4461.

100 cc. sat. solution in water contain 62.83 gms.  $\text{Sr}(\text{NO}_2)_2 \cdot \text{H}_2\text{O}$  at 19.5°. 100 cc. sat. solution in 90% alcohol contain 0.42 gms.  $\text{Sr}(\text{NO}_2)_2 \cdot \text{H}_2\text{O}$  at 20°. 100 cc. sat. solution in abs. alcohol contain 0.04 gms.  $\text{Sr}(\text{NO}_2)_2 \cdot \text{H}_2\text{O}$  at 20°. (Vogel, 1903.)

STRONTIUM NITRATE  $\text{Sr}(\text{NO}_3)_2$ 

NO

SOLUBILITY IN WATER  
(Berkeley and Appleby, 1911)

t°	d. of Sat. Sol.	Gms. $\text{Sr}(\text{NO}_3)_2$ per 100 Gms. $\text{H}_2\text{O}$	Solid Phase	t°	d. of Sat. Sol.	Gms. $\text{Sr}(\text{NO}_3)_2$ per 100 Gms. $\text{H}_2\text{O}$	Solid Phase
0.58	1.28561	40.124	$\text{Sr}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$	39.74	1.51282	90.086	$\text{Sr}(\text{NO}_3)_2$
14.71	1.39380	60.867	"	47.73	1.51150	91.446	"
26.40	1.48831	82.052	"	61.34	1.51048	93.856	"
29.06	1.51098	87.648	"	68.96	1.51057	95.576	"
29.3	-	-	" + $\text{Sr}(\text{NO}_3)_2$	78.98	1.51091	97.865	"
30.28	1.51441	88.577	$\text{Sr}(\text{NO}_3)_2$	88.94	1.51174	100.136	"
32.58	1.51408	88.943	"				

The determinations were made with very great accuracy.

(Cont'd)

# Sr STRONTIUM

## SOLUBILITY IN WATER--Cont.

More recent determinations by Sieverts and Petzold, 1933, in agreement with the preceding.

	Gms. Sr(NO <sub>3</sub> ) <sub>2</sub> per 100 Gms. t°			Gms. Sr(NO <sub>3</sub> ) <sub>2</sub> per 100 Gms. t°		
	Sat. Sol.	Solid Phase		Sat. Sol.	Solid Phase	
NO	- 0.8	5.0	Ice	-14.5	44.4m	Ice
	- 1.4	7.5	"	+ 0.1	28.2	Sr(NO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
	- 2.5	12.7	"	20	40.7	"
	- 4.55	21.7	"	28	45.8	"
	- 5.4	24.7	" + Sr(NO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O	29.3	47.0	" + Sr(NO <sub>3</sub> ) <sub>2</sub>
	- 6.6	28.9m	"	35.0	47.2	Sr(NO <sub>3</sub> ) <sub>2</sub>
	- 7.6	31.4m	"	60	48.3	"
	- 8.8	35.1m	"	80	49.2	"
	- 9.8	37.3m	"	105	51.2	"
	-13.2	41.9m	"	13.7	46.6m	"
	-13.9	42.6m	"	- 5.0	45.7m	"

m = metastable

## SOLUBILITY IN WATER ABOVE 100° (Benrath, 1942)

t°	Gms. Sr(NO <sub>3</sub> ) <sub>2</sub> per 100 gms. Sat. Sol.	t°	Gms. Sr(NO <sub>3</sub> ) <sub>2</sub> per 100 gms. Sat. Sol.
179	55	370	75
225	60	425	80
265	65	475	85
312	70		

## THE SYSTEM STRONTIUM NITRATE - NITRIC ACID - WATER (Sieverts and Petzold, 1933a)

Additional data are given at -15°, -8°, -5° and +20°.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
Sr(NO <sub>3</sub> ) <sub>2</sub>	HNO <sub>3</sub>	Solid Phase	Sr(NO <sub>3</sub> ) <sub>2</sub>	HNO <sub>3</sub>	Solid Phase
At -25°			At -10°		
1.14	24.66	Ice + Sr.4	4.35	12.0	Ice
0.69	31.4	Sr.4	8.01	10.8	"
0.57	35.1	"	9.93	9.89	"
			9.73	10.43	" + Sr.4
			5.99	15.6	Sr.4
			3.54	20.4	"
			2.49	25.45	"

Sr.4 = Sr(NO<sub>3</sub>)<sub>2</sub>·4H<sub>2</sub>O

(Cont.)

## THE SYSTEM STRONTIUM NITRATE - NITRIC ACID - WATER--Cont.

Gms. per 100 gms. sat. sol.			Gms. per 100 Gms. sat. sol.		
Sr(NO <sub>3</sub> ) <sub>2</sub>	HNO <sub>3</sub>	Solid Phase	Sr(NO <sub>3</sub> ) <sub>2</sub>	HNO <sub>3</sub>	Solid Phase
At 0°			At 25°		
23.1	3.20	Sr.4	41.4	1.88	Sr.4
16.9	7.4	"	37.65	4.36	"
10.6	13.4	"	34.6	6.29	"
5.39	21.6	"	33.0	7.37	"
3.12	29.5	"	29.2	10.05	"
2.18	35.2	"	27.2	11.6	" + Sr(NO <sub>3</sub> ) <sub>2</sub>
2.02	36.9	" + Sr(NO <sub>3</sub> ) <sub>2</sub>	24.85	13.1	Sr(NO <sub>3</sub> ) <sub>2</sub> NO
1.46	39.25	Sr(NO <sub>3</sub> ) <sub>2</sub>	14.3	21.9	"
0.56	44.8	"	10.0	25.3	"
0.08	63.6	"	5.03	31.8	"
			4.48	32.9	"
			3.44	35.1	"
			2.16	38.45	"
			1.36	40.2	"
At 15°			At 50°		
25.4	8.1	Sr.4			
18.5	13.4	"			
13.3	18.6	"			
10.9	21.7	"			
8.34	25.95	"	39.55	4.99	Sr(NO <sub>3</sub> ) <sub>2</sub>
7.83	27.04	" + Sr(NO <sub>3</sub> ) <sub>2</sub>	28.9	11.8	"
3.79	33.2	Sr(NO <sub>3</sub> ) <sub>2</sub>	14.5	22.65	"
2.22	37.4	"	6.03	32.7	"
			2.40	40.8	"
			1.15	46.0	"
			0.07	63.4	"

Sr.4 = Sr(NO<sub>3</sub>)<sub>2</sub>·4H<sub>2</sub>OSOLUBILITY OF STRONTIUM NITRATE IN AQUEOUS ALCOHOL AT 25°  
(D'Ans and Siegler, 1913)

Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	Gms. per 100 Gms. Sat. Sol.		Solid Phase	Wt. % C <sub>2</sub> H <sub>5</sub> OH in Solvent	Gms. per 100 Gms. Sat. Sol.		Solid Phase
	C <sub>2</sub> H <sub>5</sub> OH	Sr(NO <sub>3</sub> ) <sub>2</sub>			C <sub>2</sub> H <sub>5</sub> OH	Sr(NO <sub>3</sub> ) <sub>2</sub>	
0	0	44.25	A	10	6	40.05	B (u)
4	1.7	42.8	A	15.05	9.5	36.7	B (u)
6	2.6	42.1	A	18.8tp	12.35	34.3	B + A
10.8	4.95	40.4	A	20.6	13.8	33.2	B
16	7.95	37.6	A	40.65	32.35	20.5	B
20tp	12.35	34.3	A + B	59.9	53.6	10.5	B
0	0	46.6	B (u)	79.2	77.15	2.6	B
6	3.45	42.7	B (u)	99.4	99.38	0.02	B

tp = transition point (u) = unstable

A = Sr(NO<sub>3</sub>)<sub>2</sub>·4H<sub>2</sub>OB = Sr(NO<sub>3</sub>)<sub>2</sub>

# Sr STRONTIUM

## SOLUBILITY OF STRONTIUM NITRATE IN AQUEOUS ALCOHOL AT 25°--Cont.

Additional Results by Jankovic, 1958 at 25°

Mole % H <sub>2</sub> O in solvent	Sp. Gr.	Sat. Sol.		Mole % H <sub>2</sub> O in solvent	Sp. Gr.	Sat. Sol.	
		25	Wt. % Sr(NO <sub>3</sub> ) <sub>2</sub>			25	Wt. % Sr(NO <sub>3</sub> ) <sub>2</sub>
96.0	1.3968		39.59	59.1	0.9759		8.43
90.7	1.2923		33.30	49.5	0.9310		4.83
83.8	1.1909		24.46	44.7	0.9114		3.42
77.7	1.1228		19.34	39.6	0.8738		2.42
25.3	1.0964		17.64	32.3	0.8541		1.64
68.1	1.0326		12.98	21.6	0.8441		0.97

NO

100 gms. abs. ethyl alcohol dissolve 0.0062 to 0.0086 gm. Sr(NO<sub>3</sub>)<sub>2</sub> at 25°. 100 gms. abs. -2-propanol dissolve 0.0014 to 0.0023 gm. Sr(NO<sub>3</sub>)<sub>2</sub> at 25°. (Ferner and Mellon, 1934.)

100 cc. pyridine dissolve 0.64 gm. Sr(NO<sub>3</sub>)<sub>2</sub> at 0° and 0.7 gm. at 25°. (Muller R., 1924.)

100 grams of a saturated solution of strontium nitrate in furfural contain 0.2 gms. Sr(NO<sub>3</sub>)<sub>2</sub>·4H<sub>2</sub>O at 25°. (Trimble, 1941.)

100 cc. anhydrous hydrazine dissolve 5 gms. Sr(NO<sub>3</sub>)<sub>2</sub> at room temp. (Welsh and Brodersen, 1915.)

A saturated solution in tri-n-butyl phosphate at 25-27° contains 0.81% Sr(NO<sub>3</sub>)<sub>2</sub>. (Wendlandt and Bryant, 1956.)

## SOLUBILITY OF STRONTIUM NITRATE IN CELLOSOLVES (MONOALKYL ETHERS OF ETHYLENE GLYCOL)

(Kobe and Motsch, 1952)

t°	Gms. Sr(NO <sub>3</sub> ) <sub>2</sub> per 100 gms.		
	Methyl Cellosolve	Ethyl Cellosolve	Butyl Cellosolve
30	1.66	0.048	0.023
60	0.663	0.043	0.021
90	0.345	0.027	0.017
120	0.187	0.021	0.015

## EFFECT OF WATER IN BUTYL CELLOSOLVE AT 30°

% H <sub>2</sub> O in solvent:	0.0	1.0	2.0	4.0	8.0
% Sr(NO <sub>3</sub> ) <sub>2</sub> in sat. sol.	0.023	0.048	0.069	0.195	1.21

• • •

SOLUBILITY OF STRONTIUM NITRATE IN LIQUID AMMONIA  
(Portnow and Schurawlew, 1935)

t°	Gms.		Solid Phase	t°	Gms.		Solid Phase
	Sr(NO <sub>3</sub> ) <sub>2</sub> per 100 gms. NH <sub>3</sub>				Sr(NO <sub>3</sub> ) <sub>2</sub> per 100 gms. NH <sub>3</sub>		
-90	4.7	(?)	NH <sub>3</sub> + Sr(NO <sub>3</sub> ) <sub>2</sub> ·8NH <sub>3</sub>	25	87.08	(2)	Sr(NO <sub>3</sub> ) <sub>2</sub>
-65	66.36		Sr(NO <sub>3</sub> ) <sub>2</sub> ·8NH <sub>3</sub>	31	85.80		"
-19.5	10.89		Sr(NO <sub>3</sub> ) <sub>2</sub> ·8NH <sub>3</sub>	33	87.44		"
- 3.0	37.99		Sr(NO <sub>3</sub> ) <sub>2</sub> ·4NH <sub>3</sub>	36	101.6		"
0.0	40.39	(1)	Sr(NO <sub>3</sub> ) <sub>2</sub> ·2NH <sub>3</sub> (?)	37	101.4		"
-14.0	59.46		Sr(NO <sub>3</sub> ) <sub>2</sub> ·2NH <sub>3</sub> (?)	42	120.4		"
22.0	68.65		Sr(NO <sub>3</sub> ) <sub>2</sub>	43.5	128.7		"

(1) = Linhard and Stephan, 1934; (2) = Hunt and Boncyk, 1933.

Melting points are given for:

Sr(NO <sub>3</sub> ) <sub>2</sub> + SrOH <sub>2</sub>	(Wolf, 1935)
Sr(NO <sub>3</sub> ) <sub>2</sub> + LiNO <sub>3</sub>	(Gromakov and Gromakova, 1953)
Sr(NO <sub>3</sub> ) <sub>2</sub> + CsNO <sub>3</sub>	(Plyushchev, Markina and Shklover, 1956)

STRONTIUM NIOBATES Sr(NbO<sub>3</sub>)<sub>2</sub>

NbO

## SOLUBILITY IN WATER

t°	Solubility	
15	0.00607 gms. Sr(NbO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O per liter	(Krylov and Alekseev, 1954)
25	0.01032	"
50	0.01205	"

At 20° the K<sub>sp</sub> of Sr(NbO<sub>3</sub>)<sub>2</sub> is  $4.2 \times 10^{-18}$  (Lapitskii and Pchelkin, 1956).

The solubility of anhydrous strontium hexaniobate in water is  $2.6 \times 10^{-14}$  (?) (Pchelkin and Lapitskii, 1956).

## STRONTIUM OXIDE SrO

O

Fused SrCl<sub>2</sub> dissolves 18.3 gms. SrO per 100 gms. of the fused melt at 910°. (Arndt, 1907.)



# Sr STRONTIUM

## OH STRONTIUM HYDROXIDE $\text{Sr}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$

SOLUBILITY IN WATER  
(Scheibler, 1883)

t°	Grams per 100 Grams Solution		Grams per 100 cc. Solution	
	SrO	$\text{Sr}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$	SrO	$\text{Sr}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$
0	0.35	0.90	0.35	0.90
10	0.48	1.23	0.48	1.23
20	0.68	1.74	0.68	1.74
30	1.00	2.57	1.01	2.59
40	1.48	3.80	1.51	3.87
50	2.13	5.46	2.18	5.59
60	3.03	7.77	3.12	8.00
70	4.35	11.16	4.55	11.67
80	6.56	16.83	7.02	18.01
90	12.0	30.78	13.64	34.99
100	18.6	47.71	22.85	58.61

Later determinations agreeing closely with the above are given by Grube and Hussbaum, 1928, and Ahrens, 1930.

The following results by Klinkenberg, 1929; and Rehders and Klinkenberg, 1929, differ considerably from those of other investigators at the higher temperatures.

t°	Gms. per 100 gms. sat. sol.		Solid Phase	t°	Gms. per 100 gms. sat. sol.		Solid Phase
	gms. sat. sol.	SrO			gms. sat. sol.	SrO	
25	0.85		$\text{Sr}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$	70	5.00		$\text{Sr}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$
30	1.02		"	80	8.38		"
40	1.48		"	85	12.08		" + $\text{Sr}(\text{OH})_2 \cdot \text{H}_2\text{O}$
50	2.20		"	90	11.61		$\text{Sr}(\text{OH})_2 \cdot \text{H}_2\text{O}$
60	3.29		"	100	10.83		"

THE SYSTEM STRONTIUM HYDROXIDE - STRONTIUM NITRATE - WATER AT 25°  
(Parsons and Perkins, 1910)

d. of sat. sol.	Gms. per 100 Gms. $\text{H}_2\text{O}$		Solid Phase	d. of sat. sol.	Gms. per 100 Gms. $\text{H}_2\text{O}$		Solid Phase
	SrO as $\text{Sr}(\text{OH})_2$	$\text{Sr}(\text{NO}_3)_2$			SrO as $\text{Sr}(\text{OH})_2$	$\text{Sr}(\text{NO}_3)_2$	
1.481	0	79.27	$\text{Sr}(\text{NO}_3)_2$	1.267	1.11	37.81	$\text{Sr}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$
1.492	0.38	79.47	"	1.217	1.01	28.80	"
1.494	0.78	80.83	"	1.178	0.95	23.83	"
1.506	1.76	81.06	$\text{Sr}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$	1.148	0.91	17.96	"
1.490	1.71	74.27	"	1.108	0.84	12.78	"
1.419	1.51	63.71	"	1.079	0.81	8.96	"
1.381	1.41	56.30	"	1.059	0.79	6.29	"
1.327	1.27	46.97	"	1.033	0.78	4.45	"

THE SYSTEM  $\text{Sr}(\text{OH})_2 - \text{Sr}(\text{SH})_2 - \text{H}_2\text{O}$   
(Terres and Bruckner, 1929)

These results when plotted give curves composed of two branches corresponding respectively to the solid phases  $\text{Sr}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$  and  $\text{Sr}(\text{SH})_2 \cdot 4\text{H}_2\text{O}$ .

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
$\text{Sr}(\text{OH})_2$	$\text{Sr}(\text{SH})_2$	$\text{Sr}(\text{OH})_2$	$\text{Sr}(\text{SH})_2$	$\text{Sr}(\text{OH})_2$	$\text{Sr}(\text{SH})_2$	$\text{Sr}(\text{OH})_2$	$\text{Sr}(\text{SH})_2$
<u>Results at 0°</u>		0.62	15.8	0.80	26.20	<u>Results at 80°</u>	
0.41	0.00	0.60	18.3	0.42	28.30		
0.30	1.56	0.55	20.3	0.30	29.25	7.78	0.00
0.25	6.68	1.00	24.0	0.10	31.60	5.60	5.60
0.22	12.65	0.25	26.0	0.00	31.60	5.00	9.50
0.20	14.80	0.20	26.8	<u>Results at 60°</u>		4.88	15.50
0.16	18.20	0.15	27.5			4.10	19.60
0.15	19.05	0.00	29.7			2.70	27.50
0.10	23.40	<u>Results at 40°</u>		3.63	0.00	2.10	28.00
0.10	24.80			3.15	1.60	1.40	30.40
0.20	27.5	1.75	0.00	3.04	6.08	0.05	35.60
0.00	27.50	1.65	1.40	3.16	11.85	0.00	35.60
<u>Results at 20°</u>		1.60	4.87	3.15	16.72	<u>Results at 100°</u>	
		1.60	10.83	1.75	25.0		
0.82	0.0	1.55	15.93	0.60	30.8	23.20	0.00
0.72	5.9	1.50	20.00	0.10	33.6	14.00	7.40
0.70	11.4	1.10	24.10	0.00	33.2	0.15	37.80
						0.00	37.80

SOLUBILITY OF STRONTIUM HYDROXIDE IN VARIOUS AQUEOUS SOLUTIONS AT 25°  
(Rothmund, 1910)

Aqueous Solution of:	Mols. $\text{Sr}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$ per Liter	Gms. $\text{Sr}(\text{OH})_2$ per Liter
Water alone	0.0835	10.16
0.5 n Methyl Alcohol	0.0820	9.97
0.5 n Ethyl Alcohol	0.0744	9.05
0.5 n Propyl Alcohol	0.0708	8.61
0.5 n Amyl Alcohol (tertiary)	0.0630	7.66
0.5 n Acetone	0.0692	8.42
0.5 n Ether	0.0645	7.85
0.5 n Glycol	0.0922	11.21
0.5 n Glycerol	0.1094	13.31
0.5 n Mannitol	0.1996	24.29
0.5 n Urea	0.0820	9.97
0.5 n Ammonia	0.0785	9.55
0.5 n Dimethylamine	0.0586	7.13
0.5 n Pyridine	0.0694	8.44

Data for equilibrium in the system strontium hydroxide, phenol and water at 25° are given by van Meurs (1916).

## Sr STRONTIUM

### SOLUBILITY OF STRONTIUM HYDROXIDE IN AQUEOUS ETHANOL SOLUTIONS AT 25° (Jankovic, 1958)

solvent	Sp. Gr. $\frac{25}{25}$	Mg. Sr(OH) <sub>2</sub> per 100		solvent	Sp. Gr. $\frac{25}{25}$	Mg. Sr(OH) <sub>2</sub> per 100	
		gms. sat.	sol.			gms. sat.	sol.
98.2	1.0006	735.5		64.5	0.8936	40.5	
95.7	0.9892	554.4		59.0	0.8790	27.8	
92.0	0.9760	383.6		47.4	0.8566	9.7	
88.8	0.9604	280.7		34.3	0.8359	6.1	
80.4	0.9394	141.0		25.5	0.8230	4.4	
74.6	0.9214	81.5		12.1	0.8043	0.2	
70.2	0.9087	60.1					

## OH

### SOLUBILITY OF STRONTIUM HYDROXIDE IN AQUEOUS SOLUTIONS OF CANE SUGAR (Sidersky, 1921)

The mixtures were agitated from time to time during 24 hours. The dissolved strontium hydroxide was determined by titration with 1.0 n HCl, and the sugar by polarization. The determinations were plotted and the following table constructed from the curves.

Wt. % of Sugar in solution	Gms. SrO per 100 gms. sat. sol. at				Gms. Sr(OH) <sub>2</sub> ·8H <sub>2</sub> O per 100 gms. sat. sol. at			
	3°	15°	24°	40°	3°	15°	24°	40°
0.0	0.39	0.57	0.80	1.48	0.98	1.46	2.05	3.80
1.0	0.45	0.65	0.90	1.68	1.15	1.67	2.30	4.31
5.0	0.79	1.03	1.40	2.51	2.03	2.64	3.58	6.47
10.0	1.21	1.48	2.03	3.55	3.10	3.79	5.20	9.10
15.0	1.64	1.94	2.66	4.58	4.21	4.97	6.81	11.75
18.0	1.90	2.21	2.05	5.20	4.89	5.67	7.78	13.33
20.0	2.08	2.39	3.30	-	5.33	6.13	8.45	-
25.0	2.51	2.85	3.90	-	6.44	7.31	10.00	-

### THE SYSTEM STRONTIUM HYDROXIDE - SUCROSE - WATER (Klinkenberg, 1929; Reinders and Klinkenberg, 1929)

The results upon this system by Grube and Nussbaum, 1928, are considered by Reinders and Klinkenberg to be in error.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
SrO	C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>		SrO	C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>	
<u>Results at 25°</u>					
0.86	0.0	Sr(OH) <sub>2</sub> ·8H <sub>2</sub> O	6.40	28.1	Sr(OH) <sub>2</sub> ·8H <sub>2</sub> O
1.58	4.10m	" + 2.1	1.33	4.20	1.1.6
1.45	3.63	" + 1.1.6	1.29	8.19	"
2.27	9.39	Sr(OH) <sub>2</sub> ·8H <sub>2</sub> O	1.38	12.1	"
3.23	14.3	"	1.82	23.5	"
4.50	20.2	"	0.0	67.89	C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>
5.80	25.5	"			

(Cont.)

m = metastable

## THE SYSTEM STRONTIUM HYDROXIDE - SUCROSE - WATER--Cont.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
SrO	C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>	Solid Phase	SrO	C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>	Solid Phase
<u>Results at 35°</u>			<u>Results at 55°</u>		
1.23	0.0	Sr(OH) <sub>2</sub> ·8H <sub>2</sub> O	2.68	0	Sr(OH) <sub>2</sub> ·8H <sub>2</sub> O
1.6	1.9	" + 2.1	3.25	2.16	"
1.8	6.7	1.1.6 + "	3.80	4.09	"
2.11	4.2Om	" + Sr(OH) <sub>2</sub> ·8H <sub>2</sub> O	5.17	8.13	"
0.0	69.55	C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>	2.75	0.32	" + 2.1
<u>Results at 45°</u>			1.51	2.56	2.1
1.81	0	Sr(OH) <sub>2</sub> ·8H <sub>2</sub> O	2.15	12.7	"
1.95	0.6	" + 2.1	3.57	28.1	"
2.35	14.0	1.1.6 + "	3.44	11.57	1.1.6
3.0	5.1m	" + Sr(OH) <sub>2</sub> ·8H <sub>2</sub> O	3.26	16.2	"
4.0	72.0	" + C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>	3.45	24.6	"
0.0	71.3	C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>	3.80	36.9	"
1.51	2.50cs	1.2	4.42	63.6	"
2.42	8.0cs	1.1.6	0.01	73.1	C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>
			2.57	73.5	"
			<u>Results at 75° (1)</u>		
m = metastable			5.78	0.	Sr(OH) <sub>2</sub> ·8H <sub>2</sub> O
cs = congruently saturated			5.99	0.2	2.1
2.1 = 2SrO·C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>			4.16	0.13	"
1.1.6 = SrO·C <sub>12</sub> H <sub>22</sub> O <sub>11</sub> ·6H <sub>2</sub> O			2.27	0.55	"
1.1 = SrO·C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>			1.63	3.74	"
(1) Niskizawa and Hackihama, 1929			1.88	7.72	"
			2.38	14.92	"
			3.25	23.65	"
			4.25	33.35	"
			5.60	46.80	"
			4.15	31.31	" + 1.1
			3.68	32.2	1.1
			3.95	44.56	"
			3.41	53.69	"
			2.94	65.43	"
			2.33	75.5	"
			2.26	78.63	" + C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>
			1.06	79.25	C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>
			0.0	78.58	"

OH

# Sr STRONTIUM

## PO STRONTIUM PHOSPHATES

THE SYSTEM STRONTIUM OXIDE - PHOSPHORUS PENTOXIDE - WATER AT 25°  
(Tartar and Lorah, 1929)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	SrO	P <sub>2</sub> O <sub>5</sub>			SrO	P <sub>2</sub> O <sub>5</sub>	
1.687	0.05	61.97	SrH <sub>4</sub> (PO <sub>4</sub> ) <sub>2</sub>	1.351	9.25	23.58	SrH <sub>4</sub> (PO <sub>4</sub> ) <sub>2</sub>
1.594	0.13	56.49	"	1.294	7.84	20.79	Sr <sub>2</sub> HPO <sub>4</sub>
1.527	0.44	51.07	"	1.278	7.52	19.81	"
1.455	1.78	43.80	"	1.230	6.53	16.66	"
1.4418	3.24	38.73	"	1.194	6.32	13.41	"
1.410	4.61	35.90	"	1.169	5.11	12.70	"
1.394	6.52	31.65	"	1.112	4.13	7.80	"
1.379	8.08	27.63	"	1.083	3.18	6.02	"
1.360	8.42	25.92	"	1.074	2.67	5.68	"
1.357	8.88	24.71	"				

At 35°, the pKsp (soly. prod. constant) for SrHPO<sub>4</sub> is 7.00 - 8.1  $\mu$  and the pKsp for Sr<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> is 27.8 at  $\mu = 0.0035$ . ( $\mu$  = ionic strength) (Holt, Pierce and Kajdi, 1954.)

## PO STRONTIUM ALKYL PHOSPHATES

SOLUBILITY OF EACH SEPARATELY IN WATER  
(Bailey, 1919)

Constant agitation was not employed for securing saturation. The solutions were analyzed by evaporating to dryness and weighing the residues.

Compound and Formula			t°	Gms. hydrated compd. per 100 gms. sat. sol.
Strontium Methyl Phosphate	SrCH <sub>3</sub> PO <sub>4</sub> ·H <sub>2</sub> O		14	1.24
"	"	"	50	0.75
"	"	"	100	0.38
"	"	(Acid Salt)		
"	"	Sr[CH <sub>3</sub> HPO <sub>4</sub> ] <sub>2</sub> ·H <sub>2</sub> O	17	27.15
"	Ethyl	"	20	1.29
"	Propyl	"	18.5	1.96
"	Allyl	"	20	1.80
"	Iso propyl	"	20	0.40
"	Iso butyl	"	18	0.89

## STRONTIUM GLYCERO PHOSPHATES

P0

SOLUBILITY OF EACH SEPARATELY IN WATER  
(Bailly, 1916; Bailly and Gaume, 1924)

Compound and Formula	t°	Gms. anhy. compd. per 100 gms. sat. sol.
Strontium alpha-glycerophosphate (cryst.) $\text{Sr}(\text{C}_3\text{H}_5)(\text{OH})_2\cdot\text{PO}_4$	16	1.73
Strontium beta-glycerophosphate (cryst.) $\text{Sr}(\text{C}_3\text{H}_5)(\text{OH})_2\cdot\text{PO}_4\cdot 2\text{H}_2\text{O}$	17	2.31
Strontium neutral glycerophosphate $\text{Sr}(\text{C}_2\text{H}_4(\text{OH})\cdot\text{PO}_4\cdot\text{H}_2\text{O}$	16	1.28
Strontium neutral glycerophosphate $\text{Sr}(\text{C}_2\text{H}_4(\text{OH})\cdot\text{PO}_4\cdot\text{H}_2\text{O}$	55	0.58

100 gms.  $\text{H}_2\text{O}$  dissolve 2.69 gms. anhydrous strontium neutral glycerophosphate at 18°. (H. Rogier, These, Paris, 1912.)

100 gms. sat. solution of  $\text{Sr}(\text{C}_3\text{H}_5)(\text{OH})_2\text{PO}_4\cdot 2\text{H}_2\text{O}$  in water contain 2.09 gm.  $\text{Sr}(\text{C}_3\text{H}_5)(\text{OH})_2\text{PO}_4$  at 18° and 0.8 gm. at 65°. (Rogier and Fiore, 1913.)

STRONTIUM SULFATE  $\text{SrSO}_4$ 

S0

SOLUBILITY OF PRECIPITATED STRONTIUM SULFATE AND OF CALCINED  
"CELESTINA" (96.67%  $\text{SrSO}_4$ ) IN WATER  
(Gallo, 1935)

t°	Gms. $\text{SrSO}_4$ per 100 cc sat. sol.		t°	Gms. $\text{SrSO}_4$ per 100 cc sat. sol.	
	Solid Phase Pptd. $\text{SrSO}_4$	Solid Phase "Celestina"		Solid Phase Pptd. $\text{SrSO}_4$	Solid Phase "Celestina"
5	0.0121	0.0119	60	0.0131	0.0125
10	0.0129	0.0123	70	0.0123	0.0119
20	0.0132	0.0132	80	0.0116	0.0111
30	0.0138	0.0136	90	0.0115	0.0107
40	0.0141	0.0136	95	0.0113	0.0108
50	0.0135	0.0128			

## Results of Kohlrausch, 1908

2.85°	0.01133 gms. per 100 cc $\text{H}_2\text{O}$
17.4	0.01143 gms. per 100 cc $\text{H}_2\text{O}$
32.3	0.01143 gms. per 100 cc $\text{H}_2\text{O}$

# Sr STRONTIUM

## Results above 200°

(Booth and Bidwell, 1950)

t°	Gms. SrSO <sub>4</sub> per 100 gms. H <sub>2</sub> O	t°	Gms. SrSO <sub>4</sub> per 100 gms. H <sub>2</sub> O
200	0.0292	290	0.0151
214	0.0258	311	0.0085
242	0.0220	340	0.0040
258	0.0139	350	0.0027
264	0.0150	370	0.0021
280	0.0102	395	0.0018

50

## SOLUBILITY OF STRONTIUM SULFATE IN SULFURIC ACID SOLUTIONS

(Results of Castagnon and Larcebau, 1951 at 10°)

Wt. % H <sub>2</sub> SO <sub>4</sub>	Gms. SrSO <sub>4</sub> per 100 ml. sat. sol.	Wt. % H <sub>2</sub> SO <sub>4</sub>	Gms. SrSO <sub>4</sub> per 100 ml. sat. sol.
10	0.0025	60	0.044
20	0.004	80	0.135
40	0.0175	100	6.926
			(7.822 at room temp.)

## Results at Other Temperatures

t°	Conc. of H <sub>2</sub> SO <sub>4</sub>	Gms. SrSO <sub>4</sub> per 100 Gms. Acid	Authority
ord.	concentrated	5.68	(Sturve, 1870)
ord.	fuming	9.77	(Sturve, 1870)
ord.	91%	0.08	(Varenne and Paulean, 1881)
70	Sp. Gr. 1.843 = 99%	14	(Garside, 1875)
ord.	Absolute H <sub>2</sub> SO <sub>4</sub>	21.7*	(Bergius, 1910)

\*per 100 cc. Sat. Sol.

## SOLUBILITY OF STRONTIUM SULFATE IN AQUEOUS SOLUTIONS OF HYDROCHLORIC, NITRIC, CHLORACETIC AND FORMIC ACIDS (Banthisch, 1884)

cc. of Aq. Acid containing 1 Mg. Equiv. in each case	In Aq. HCl		In Aq. HNO <sub>3</sub>		In Aq. CH <sub>3</sub> ClCOOH		In Aq. HCOOH	
	Gms. per 100 cc. Sol.		Gms. per 100 cc. Sol.		Gms. per 100 cc. Sol.		Gms. per 100 cc. Sol.	
	HCl	SrSO <sub>4</sub>	HNO <sub>3</sub>	SrSO <sub>4</sub>	CH <sub>3</sub> ClCOOH	SrSO <sub>4</sub>	HCOOH	SrSO <sub>4</sub>
0.2	18.23	0.161	31.52	0.381	-	-	-	-
0.5	7.29	0.207	12.61	0.307	-	-	-	-
1.0	3.65	0.188	6.30	0.217	94.47	0.026	46.02	0.024
2.0	1.82	0.126	3.15	0.138	47.23	0.022	-	-
10.0	0.36	0.048	0.63	0.049	-	-	-	-

Other data on the solubility of  $\text{SrSO}_4$  in dilute  $\text{HNO}_3$  solutions containing K, Mg, Al and Sr nitrates is given by Chrelashvili and Nadareishvili, 1953.

Using the polarographic method, Heyrovsky and Berezicky, 1929, found the solubility of strontium sulfate in water and dilute aqueous HCl to be:

Normality of aq. HCl	Gm. Equiv. $\text{SrSO}_4$ dissolved per liter
0.0 (= $\text{H}_2\text{O}$ )	0.0015
0.001	0.0011
0.01	0.0018

100 gms. 95 per cent formic acid dissolve 0.02 gm.  $\text{SrSO}_4$  at  $18.5^\circ$ . (Aschan, 1913.)

80

SOLUBILITY OF PRECIPITATED STRONTIUM SULFATE AND  
OF "CELESTINA" IN AQUEOUS SOLUTIONS OF AMMONIUM SULFATE AT  $25^\circ$   
(Gallo, 1935)

Gms. $(\text{NH}_4)_2\text{SO}_4$ per 100 gms. aqueous solvent	Gms. $\text{SrSO}_4$ per 100 cc sat. sol.	
	Solid Phase Pptd. $\text{SrSO}_4$ cc	Solid Phase "Celestina"
2.9	0.0100	0.0097
8.5	0.0082	0.0079
15.0	0.0074	0.0074

SOLUBILITY OF STRONTIUM SULFATE IN AQUEOUS SALT SOLUTIONS  
(Gallo, 1936)

Solvent, Aqueous 10% solution of:	Gms. $\text{SrSO}_4$ per 100 cc sat. sol. at:	
	$20^\circ$	$98^\circ$
$\text{CaCl}_2$	0.0313	0.0358
$\text{NH}_4\text{Cl}$	0.0639	0.0690
$\text{NH}_4\text{NO}_3$	0.0701	0.0809
$\text{NaCl}$	0.0630	0.0691
$\text{NaNO}_3$	0.0703	0.0842

SOLUBILITY OF STRONTIUM SULFATE IN AQUEOUS SALT SOLUTIONS  
(Virck, 1862)

In Aq. $\text{NaCl}$		In Aq. $\text{KCl}$		In Aq. $\text{MgCl}_2$		In Aq. $\text{CaCl}_2$	
(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
8.44	0.165	8.22	0.193	1.59	0.199	8.67	0.176
15.54	0.219	12.54	0.193	4.03	0.206	16.51	0.185
22.17	0.181	18.08	0.251	13.63	0.242	33.70	0.171

(a) = Gms. salt per 100 gms. aq. solution. (b) = Gms.  $\text{SrSO}_4$  per 100 gms. solvent.



## Sr STRONTIUM

### SOLUBILITY OF STRONTIUM SULFATE IN AQUEOUS SOLUTIONS OF AMMONIUM ACETATE AT 25° (Marden, 1916)

Gms. per 100 Gms. Sat. Sol.		Gms. per 100 Gms. Sat. Sol.	
CH <sub>3</sub> COONH <sub>4</sub>	SrSO <sub>4</sub>	CH <sub>3</sub> COONH <sub>4</sub>	SrSO <sub>4</sub>
0	0.0151	10.68	0.0942
2.13	0.0451	21.37	0.115
5.34	0.0732		

### SOLUBILITY OF STRONTIUM SULFATE IN AQUEOUS CALCIUM NITRATE AT ROOM TEMPERATURE (Raffo and Rossi, 1915)

50

Analyzed solutions of Sr(NO<sub>3</sub>)<sub>2</sub>, Ca(NO<sub>3</sub>)<sub>2</sub> and CaSO<sub>4</sub> were mixed at 60° and allowed to stand at room temperature 1 to 2 days. The resulting SrSO<sub>4</sub> was determined and the difference between the amount found and the amount which would have resulted if all the Sr(NO<sub>3</sub>)<sub>2</sub> had been converted to SrSO<sub>4</sub>, was taken as the amount of SrSO<sub>4</sub> dissolved. Gradually increasing concentrations of Ca(NO<sub>3</sub>)<sub>2</sub> were used.

Gms. per 100 cc. Sat. Sol.		Gms. per 100 cc. Sat. Sol.	
Ca(NO <sub>3</sub> ) <sub>2</sub>	SrSO <sub>4</sub>	Ca(NO <sub>3</sub> ) <sub>2</sub>	SrSO <sub>4</sub>
0.5	0.0483	4	0.1489
1	0.0619	5	0.1698
2	0.1081	6	0.1955
3	0.1275		

### SOLUBILITY OF STRONTIUM SULFATE IN AQUEOUS SODIUM CARBONATE AT 25° (Herz, 1910)

Freshly prepared and dried SrSO<sub>4</sub> was shaken 5 days with aqueous sodium carbonate solutions and the supernatant clear solutions analyzed.

Normality of Aqueous		Gm. Mols. per Liter Sat. Sol.	
Na <sub>2</sub> CO <sub>3</sub>	Na <sub>2</sub> CO <sub>3</sub>	Na <sub>2</sub> CO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>
	2	2	2
0.6025		0.0382	0.5643
1.205		0.076	1.129
2.41		0.153	2.257

Strontium sulfate is 23 times as soluble in 3 N NaNO<sub>3</sub> solution as in pure water. (Belfiori, 1940.)

SOLUBILITY OF STRONTIUM SULFATE IN AQUEOUS ETHANOL AT 25°  
(Jankovic, 1958)

mole % H <sub>2</sub> O in solvent	Sp. Gr. $\frac{25}{25}$	Mg. SrSO <sub>4</sub> per 100 gms. sat. sol.
94.4	0.9753	6.7
92.4	0.9701	4.3
88.9	0.9632	1.9
83.2	0.9468	0.4

SOLUBILITY OF STRONTIUM SULFATE IN AQUEOUS SOLVENTS AT 19°  
(Kolthoff and Vogelenzang, 1919)

Gms. SrSO<sub>4</sub> per liter

Aqueous 25% Ethyl alcohol	0.019
Aqueous 50% Ethyl alcohol	0.000
Aqueous 50% Ethyl alcohol + 0.1 n HCl	0.120
Aqueous 50% Ethyl alcohol + 0.1 n NH <sub>4</sub> Cl	0.040

STRONTIUM THIOSULFATE SrS<sub>2</sub>O<sub>3</sub>

SO

SOLUBILITY OF STRONTIUM THIO SULFATE IN WATER  
(Portillo, 1929)

t°	Gms. SrS <sub>2</sub> O <sub>3</sub> per 100 gms. sat. sol.	Solid Phase
0	8.78	SrS <sub>2</sub> O <sub>3</sub> ·3H <sub>2</sub> O
12.8	13.82	"
27.5	21.10	"
40.0	26.80	"

100 gms. of a saturated solution of strontium thiosulfate in a solvent composed equal volumes of water and acetone contain 0.35 gm. SrS<sub>2</sub>O<sub>3</sub> at 18°.5. (Leo, 1923.)

STRONTIUM COPPER (I) THIOSULFATE

0.070 gms. Sr[Cu(S<sub>2</sub>O<sub>3</sub>)]<sub>2</sub>·4H<sub>2</sub>O dissolve in 100 cc water at 0°. (Araquistain, 1955.)

STRONTIUM DITHIONATE SrS<sub>2</sub>O<sub>6</sub>·4H<sub>2</sub>O

100 gms. sat. solution of strontium dithionate in water contain 4.51 gms. SrS<sub>2</sub>O<sub>6</sub> at 0°, 7.37 gms. at 10°, 10.8 gms. at 20° and 14.9 gms. at 30°. (deBaat, 1926.)

## Sr STRONTIUM

### SOLUBILITY OF STRONTIUM DITHIONATE IN AQUEOUS ETHYL ALCOHOL AT 30° (deBaar, 1926)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
SrS <sub>2</sub> O <sub>6</sub>	C <sub>2</sub> H <sub>5</sub> OH		SrS <sub>2</sub> O <sub>6</sub>	C <sub>2</sub> H <sub>5</sub> OH	
14.90	0.0	SrS <sub>2</sub> O <sub>6</sub> ·4H <sub>2</sub> O	0.08	60.39	SrS <sub>2</sub> O <sub>6</sub> ·4H <sub>2</sub> O
5.40	14.48	"	0.0012	76.13	"
0.68	37.22	"	0.000	98.53	"

## SO STRONTIUM TETRATHIONATE SrS<sub>4</sub>O<sub>6</sub>·6H<sub>2</sub>O

### SOLUBILITY OF STRONTIUM TETRA THIONATE IN WATER (Portillo, 1929)

t°	Gms. SrS <sub>4</sub> O <sub>6</sub> per 100 gms. sat. sol.	Solid Phase
0	19.91	SrS <sub>4</sub> O <sub>6</sub> ·6H <sub>2</sub> O
12.9	26.33	"
30.0	38.98	"

## Se STRONTIUM SELENITE SrSeO<sub>3</sub>

The K<sub>sp</sub> is  $8.5 \times 10^{-7}$  at room temperature. (Chukhlantsev, 1956.)

## Se STRONTIUM SELENATE SrSeO<sub>4</sub>

0.1361 gms. SrSeO<sub>4</sub> dissolve in 100 ml. of water at 10° (Dolique, 1943).

## Ta STRONTIUM TANTALATES

### SOLUBILITIES IN WATER AT 25° (Lapitskii and Efimov, 1956)

Salt	Solubility
Sr(TaO <sub>3</sub> ) <sub>2</sub>	$2.36 \times 10^{-5}$ g/100 ml.
Sr <sub>8</sub> Ta <sub>12</sub> O <sub>38</sub> ·33H <sub>2</sub> O	$5.00 \times 10^{-3}$ g/100 ml.

## STRONTIUM TUNGSTATES

WO

0.0284 gms.  $\text{SrWO}_4$  are dissolved in one liter of saturated solution in water at 25°. (Berkem, 1943.)

100 cc.  $\text{H}_2\text{O}$  dissolve 0.35 gm.  $\text{SrW}_2\text{O}_7 \cdot 3\text{H}_2\text{O}$  at 15°. (Lefort, 1878.)

TANTALUM BROMIDE  $\text{TaBr}_5$ 

Br

SOLUBILITY OF TANTALUM BROMIDE IN ORGANIC SOLVENTS  
(Namoradze and Zvjagincev, 1939)

In $\text{CCl}_4$						In $\text{C}_2\text{H}_5\text{Br}$					
20°	0.392	gms.	per 100 ml.	Sat.	Sol.	0°	0.256	gms.	per 100 ml.	Sat.	Sol.
30°	1.465	"	"	"	"	20°	.390	"	"	"	"
						25°	.428	"	"	"	"

TANTALUM CARBIDE  $\text{TaC}$ 

C

X-ray analysis of the systems  $\text{TaC} - \text{TiC}$  and  $\text{TaC} - \text{ZnC}$  show continuous solid solutions. (Kovalskii and Umanskii, 1946.)

Data for the system  $\text{TaC} - \text{C}$  are given by Ellinger, 1942.

TANTALUM CHLORIDE  $\text{TaCl}_5$ 

Cl

SOLUBILITY OF TANTALUM CHLORIDE IN TITANIUM CHLORIDE  
(Tarasenkov and Komandin, 1940)

Temperature	25	50	100
Gms. $\text{TaCl}_5$ per 100 gms. $\text{TaCl}_5 + \text{TiCl}_4$	14.3	27.1	33.9

SOLUBILITY OF TANTALUM CHLORIDE IN ORGANIC SOLVENTS  
(Namoradze and Zvjagincev, 1939)

Solvent	t°	Gms. $\text{TaCl}_5$ per 100 ml. Sat. Sol.	Solvent	t°	Gms. $\text{TaCl}_5$ per 100 ml. Sat. Sol.
$\text{CCl}_4$	20	0.838	$\text{C}_6\text{H}_5\text{NO}_2$	20	5.576
$\text{CCl}_4$	30	1.249	$\text{C}_6\text{H}_5\text{NO}_2$	40	5.684
$\text{CCl}_4$	38	1.556	$(\text{CH}_2)_2(\text{NH}_2)_2$	20	1.336
$\text{CS}_2$	0	1.285	$\text{C}_2\text{H}_5\text{Br}$	0	11.14*
$\text{CS}_2$	14	2.639	$\text{C}_2\text{H}_5\text{Br}$	20	17.43
$\text{CS}_2$	20	3.118	$\text{CHCl}_3$	20	5.739**
$\text{CS}_2$	25	3.744			

\*When a solution saturated at 20° was cooled to 0° and held there for 12 hours, the saturated solution had the same composition as at 20° (17.42). \*\* $\text{TaCl}_5$  forms colloidal solutions with  $\text{CHCl}_3$ , which yield gels

## Ta TANTALUM

upon cooling. A much longer time was needed to approach "saturation" in this solvent than in the others. The figure given is the result after 50 hours, but may not represent fine equilibrium.

Melting points are given for

TaCl <sub>5</sub> + AlCl <sub>3</sub> + CsCl	(Morozov and Simonich, 1957)
TaCl <sub>5</sub> + AlCl <sub>3</sub>	(Morozov, Korshunov and Simonich, 1956)
TaCl <sub>5</sub> + NaCl	(Morozov, Korshunov and Simonich, 1956)
TaCl <sub>5</sub> + NaCl + AlCl <sub>3</sub>	(Morozov, Korshunov and Simonich, 1956)
TaCl <sub>5</sub> + FeCl <sub>3</sub>	(Morozov, 1956)
TaCl <sub>5</sub> + FeCl <sub>3</sub> + AlCl <sub>3</sub>	(Morozov, 1956)

## F TANTALUM FLUORIDE TaF<sub>5</sub>

Data for the partition of Ta(V) between aqueous HF solutions (1-20N) and diethylether are given by Bock and Herrmann, 1956.

## F TANTALUM POTASSIUM FLUORIDE TaK<sub>2</sub>F<sub>7</sub>

### SOLUBILITY IN AQUEOUS HYDROFLUORIC AND POTASSIUM FLUORIDE SOLUTIONS (Ruff and Schiller, 1911)

The tantalum salt was purified by repeated crystallizations from pure anhydrous HF. After drying at 120°, it was shaken in platinum flasks for 3 hour periods at constant temperature with HF or KF solutions or both together. The saturated solutions were filtered by means of a platinum funnel and subjected to analysis.

The solid phases were identified only by their crystal forms and it is possible that still others may be present.

Mixture Shaken in Pt. Flask	t°	Gms. per 100 Gms. Sat. Sol.			Solid Phase
		TaF <sub>5</sub>	KF	HF	
K <sub>2</sub> TaF <sub>7</sub> +H <sub>2</sub> O	18	0.25	0.12	0.029	K <sub>x</sub> Ta <sub>y</sub> O <sub>z</sub> F <sub>u</sub> +K <sub>2</sub> TaF <sub>7</sub>
" + aq. 4.77% KF	18	0.10	4.79	0.074	"
" + aq. 7.35% KF	16	0.09	6.73	0.015	"
" + aq. 4.47% HF	18	1.33	0.56	4.47	K <sub>2</sub> TaF <sub>7</sub>
" + aq. 4.2% HF	18.5	1.24	0.52	4.2	"
" + aq. 24.3% HF	18	5.35	2.25	24.3	"
" + aq. 10.44% HF + 21.92% KF }	18	0.036	21.93	10.44	"
" + H <sub>2</sub> O	85	2.18	1.69	0.85	K <sub>x</sub> Ta <sub>y</sub> O <sub>z</sub> F <sub>u</sub> +K <sub>2</sub> TaF <sub>7</sub>
" + aq. 4.77% KF	85	0.96	5.27	1.17	"
" + aq. 4.47% HF	90	5.73	2.41	4.47	K <sub>2</sub> TaF <sub>7</sub>
" + aq. 4.2% HF	90	6	2.52	4.2	"
" + aq. 23.3% HF	90	10.9	4.59	24.3	"
" + aq. 21.92% KF + 10.44% HF }	90	1.18	22.42	10.44	"

## TANTALUM OXIDE TaO

0

SOLUBILITY IN STEAM AT HIGH TEMPERATURES AND PRESSURES  
(as listed by Ellis and Fyfe, 1957)

t°	Wt. % TaO in steam at 1000 bars pressure
400	0.0009
500	0.003
600	0.0013

TANTALUM (V) HYDROXIDE Ta(OH)<sub>5</sub>

OH

SOLUBILITY IN AQUEOUS SULFURIC ACID SOLUTIONS  
(Haissinsky and Bovy, 1950)

Normality of H <sub>2</sub> SO <sub>4</sub>	Mg. Ta <sub>2</sub> O <sub>5</sub> per liter	Normality of H <sub>2</sub> SO <sub>4</sub>	Mg. Ta <sub>2</sub> O <sub>5</sub> per liter
1	1.67	10	13 + 4
5	4.0 + 0.1	12	9.5 + 5
8	5.9 ± 0.2	15	13.5 ± 1

For data on the solubility of freshly roasted Ta<sub>2</sub>O<sub>5</sub>, and its various crystal modifications, in H<sub>2</sub>O, dilute HCl and dilute H<sub>2</sub>SO<sub>4</sub> see Lapitskii, Pospelova and Artamonova, 1956.

A study of the solubility of tantalic acid in aqueous glycolic, lactic, malic and citric acids is reported by Fairbrother and Taylor, 1956.

TERBIUM BROMATE Tb(BrO<sub>3</sub>)<sub>3</sub>

BrO

SOLUBILITY OF TERBIUM BROMATE IN WATER  
(James et al., 1927)Solid Phase Tb(BrO<sub>3</sub>)<sub>3</sub>·9H<sub>2</sub>O throughout.

t°	Gms. per 100 gms. sat. sol.		t°	Gms. per 100 gms. sat. sol.	
	Tb(BrO <sub>3</sub> ) <sub>3</sub> ·9H <sub>2</sub> O	Tb(BrO <sub>3</sub> ) <sub>3</sub>		Tb(BrO <sub>3</sub> ) <sub>3</sub> ·9H <sub>2</sub> O	Tb(BrO <sub>3</sub> ) <sub>3</sub>
0	39.91	30.73	25	57.11	43.97
5	43.61	33.58	30	60.29	46.42
10	47.28	36.41	35	63.35	48.78
15	50.59	38.95	40	66.45	51.17
20	53.93	41.53	45	69.44	53.47

**Tb TERBIUM**

**NO TERBIUM NITRATE**

Data for the distribution of  $\text{Tb}(\text{NO}_3)_3$  between tri-n-butyl phosphate and aqueous  $\text{HNO}_3$  are given by Weaver, Kappelmann and Topp, 1953.

**PO TERBIUM DIMETHYL PHOSPHATE  $\text{Tb}[(\text{CH}_3)_2\text{PO}_4]_2$**

**SOLUBILITY OF TERBIUM DIMETHYL PHOSPHATE IN WATER**  
(Marsh, 1939)

t°	Gms. $\text{Tb}[(\text{CH}_3)_2\text{PO}_4]_2$ per 100 gms. $\text{H}_2\text{O}$	Solid Phase
0	24.2	$\text{Tb}[(\text{CH}_3)_2\text{PO}_4]_2$
25	12.6	"
50	8.07	"

**SO TERBIUM SULFATE  $\text{Tb}_2(\text{SO}_4)_3 \cdot 8\text{H}_2\text{O}$**

100 gms.  $\text{H}_2\text{O}$  dissolve 3.561 gms.  $\text{Tb}_2(\text{SO}_4)_3 \cdot 8\text{H}_2\text{O}$  at 20° and 2.51 gms. at 40°. (Jackson and Riennacker, 1930.)

**Te TELLURIUM**

100 gms. methylene iodide,  $\text{CH}_2\text{I}_2$ , dissolve 0.1 gm. Te at 12°. (Retgers, 1893.)

**DISTRIBUTION OF TELLURIUM BETWEEN AQUEOUS HYDROCHLORIC ACID AND  
ETHER AT ROOM TEMPERATURE**  
(Mylius, 1911)

When 1 gm. of tellurium as the chloride,  $\text{TeCl}_4$ , is dissolved in 100 cc. of aqueous  $\text{HCl}$  and shaken with 100 cc. of ether, the following per cents of the metal enter the ethereal layers. With 20%  $\text{HCl}$ , 34 per cent; 15%  $\text{HCl}$ , 12 per cent; 10%  $\text{HCl}$ , 3 per cent; 5%  $\text{HCl}$ , 0.2 per cent and with 1%  $\text{HCl}$ , only a trace of the tellurium.

Fusion-point curves for mixtures of tellurium and each of the following metals are given by Pelabon (1909): Sb, Sn, Pb, Ag, Au and As. Results for mixtures of Te and Zn are given by Kobayashi (1911-12). For Te + Tl see Hahn and Klinger, 1949.

Results for mixtures of Te + Br and Te + I are given by Damiens, 1920, 1921.

## TELLURIUM BROMIDES AND CHLORIDES

SOLUBILITY OF TELLURIUM DOUBLE BROMIDES AND CHLORIDES IN AQUEOUS  
HYDROCHLORIC AND HYDROBROMIC ACIDS AT 22°  
(Wheeler, 1893a)

Tellurium Double Salt	Solvent	Gms. Double Salt per 100 Gms. Solvent	
		of 1.49 Sp. Gr.	of 1.08 Sp. Gr.
Te Caesium Bromide TeBr <sub>4</sub> ·2CsBr	Aq. HBr	0.02	0.13
Te Potassium Bromide TeBr <sub>4</sub> ·2KBr	Aq. HBr	6.57	62.90
Te Rubidium Bromide TeBr <sub>4</sub> ·2RbBr	Aq. HBr	0.25	3.88
Te Caesium Chloride TeCl <sub>4</sub> ·2CsCl	Aq. HCl*	0.05	0.78
Te Rubidium Chloride TeCl <sub>4</sub> ·2RbCl	Aq. HCl*	0.34	13.09

\*Sp. Gr. of Aq. HCl solutions 1.2 and 1.05 respectively.

Data for the partition of Te IV between aqueous HF (1 - 20 N) solutions and ethyl ether at 20° are given by Bock and Herrmann, 1956.

TELLURIUM TETRAIODIDE TeI<sub>4</sub>SOLUBILITY IN MIXTURES OF AQUEOUS HYDRIODIC ACID AND IODINE AT 25°  
(Menke, 1912)

Weighed amounts of TeI<sub>4</sub> + I + 65 wt. % HI solution were shaken in sealed glass tubes for 10 days. Both the clear saturated solution and the solid phase were analyzed.

Composition of Original Mixture in Gms.			Gms. per 100 Gms. Solution		Solid Phase
TeI <sub>4</sub>	I	64% HI	TeI <sub>4</sub>	I	
3	1.5	19.25	12	11.7	Small amt. TeI <sub>4</sub> ·HI·8H <sub>2</sub> O
2	0.5	9.61	13	0	much "
2	0.5	9.61	13.5	8.2	" "
3	3	8.99	20	21.8	small amt. "
Excess	None	5 (cc.)	9	0.19	TeI <sub>4</sub> ·HI·8H <sub>2</sub> O
2	9	9.10	10	52.4	Iodine
4	10	9.27	15	47.7	"
3	7	9.02	17.5	47.9	"
None	Excess	5 (cc.)	None	61.1	"

Data for the extraction of TeI<sub>4</sub> from 6.9 N HCl by ethyl ether are given by Kitahara, 1948.



## Te TELLURIUM

### I $\alpha$ -DIMETHYL TELLURONIUM IODIDE $\text{Te}(\text{CH}_3)_2\text{I}_2$

SOLUBILITY OF  $\alpha$  DIMETHYL TELLURONIUM IODIDE IN SEVERAL SOLVENTS AT 25°  
(Lowry and Gilbert, 1929)

Solvent	Gms. $\text{Te}(\text{CH}_3)_2\text{I}_2$ per 100 cc solvent	Solvent	Gms. $\text{Te}(\text{CH}_3)_2\text{I}_2$ per 100 cc solvent
Acetone	9.97	Ethyl Alcohol	2.18
Benzene	7.09	Carbon Tetrachloride	0.58
Chloroform	5.51	Cyclo Hexane	0.10
Acetonitrile	5.21		

### O TELLURIUM DIOXIDE $\text{TeO}_2$

#### SOLUBILITY IN AQUEOUS HYDROCHLORIC ACID SOLUTIONS

##### Results at 12°

(Parker and Robinson, 1931)

Moles per Liter		Moles per Liter	
$\text{TeO}_2$	HCl	$\text{TeO}_2$	HCl
0.019	0.83	1.86	7.34
0.14	1.70	2.42	8.22
0.52	4.69	3.42	12.38
0.82	6.80	4.53	16.65
1.30	6.30	3.13	15.07

##### Results at 18°

(Kasarnawsky, 1924)

Moles per Liter	
$\text{TeO}_2$	HCl
0.00057	0.10
0.00120	0.22
0.00370	0.46
0.00910	0.92

##### Results at 25° (Issa and Awad, 1954)

Moles per Liter		Initial pH	Moles per Liter		Initial pH
$\text{TeO}_2$	HCl		$\text{TeO}_2$	HCl	
0.0102	1	0.092	0.000099	0.005	2.47
0.00391	0.5	0.41	0.00002574	0.001	3.17
0.000770	0.1	1.11	0.00001485	0.0005	3.40
0.0004207	0.05	1.38	0.00001326	0.0001	4.07
0.0001638	0.01	2.05	0.0000375	0.0	6.5

These authors also give solubility data in Clark and Lubs buffer solutions at various pH. In all cases minimum solubility occurs at about pH 4. Solubilities in buffers are:

Initial pH	Final pH	Moles $\text{TeO}_2$ per liter	Initial pH	Final pH	Moles $\text{TeO}_2$ per liter
1.11	1.11	0.000770	6.03	5.99	0.00009405
2.39	2.39	0.000203	7.07	7.02	0.000146
3.05	3.05	0.0000544	8.0	7.93	0.0003613
4.2	4.2	0.0000297			
4.96	4.93	0.0000544			

SOLUBILITY OF TELLURIUM DIOXIDE IN AQUEOUS SOLUTIONS OF HYDROBROMIC  
ACID AT 12°  
(Parker and Robinson, 1931)

In the case of the aqueous HBr solutions the solid phase showed a progressive increase in Br content but did not reach that required for tellurium tetrabromide.

Gms. Mols. per liter		Gms. Mols. per liter	
TeO <sub>2</sub>	HBr	TeO <sub>2</sub>	HBr
0.0199	0.735	0.471	3.140
0.070	1.115	0.569	3.496
0.103	1.396	0.852	5.082
0.144	1.719	1.137	6.320
0.265	2.298	1.667	9.170

SOLUBILITY OF TELLURIUM DIOXIDE IN AQUEOUS SOLUTIONS OF HYDROFLUORIC  
ACID AT 10°  
(Prideaux and Millott, 1920)

The authors' quite irregular results for solutions in contact with TeO<sub>2</sub> were plotted and the above values taken from the average curve drawn through them.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
HF	TeO <sub>2</sub>		HF	TeO <sub>2</sub>	
0.22	0.12	TeO <sub>2</sub>	15	42	TeO <sub>2</sub>
2.5	5.0	"	17.5	52.5	"
5.0	10.0	"	20.0	65	"
7.5	16.0	"	24	42.6	TeF <sub>4</sub> ·TeO <sub>2</sub> ·2H <sub>2</sub> O
10.0	22.5	"	26.4	45.7	" + TeF <sub>4</sub> ·TeO <sub>2</sub> ·H <sub>2</sub> O
12.5	30.0	"	28.5	58.0	TeF <sub>4</sub> ·TeO <sub>2</sub> ·H <sub>2</sub> O

Data for the system TeO<sub>2</sub> - HNO<sub>3</sub> - H<sub>2</sub>O at 25° and 70° are given by Vorob'eva and Vladimirova, 1957.

## Te TELLURIUM

### TELLURIC ACID $\text{H}_2\text{TeO}_4$

#### SOLUBILITY IN WATER (Mylius, 1901)

t°	Gms. $\text{H}_2\text{TeO}_4$ per 100	Mols. $\text{H}_2\text{TeO}_4$ per 100	Solid Phase	t°	Gms. $\text{H}_2\text{TeO}_4$ per 100	Mols. $\text{H}_2\text{TeO}_4$ per 100	Solid Phase
	Gms. Sol.	Mols. $\text{H}_2\text{O}$			Gms. Sol.	Mols. $\text{H}_2\text{O}$	
0	13.92	1.51	$\text{H}_2\text{TeO}_4 \cdot 6\text{H}_2\text{O}$	30	33.36	4.67	$\text{H}_2\text{TeO}_4 \cdot 2\text{H}_2\text{O}$
5	17.84	2.03	"	40	36.38	5.33	"
10	26.21	3.31	"	60	43.67	7.04	"
15	32.79	4.55	"	80	51.55	9.93	"
10	25.29	3.14	$\text{H}_2\text{TeO}_4 \cdot 2\text{H}_2\text{O}$	100	60.84	14.52	"
18	28.90	3.82	"	110	67	19	"

## Th THORIUM

The solubility of thorium in mercury was found by Parks and Prime, 1936, to be 0.0154 weight percent (= 0.0136 atomic percent) at 25°.

### THORIUM EMANATIONS

A complete list of references for the solubility of thorium emanations in various solvents is given by Markham and Kobe, 1941b.

## BO THORIUM BORATE

The precipitate which results when thorium nitrate is added to a solution of borax is not a stable compound. Solubility determinations made by four successive extractions of it at 18° with water, gave the following gms. of material per 100 gms.  $\text{H}_2\text{O}$ ; 0.5366, 0.1250, 0.0611 and 0.0560. After the fourth extraction, the residue then contained 10.14%  $\text{B}_2\text{O}_3$  and after boiling 10 gms. with 100 cc. of  $\text{H}_2\text{O}$  for 6 hrs. and repeating this four times, it contained 9.63 - 9.81%  $\text{B}_2\text{O}_3$ . (Karl, 1910.)

## CH THORIUM ACETATE $\text{Th}(\text{CH}_3\text{COO})_4$

#### SOLUBILITY IN ORGANIC SOLVENTS AT 30° (Muniyappan and Anjanryalu, 1957, 1957a)

Monoethanol amine	70.81 g. salt per 100 g. solvent
Ethylene glycol	0.41 g. salt per 100 g. solvent
Ethylenediamine	4.30 g. salt per 100 g. solvent

## THORIUM CHLOROACETATES (BASIC)

SOLUBILITY IN WATER AT 25°  
(Karl, 1910)

Name of Salt	Formula	Gms. Salt per 100 Gms. H <sub>2</sub> O
Basic Thorium Monochloroacetate	$(ClCH_2COO)_2Th(OH)_2 \cdot H_2O$	0.0663
Basic Thorium Dichloroacetate	$(Cl_2CHCOO)_2Th(OH)_2$	0.0887
Basic Thorium Trichloroacetate	$(Cl_3CCOO)_2Th(OH)_2$	0.0091

THORIUM m NITROBENZENE SULFONATE  $Th(C_6H_4 \cdot NO_2 \cdot SO_3)_4 \cdot 7H_2O$ 

CH

100 gms. H<sub>2</sub>O dissolve 61 gms. of the anhydrous salt at 15°.  
(Holmberg, 1907.)

THORIUM PICRATE  $Th(C_6H_2N_3O_7)_4 \cdot 10H_2O$ 

100 gms. H<sub>2</sub>O dissolve 0.3052 gm. of the salt at 25°. (Karl, 1910.)

THORIUM HIPPURATE  $Th(C_6H_5 \cdot CO \cdot CH_2 \cdot NH \cdot COO)_4$ 

100 gms. H<sub>2</sub>O dissolve 0.0318 gm. of the salt at 25°. (Karl, 1910.)

## Results giving extraction and partition data of thorium IV:

System:	t°:	Reference:
Between tributyl phosphate and aqueous HCl or HNO <sub>3</sub> .	22	Peppard, Mason and Maier, 1956
Salicylic acid, methoxybenzoic acid and cinnamic acid complexes between methyl isobutyl acetone and water and between chloroform and water.	25	Bernstrom, 1956, 1956a
Extraction of 5,7 dihalo-, 5,7 di-bromo- 5,7 diiodo and 5 chloro 7 iodo thorium derivatives of 8 quinolino] (oxine) from water by chloroform.	25	Dyrssen, Dyrssen and Johansson, 1956
Benzene, chloroform, methyl isobutyl ketone and aqueous solutions containing acetylacetone containing NaClO <sub>4</sub> .	25	Rydberg, 1954
8-hydroxyquinoline (oxine) derivatives by chloroform and hexone from water	25	Dyrssen and Dahlberg, 1953

THORIUM OXALATE  $\text{Th}(\text{C}_2\text{O}_4)_2$ 

## SOLUBILITY OF THORIUM OXALATE IN AQUEOUS OXALIC ACID SOLUTIONS

Results at 25°

(Hauser and Wirth, 1912)

Normality of Aq. $\text{H}_2\text{C}_2\text{O}_4$	Gm. $\text{ThO}_2$ per 1000 Gms. Sat. Sol.	Solid Phase
1	0.0015	$\text{Th}(\text{C}_2\text{O}_4)_2 \cdot 6\text{H}_2\text{O}$
Sat. Solution	0.0030	" + $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$

Results at 50°

(Colani, 1913)

Gms. per 100 Gms. Sat. Sol.

$\text{H}_2\text{C}_2\text{O}_4$	Th
1.7	0.0002
9.3	0.001
23	0.003

## SOLUBILITY OF THORIUM OXALATE IN AQUEOUS SOLUTIONS OF HYDROCHLORIC ACID

Results at 17°

(Colani, 1913)

Gms. per 100 Gms.  
Sat. Sol.HCl  $\text{Th}(\text{C}_2\text{O}_4)_2$ 

0	0.0017
1.2	0.0035
3.6	0.0061
4.6	0.0094
8.4	0.017
13.1	0.028
16.2	0.038
19.8	0.064

Results at 25°

(Hauser and Wirth, 1912)

Conc. of  
Aq. HCl in  
Per centGm.  $\text{ThO}_2$  per  
1000 Gms.  
Sat. Sol.

Solid Phase

24.8	0.100	$3\text{Th}(\text{C}_2\text{O}_4)_2 \cdot \text{ThCl}_4 \cdot 2\text{H}_2\text{O}$
37	3.450	"
37.6	3.492	"

(Data of Spitzer, 1917)

Normality  
of Aq. HClGm.  $\text{ThO}_2$   
per literResults at 50° (Colani, 1913)

Gms. per 100 Gms. Sat. Sol.

HCl  $\text{Th}(\text{C}_2\text{O}_4)_2$ 

0	0.0017
4.1	0.010
8.4	0.028
12.4	0.057
16.1	0.103
18	0.134
19.9	0.169
21.6	0.232

0.04	0.0006
0.09	0.0017
0.23	0.0047
0.38	0.0070
0.48	0.0085
0.50	0.012
0.64	0.016
0.82	0.021
1.00	0.024

SOLUBILITY OF THORIUM OXALATE IN AQUEOUS SOLUTIONS OF SULFURIC  
ACID AT 25°

(Results of Hauser and  
Wirth, 1909a, 1912;  
Wirth, 1912)

(Results of Spitzer 1917)

Solid Phase $\text{Th}(\text{C}_2\text{O}_4)_2 \cdot 6\text{H}_2\text{O}$ throughout.		Normality of Aq. $\text{H}_2\text{SO}_4$	Gm. $\text{ThO}_2$ per liter	Normality of Aq. $\text{H}_2\text{SO}_4$	Gm. $\text{ThO}_2$ per liter
Normality of Aq. $\text{H}_2\text{SO}_4$	Gms. $\text{ThO}_2$ per 1000 Gms. Sat. Sol.	0.007	0.0005	0.49	0.053
		0.02	0.0020	0.50	0.055
		0.03	0.0030	0.58	0.060
		0.06	0.0069	0.90	0.090
		0.10	0.0120	0.98	0.108
0.25	0.07	0.20	0.0180	(1.00)	(0.120)
0.5	0.14	0.40	0.0430	1.18	0.120
1	0.26	0.48	0.0460		
2.1	0.418				
3.2	0.71				
4.32	1.10				
4.9	1.32				
6.175	1.513				
6.885	1.794				
8.45	2.473				

SOLUBILITY OF THORIUM OXALATE AT 25° IN AQUEOUS SOLUTIONS OF SULFURIC  
ACID SATURATED WITH CERIUM OXALATE ( $\text{Ce}_2(\text{C}_2\text{O}_4)_3 \cdot 10\text{H}_2\text{O}$ )  
(Spitzer, 1917)

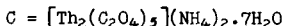
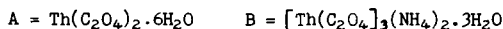
Normality of Aq. $\text{H}_2\text{SO}_4$	Gm. $\text{ThO}_2$ per liter	Normality of Aq. $\text{H}_2\text{SO}_4$	Gm. $\text{ThO}_2$ per liter
0.014	0.0009	0.47	0.015
0.050	0.0030	0.63	0.019
0.100	0.0040	0.90	0.043

SOLUBILITY OF THORIUM OXALATE IN AQUEOUS SOLUTIONS OF NITRIC ACID AT 25°  
(Spitzer, 1917)

Normality of Aq. $\text{H}_2\text{SO}_4$	Gm. $\text{ThO}_2$ per liter	Normality of Aq. $\text{H}_2\text{SO}_4$	Gm. $\text{ThO}_2$ per liter
0.016	0.0003	0.50	0.0110
0.06	0.0013	0.78	0.0144
0.24	0.0045	1.00	0.0330
0.47	0.0101		

# THORIUM Th

## SOLUBILITY OF THORIUM OXALATE IN AQUEOUS SOLUTIONS OF AMMONIUM OXALATE AT 25° (Hauser and Wirth, 1909a, 1912)



Gm. Mols. per 1000 Gms. Sat. Sol.		Solid Phase	Normality of Aq. (NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	Gms. ThO <sub>2</sub> per 1000 Gms. Sat. Sol.	Solid Phase
(NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	Th(C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub>				
0.00033	0.00005	A	0.01	0.040	A
0.00072	0.00012	A	0.10	2.203	A
0.00120	0.000208	A	0.5*	7.660	C
0.00153	0.00026	A	0.5*	10.63	C
0.601**	0.195	B	0.5*	15.90	C
1.181**	0.427	B	0.5*	17.60	C
1.420**	0.540	B	0.5*	17.75	C
1.480**	0.563	B			

CO

\*In these cases the greater part of the ammonium salt entered the solid phase complex and it was, therefore, necessary to add additional ammonium oxalate until constant results were obtained.

\*\*In these cases the solvent was saturated ammonium oxalate solutions containing an excess of the crystals.

Gm. mols. (NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub> per liter	Gm. ThO <sub>2</sub> per liter	Gm. mols. (NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub> per liter	Gm. ThO <sub>2</sub> per liter	Gm. mols. (NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub> per liter	Gm. ThO <sub>2</sub> per liter
0.00 (H <sub>2</sub> O)	0.00007	0.0075	0.070	0.0300	0.600
0.0006	0.0023	0.0100	0.100	(0.0410)	(0.410)
0.0010	0.0040	0.0150	0.180	0.0500	1.000
0.0025	0.010	0.0200	0.340	(0.0900)	(5.550)
0.0050	0.040	0.0250	0.450		

## SOLUBILITY OF THORIUM OXALATE IN VARIOUS AQUEOUS SOLUTIONS AT 25° (Spitzen, 1917)

Aq. solvent	Gm. ThO <sub>2</sub> per liter	Aq. solvent	Gm. ThO <sub>2</sub> per liter
0.1 n NH <sub>4</sub> Cl	0.0003	0.5 n HClO <sub>4</sub>	0.0130
0.1 n (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	0.0010	0.5 n HClO <sub>4</sub>	0.0130
0.1 n NaCl	0.0002	0.5 n H <sub>3</sub> BO <sub>3</sub>	0.0001
0.1 n Na <sub>2</sub> SO <sub>4</sub>	0.0006	0.5 n C <sub>6</sub> H <sub>6</sub> O <sub>6</sub>	0.0040
0.5 n HBr	0.0115	0.5 n CCl <sub>3</sub> COOH	0.0120
0.5 n HI	0.0112	0.5 n KHSO <sub>4</sub>	0.0300
0.5 n H <sub>2</sub> CrO <sub>4</sub>	0.0110	1.0 n KHSO <sub>4</sub>	0.0770

A thorium ammonium oxalate of the composition Th(C<sub>2</sub>O<sub>4</sub>.NH<sub>4</sub>)<sub>4</sub>.4H<sub>2</sub>O is described by Brauner (1898). It is partially hydrolytically decomposed in aqueous solution and a solubility determination made by analyzing the solution from which the nearly pure salt began to crystallize, showed that 100 gms. H<sub>2</sub>O contain 90.3 gms. Th(C<sub>2</sub>O<sub>4</sub>.NH<sub>4</sub>)<sub>4</sub>.4H<sub>2</sub>O and 9.3 gms. of (NH<sub>4</sub>)<sub>2</sub>C<sub>2</sub>O<sub>4</sub> (= an additional 1/2 mol. wt.)

0.51 gms.  $\text{Th}(\text{C}_2\text{O}_4)_2 \cdot 2\text{H}_2\text{O}$  dissolve in 100 gms. liquid ammonia at 25°. (Watt, Jenkins and McCuiston, 1950.)

### THORIUM OXALATE \_ CHLORIDE

SOLUBILITY OF THORIUM CHLOROOXALATE,  $3\text{Th}(\text{C}_2\text{O}_4)_2 \cdot \text{ThCl}_4 \cdot 2\text{H}_2\text{O}$ , IN AQUEOUS HYDROCHLORIC ACID  
(Colani, 1913)

t°	Gms. per 100 Gms. Sat. Sol.		t°	Gms. per 100 Gms. Sat. Sol.	
	HCl	$\text{Th}_4(\text{C}_2\text{O}_4)_3\text{Cl}_4$		HCl	$\text{Th}_4(\text{C}_2\text{O}_4)_3\text{Cl}_4$
12	23	0.12	50	21.2	0.29
15	26.3	0.17	50	23	0.34
12	29.9	0.27	50	26.8	0.46
15	32.5	0.48	50	29.8	0.75
12	33.1	0.53	50	32.3	1.51
15	35	1.03	50	34.6	2.59

Results are also given showing the effect of oxalic acid upon the solubility of the above salt in aqueous hydrochloric acid.

### Cl THORIUM CHLORIDE $\text{ThCl}_4$

THE SYSTEM THORIUM CHLORIDE - COPPER CHLORIDE - WATER AT 25°  
(Blidin, 1956)

Sat. Sol. Wt. %			Sat. Sol. Wt. %		
$\text{CuCl}_2$	$\text{ThCl}_4$	Solid Phase	$\text{CuCl}_2$	$\text{ThCl}_4$	Solid Phase
44.62	0.0	$\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$	9.56	40.63	$\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$
35.20	8.12	"	7.60	44.20	" + $\text{ThCl}_4 \cdot 8\text{H}_2\text{O}$
29.50	14.20	"	4.45	47.50	$\text{ThCl}_4 \cdot 8\text{H}_2\text{O}$
25.42	19.14	"	2.20	51.48	"
20.44	25.60	"	0.0	55.42	"
15.50	31.82	"			

100 ml. of a saturated solution in ethylene diamine at 30° contain 11.08 gms.  $\text{ThCl}_4$ . (Putnam and Kobe, 1938.)

### ClO THORIUM HEXA ANTIPYRINE PERCHLORATE $[\text{Th}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6](\text{ClO}_4)_4$

100 cc sat. solution of thorium hexa antipyrine perchlorate in water contain 0.6 gm.  $[\text{Th}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6](\text{ClO}_4)_4$  at 20°. (Wilke-Dörfurt and Schliephake, 1929.)



## Th THORIUM

### CrO THORIUM CHROMATE $\text{Th}(\text{CrO}_4)_2$

EQUILIBRIUM IN THE SYSTEM THORIUM OXIDE, CHROMIC ANHYDRIDE AND WATER  
AT 25°

(Britton, 1923)

The solutions were saturated by constant stirring in a thermostat. The solid phases were identified by analysis according to the "rest method."

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		Solid Phase
$\text{ThO}_2$	$\text{CrO}_3$		$\text{ThO}_2$	$\text{CrO}_3$	
0.044	0.033	$\text{Th}(\text{CrO}_4)_2 \cdot 3\text{H}_2\text{O}$	23.04	40.23	$\text{Th}(\text{CrO}_4)_2 \cdot \text{CrO}_3 \cdot 3\text{H}_2\text{O}$
0.452	1.376	"	21.59	41.56	"
2.09	4.58	"	17.08	44.20	"
3.08	7.15	"	7.91	52.60	"
6.52	13.09	"	7.52	56.79	"
11.27	21.75	"	9.09	57.57	"
15.62	28.00	"	17.65	61.38	" + $\text{CrO}_3$
22.87	37.27	"	6.27	61.84	$\text{CrO}_3$
23.25	37.45	"	0.0	62.87	"
24.22	39.49	" + $\text{Th}(\text{CrO}_4)_2 \cdot \text{CrO}_3 \cdot 3\text{H}_2\text{O}$			

### F THORIUM FLUORIDE $\text{ThF}_4 \cdot 4\text{H}_2\text{O}$

1000 cc. sat. solution of thorium fluoride in water contain 0.17 gm.  $\text{ThO}_3$  at 25°. (Spitzen, 1917.)

The Ksp in water at 25° is  $5.9 \times 10^{-8}$ . (Dodgen, 1952.)

Data for the distribution of thorium between  $\text{LaF}_3$  crystals and its saturated solutions in 3% and 12%  $\text{HNO}_3$  are given by Khlopin and Merkulova, 1949.

### F THORIUM POTASSIUM FLUORIDE $\text{ThK}_2\text{F}_6 \cdot 4\text{H}_2\text{O}$

1000 cc. sat. sol. of thorium potassium fluoride in water contain 0.4 gm.  $\text{ThO}_2$  at 25°. (Spitzen, 1917.)

### IO THORIUM IODATE $\text{Th}(\text{IO}_3)_4$

At 25°, 0.203 gms. are dissolved in one liter of a saturated solution in water. (Spacu and Spacu, 1948.)

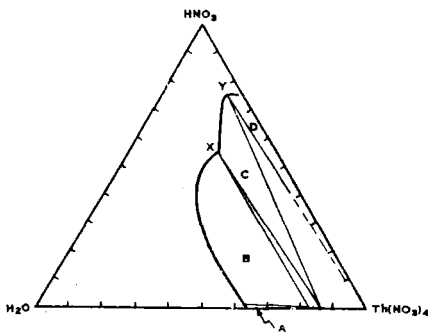
0.08 gms.  $\text{Th}(\text{IO}_3)_4$  dissolve in 100 gms. liquid ammonia at 25°. (Watt, Jenkins and McCuiston, 1950.)

## SOLUBILITY OF THORIUM NITRATE IN WATER

(Misciatelli, 1930)

(Marshall, Gill and Secoy, 1951)

Gms. Th(NO <sub>3</sub> ) <sub>4</sub> per 100 gms. sat. sol.			Solid Phase	Gms. Th(NO <sub>3</sub> ) <sub>4</sub> per 100 gms. sat. sol.			Solid Phase
t°				t°			
- 0.2	1.0		Ice	37.3	67.07		Th(NO <sub>3</sub> ) <sub>4</sub> ·6H <sub>2</sub> O
- 1.5	9.0		"	54.5	68.78		"
- 4.0	20.0		"	72.0	73.39		"
- 6.0	33.0		"	90.2	76.39		"
- 9.0	41.0		"	99.7	78.56		"
-15.0	47.7		"	110.9	81.50		"
-25	55.7		"	111	-		" + Th(NO <sub>3</sub> ) <sub>4</sub> ·4H <sub>2</sub> O
-35	60.6		"	120.6	82.01		Th(NO <sub>3</sub> ) <sub>4</sub> ·4H <sub>2</sub> O
-40.6	62.0		"	128	82.41		"
-43.5	64.0	Th(NO <sub>3</sub> ) <sub>4</sub> ·6H <sub>2</sub> O		130.5	82.85		"
-22	64.2	"		139.5	84.27		"
0	65.0	"		146.0	85.30		"
+10	65.2	"		149.0	85.81		"
20	65.6	"		151	-		" + Th(NO <sub>3</sub> ) <sub>4</sub> ·xH <sub>2</sub> O
				159	87.41		Th(NO <sub>3</sub> ) <sub>4</sub> ·xH <sub>2</sub> O
				211	91.82		"

THE SYSTEM THORIUM NITRATE - NITRIC ACID - WATER AT 25°  
(Ferraro, Katzin and Gibson, 1954)

A = area of hydrolyses

B =  $\text{Th}(\text{NO}_3)_4 \cdot 5\text{H}_2\text{O}$  stableC =  $\text{Th}(\text{NO}_3)_4 \cdot 4\text{H}_2\text{O}$  stableD =  $\text{Th}(\text{NO}_3)_4$  stablex = 17.70%  $\text{H}_2\text{O}$ , 28.67%  $\text{Th}(\text{NO}_3)_4$ y = 5.10%  $\text{H}_2\text{O}$ , 21.13%  $\text{Th}(\text{NO}_3)_4$

# Th THORIUM

## THE SYSTEM THORIUM NITRATE - ETHYL ETHER - WATER AT 0° AND AT 20° (Misciatelli, 1929)

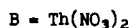
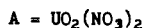
Two liquid layers are formed at concentration of ether greater than about 4 percent of the saturated solution at 0° and 2 percent at 20°.

	H <sub>2</sub> O Rich Layer			C <sub>2</sub> H <sub>5</sub> OH Rich Layer			
	Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.			
	(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	H <sub>2</sub> O	Th(NO <sub>3</sub> ) <sub>4</sub>	(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	H <sub>2</sub> O	Th(NO <sub>3</sub> ) <sub>4</sub>	Solid Phase
	<u>Results at 0°</u>						
NO	0.0	35.0	65.0	-	-	-	Th(NO <sub>3</sub> ) <sub>4</sub> ·6H <sub>2</sub> O
	4.5	28.5	67.0	41.36	13.99	44.65	Th(NO <sub>3</sub> ) <sub>4</sub> ·H <sub>2</sub> O
	5.21	28.89	65.90	41.27	12.78	45.95	"
	-	-	-	54.50	10.50	35.0	"
	-	-	-	94.2	-	5.8	Tl(NO <sub>3</sub> ) <sub>4</sub>
	5.0	36.50	58.50	70.0	7.0	23.0	None
	4.84	46.26	48.90	87.50	4.50	8.0	"
	4.99	52.63	42.40	96.08	3.33	0.33	"
	4.42	54.89	41.09	98.42	1.45	0.08	"
	4.53	62.35	33.10	99.56	0.41	0.02	"
	4.39	72.33	23.28	90.49	0.49	0.02	"
	8.3	79.66	12.09	99.92	0.07	0.01	"
	11.6	88.4	-	99.0	1.0	-	"
	<u>Results at 20°</u>						
	0.0	35.0	65.00	-	-	-	Th(NO <sub>3</sub> ) <sub>4</sub> ·6H <sub>2</sub> O
	1.92	32.50	65.52	54.10	8.40	37.50	Th(NO <sub>3</sub> ) <sub>4</sub> ·H <sub>2</sub> O
	-	-	-	62.47	7.33	30.3	"
	-	-	-	72.5	5.0	22.5	"
	-	-	-	88.58	2.19	9.22	Th(NO <sub>3</sub> ) <sub>4</sub>
	-	-	-	92.54	0.50	6.96	"
	-	-	-	88.01	-	1.9	"
	2.08	37.62	60.30	66.90	7.0	26.10	None
	1.90	43.0	55.0	89.20	3.3	7.50	"
	2.08	51.2	46.82	99.00	1.00	0.0	"
	2.50	51.60	45.90	98.50	1.50	0.0	"
	2.00	57.49	40.51	98.00	2.00	0.0	"
	2.27	62.22	35.51	98.20	1.80	0.0	"
	2.04	65.00	32.18	98.33	1.67	0.0	"
	3.90	71.52	20.58	98.08	11.92	0.0	"
	6.5	93.52	-	99.0	1.0	0.0	"

Experiments in the extraction of thorium nitrate from aqueous solutions of nitric acid by means of ether are described by Imrie, 1927.

Additional data in this system are given by Beck and Beck, 1949, 1950.

THE SYSTEM THORIUM NITRATE - URANYL NITRATE - ETHYL ETHER  
(Misciatelli, 1929)



Gms. per 100 gms. sat. sol.			Solid Phase	Gms. per 100 gms. sat. sol.			Solid Phase
$\text{UO}_2(\text{NO}_3)_2$	$\text{Th}(\text{NO}_3)_2$	$(\text{C}_2\text{H}_5)_2\text{O}$		$\text{UO}_2(\text{NO}_3)_2$	$\text{Th}(\text{NO}_3)_2$	$(\text{C}_2\text{H}_5)_2\text{O}$	
Results at 0°				Results at 20°			
22	0	78	A	0.0	1.5	98.5	B
22.5	1.02	76.48	A	3.1	1.0	95.9	B
24	3.5	72.57	A + B	5.5	0.5	94	B
19.2	4.5	76.3	B	8.78	0	91.22	B + A
18	5	77	B	Results at Higher Temperatures			
16.5	5.6	77.9	B				
12.2	7.0	81.0	B				
8.2	8.3	82.5	B 16°	17.7	1.7	80.6	B + A
3.0	8	89	B 19°	10.5	0.4	89.1	B + A
0	5.8	94.2	B 22°	8.0	-	92	B + A
			25°	7.37	-	92.63	B + A

DISTRIBUTION OF THORIUM NITRATE BETWEEN ESTERS AND WATER AT 25°  
(Templeton, Rothschild, and Hall, 1949)

"Practical" Grade Esters were Used

Total Composition ml.			% $\text{ThO}_2$ in	
Ester	Water	Saturated $\text{Th}(\text{NO}_3)_4$ Solution	Ester Phase	Water Phase
With Ethyl Butyrate				
3.0	0.0	3.0	4.76	34.31
3.0	0.2	2.8	3.74	33.41
3.0	0.4	2.6	1.95	32.08
3.0	0.6	2.4	0.81	31.02
3.0	0.8	2.2	0.23	29.68
3.0	1.0	2.0	0.07	28.81

With Ethyl Acetate

Total Composition ml.						
Ester	Water	Saturated $\text{Th}(\text{NO}_3)_4$ Solution	After 24 hrs. Agitation	+24 hrs. Standing	+24 hrs. Additional Agitation	+60 Days Standing
3.0	0.0	3.0	Miscible	Miscible	Miscible	Miscible
3.0	0.2	2.8	Miscible	Miscible	Miscible	Miscible
3.0	0.4	2.6	Indistinct Separation	Indistinct Separation	Miscible	Miscible
3.0	0.6	2.4	Indistinct Separation	Indistinct Separation	Miscible	Miscible
3.0	0.8	2.2	Two Phases	Indistinct Separation	Miscible	Miscible
3.0	1.0	2.0	Two Phases	Two Phases	Miscible	Miscible

# Th THORIUM

## DISTRIBUTION OF THORIUM NITRATE BETWEEN NITROMETHANE AND WATER AT 20° (Warner, 1953)

Th(NO<sub>3</sub>)<sub>4</sub>·4H<sub>2</sub>O used throughout.

Wt. % Th(NO <sub>3</sub> ) <sub>4</sub> in		Wt. % Th(NO <sub>3</sub> ) <sub>4</sub> in	
aqueous phase	CH <sub>3</sub> NO <sub>2</sub> phase	aqueous phase	CH <sub>3</sub> NO <sub>2</sub> phase
64.5*	1.33*	55.2	0.47
62.9	1.09	50.1	0.12
59.6	0.72	34.5	0.04
56.6	0.49	21.8	0.02

\*System saturated with Th(NO<sub>3</sub>)<sub>4</sub>·4H<sub>2</sub>O.

NO

## DISTRIBUTION OF THORIUM NITRATE BETWEEN WATER AND ORGANIC SOLVENTS AT 25° (Rothschild, Templeton, and Hall, 1948)

Because of the small temperature coefficient of solubility of thorium nitrate, the determinations were made at "room temperature," and no significant errors were introduced.

% ThO <sub>2</sub>		% ThO <sub>2</sub>		% ThO <sub>2</sub>	
Organic Phase	Aqueous Phase	Organic Phase	Aqueous Phase	Organic Phase	Aqueous Phase
Methyl-n-Hexyl Ketone		Methyl-n-Amyl Ketone		Methyl Isobutyl Ketone	
9.40	32.50	12.65	31.99	14.07	31.12
6.18	31.31	8.85	30.59	10.21	29.70
2.54	29.41	4.48	28.92	5.99	28.42
1.70	28.68	2.31	27.58	2.98	27.14
0.83	27.54	1.15	26.31	2.06	26.52
.53	26.74	0.58	24.77	1.15	25.55
.34	25.87				
.17	24.78	Isoamyl Alcohol		n-Hexyl Alcohol	
.08	23.61	13.97	31.21	13.78	32.06
Methyl-n-Hexyl Ketone + 0.5 N HNO <sub>3</sub>		10.87	29.65	11.17	30.04
		7.46	27.83	7.82	28.69
		5.62	26.88	4.53	26.95
10.34	31.97	3.60	25.54	2.91	25.69
8.02	31.08	2.31	24.13	1.69	24.16
5.65	30.16				
3.36	29.03	Methyl-n-Hexyl Ketone + 5.0 N HNO <sub>3</sub>		n-Hexyl Alcohol + 1.0 N HNO <sub>3</sub>	
1.90	27.86	7.88	30.23	10.37	29.87
0.90	25.64	3.51	29.44	8.58	28.77
Methyl-n-Hexyl Ketone + 1.0 N HNO <sub>3</sub>		2.34	28.10	6.79	27.68
		1.80	27.14	5.48	26.76
5.68	30.15	0.38	26.18	4.40	26.05
4.03	28.87	4.82	25.95	3.29	25.16
2.70	27.89	1.16	25.86		
1.65	26.74	0.63	23.73		
0.91	25.67	.34	22.53		
.55	24.48				

(Cont.)

DISTRIBUTION OF THORIUM NITRATE BETWEEN NITROMETHANE  
AND WATER AT 20°--Cont.% ThO<sub>2</sub>

Organic Phase	Aqueous Phase
n-Hexyl Alcohol + 5.0 N HNO <sub>3</sub>	

8.20	27.53
6.76	26.74
6.65	25.97
4.74	25.07
2.36	23.95
1.81	22.53

Systems containing HNO<sub>3</sub> were found to decompose somewhat upon standing and several determinations were also made after 2 to 4 weeks had elapsed.

NO

Data for the partition of Th IV between dibutyl carbitol, ether or methyl isobutyl ketone and 1 - 9 N aqueous HNO<sub>3</sub> are given by Kooi, 1956.

The distribution of Th(NO<sub>3</sub>)<sub>4</sub> between butyl phosphate or butyl ether and HNO<sub>3</sub>, Ca(NO<sub>3</sub>)<sub>2</sub> solutions was studied by Anderson, 1950. Other data using tributyl phosphate and HNO<sub>3</sub> solutions is given by Blackmore, Bearse and Calkins, 1952 and by Alcock, Best, Hesford and McKay, 1958.

The partition of Th(NO<sub>3</sub>)<sub>4</sub> between aqueous HNO<sub>3</sub> (or Ca(NO<sub>3</sub>)<sub>2</sub> solutions) and isobutyl methyl ketone at 20° was studied by Rydberg and Bernstrom, 1957.

Data for the extraction of Th(NO<sub>3</sub>)<sub>4</sub> from solutions containing thiocyanate by n-amyl and n-butyl alcohols by Asselin, Audrieth and Comings, 1950.

THE SOLUBILITY OF THORIUM NITRATE IN ORGANIC SOLVENTS AT 25°  
(Templeton and Hall, 1947)

Th(NO<sub>3</sub>)<sub>4</sub>.4H<sub>2</sub>O was shaken with each solvent, which was of "practical" grade or better, for 5 days. Samples were evaporated in platinum crucibles and the residues ignited to ThO<sub>2</sub>.

Solvent:	Gms. Th(NO <sub>3</sub> ) <sub>4</sub> per 100 gms.	Solvent:	Gms. Th(NO <sub>3</sub> ) <sub>4</sub> per 100 gms.
	Sat. Sol.		Sat. Sol.
Diisopropyl Ketone	20.8	Chloroform	0.01
Acetophenone	37.06	Carbon Tetrachloride	.05
Propiophenone	18.9	Methyl Chloroform	.01
Methyl Isobutyl Ketone	42.20	Trichloromethylene	.02
Methyl n-Amyl Ketone	36.68	Ethylene Dichloride	.05
Methyl n-Hexyl Ketone	31.06	Ethyl Bromide	.02
Isoamyl Alcohol	37.8	Chlorobenzene	.03
n-Hexyl Alcohol	33.4	Turpentine	.04
n-Butyl Alcohol	44.6	Acetone	59.3
Iso-Butyl Alcohol	39.9	Methyl Ethyl Ketone	55.7
Cyclohexanol	35.9	Ethanol (absolute)	55.6
Dioxane	42.9	Ethanol 95%	56.0

(Cont.)

# Th THORIUM

## THE SOLUBILITY OF THORIUM NITRATE IN ORGANIC SOLVENTS AT 25°--Cont.

Solvent:	Gms. Th(NO <sub>3</sub> ) <sub>4</sub> per 100 gms.	Solvent:	Gms. Th(NO <sub>3</sub> ) <sub>4</sub> per 100 gms.
	Sat. Sol.		Sat. Sol.
Methanol	65.7	Petroleum Ether	.03
Ethylene Chlorohydrin	44.4	Toluene	.02
n-Propanol	47.0	Nitrobenzene	.02
Allyl Alcohol	45.8	Aniline	.01
Isopropyl Alcohol	44.0	Dimethylaniline	.07
Benzyl Alcohol	20.9	Piperidine	.01
Diether Ether	42.8	o-Toluidine	.09
Di-n-Butyl Ether	2.69	m-Cresol	.10
Diisocamyl Ether	1.12		

NO

The following values are the highest observed solubilities in solvents which formed very viscous solutions and do not represent true equilibrium.

Ethyl Formate	32.5	Ethylene Glycol	44.4
Methyl Acetate	50	Diethylene Glycol	47.3
Ethyl Acetate	43.4	Hexamethylene Glycol	13.5
Ethyl Propionate	67.1	Glycerol	45.6
Ethyl Butyrate	56.9	Ethylene Glycol Monomethyl	
Ethyl C proate	28.6	Ether	59.2
Ethyl Benzoate	6.3	Ethylene Glycol Monoethyl	
Ethyl Phenylacetate	18.42	Ether	54.6
Ethyl Acrylate	12.6	Cyclohexanone	28.5
Methyl Salicylate	2.4	Diethyl Carbonate	8.88
		Isoquinoline	10.5

The validity of these results, which differ considerably from those of Yaffe (1949) has been the subject of some discussion (Yaffe, 1950; Templeton and Hall, 1950). Although Yaffe's data are in different units and at 20°, it is evident that they are very low with respect to those above. The authors conclude that the various solvents must have been of different purity and that the rate of attainment of equilibrium may have been slow. The figures above, therefore, must also be regarded as "practical" solubilities.

Templeton and Hall (1950a) report "total" solubilities of Th(NO<sub>3</sub>)<sub>4</sub> plus other rare earth nitrates in several organic solvents. The degree of "enrichment" in thorium in each case was determined.

100 cc of a saturated solution of thorium nitrate in ethyl ether, prepared by frequent agitation and allowing to stand over night at about 20°, contain 11.22 gms. ThO<sub>2</sub>. A saturated ethereal solution prepared as above but using thorium nitrate dehydrated at 150°, contain only 3.67 gm. TeO<sub>2</sub> per 100 cc. (Wells, 1930.)

A saturated solution of Th(NO<sub>3</sub>)<sub>4</sub>·4H<sub>2</sub>O in tri-n-butyl phosphate at 25 - 27° contains 42.5 wt. % Th(NO<sub>3</sub>)<sub>4</sub>.

THORIUM OXIDE  $\text{ThO}_2$ 

O

THORIUM HYDROXIDE  $\text{Th}(\text{OH})_4$ 

OH

SOLUBILITY OF THORIUM HYDROXIDE IN  $\text{NaOH}$  AND  $\text{HClO}_4$  SOLUTIONS AT  $25^\circ$   
(Gayer and Leider, 1954)

Freshly precipitated  $\text{Th}(\text{OH})_4$  was used.

In Aqueous $\text{NaOH}$		In Aqueous $\text{HClO}_4$	
Initial moles $\text{NaOH}$ per 1000 g. $\text{H}_2\text{O}$	Moles Th per 1000 gms. $\text{H}_2\text{O}$	Initial moles $\text{HClO}_4$ per 1000 g. $\text{H}_2\text{O}$	Moles Th per 1000 gms. $\text{H}_2\text{O}$
0.0098	$1.08 \times 10^{-5}$	0.0203	0.00648
0.0765	$2.42 \times 10^{-5}$	0.0406	0.0148
0.1595	$8.85 \times 10^{-6}$	0.101	0.0404
0.2220	$3.66 \times 10^{-6}$	0.203	0.0980
0.3022	$3.79 \times 10^{-6}$	0.406	0.200
0.3842	$4.93 \times 10^{-7}$	0.811	0.362
0.3950	$5.94 \times 10^{-7}$		
0.4342	$13.8 \times 10^{-7}$		
0.5081	$9.88 \times 10^{-7}$		
0.5257	$4.93 \times 10^{-7}$		
0.6307	$8.92 \times 10^{-7}$		
0.7023	$9.86 \times 10^{-7}$		
0.8650	$12.9 \times 10^{-7}$		

Korenman gives the  $K_{sp}$  of  $\text{Th}(\text{OH})_4$  as  $4 \times 10^{-45}$ ; Oka, 1940 found the solubility to be  $3.6 \times 10^{-9}$  moles per liter.

SOLUBILI THORIUM OXIDE IN VARIOUS AQUEOUS SOLUTIONS AT  $25^\circ$   
(Spitzer, 1917)

Aq. solvent	Gm. $\text{ThO}_2$ per liter	Aq. solvent	Gm. $\text{ThO}_2$ per liter
Water	less than 0.00002	Aq. 0.8 n $\text{C}_4\text{H}_8\text{O}_4$	0.0003
Aq. 1.0n $\text{K}_2\text{CO}_3$	less than 0.00002	Aq. 1.0n $\text{HCl}$	0.0005
Aq. 1.0n $\text{Na}_2\text{CO}_3$	less than 0.00003	Aq. 1.0n $\text{HNO}_3$	0.0006
Aq. 1.0n $\text{NaOH}$	less than 0.00005	Aq. 1.0n $\text{H}_2\text{SO}_4$	0.0020



# Th THORIUM

## PO THORIUM PHOSPHATES

### THE SYSTEM THORIUM OXIDE - PHOSPHORIC ACID - WATER AT 25° (D'Ans and Dawihl, 1929)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
P <sub>2</sub> O <sub>5</sub>	ThO <sub>2</sub>		P <sub>2</sub> O <sub>5</sub>	ThO <sub>2</sub>	
4.5	trace	Th <sub>3</sub> (PO <sub>4</sub> ) <sub>4</sub>	30	5.0	1.2.2
9.61	0.1	"	46.1	9.34	"
16.0	0.2	"	49.0	13.3	"
20.0	0.5 (?)	" + Th(HPO <sub>4</sub> ) <sub>2</sub> ·H <sub>2</sub> O	50.8	19.1	"
27.1	3.3	Th(HPO <sub>4</sub> ) <sub>2</sub> ·H <sub>2</sub> O	52.0	19.8	"
43.0 (?)	22.0m	"			

m = metastable

1.2.2 = ThHPO<sub>4</sub>·2H<sub>2</sub>PO<sub>4</sub>·2H<sub>2</sub>O

### SOLUBILITY PRODUCT CONSTANTS (Chukhlantsev and Stepanov, 1956)

$$\begin{aligned}
 [\text{Th}^{+4}]^3 [\text{PO}_4^{=}]^2 &= 2.57 \times 10^{-79} \text{ (pH calculations)} \\
 &= 2.46 \times 10^{-58} \text{ (radiophosphorous tracer)} \\
 [\text{Th}^{+4}] [\text{HPO}_4^{=}]^2 &= 9.2 \times 10^{-22} \text{ (pH calculations)} \\
 &= 1.19 \times 10^{-20} \text{ (radiophosphorous tracer)}
 \end{aligned}$$

Th<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> is 24% soluble in 10% H<sub>2</sub>SO<sub>4</sub>. (Atanasiv and Babor, 1938.)

D'Ans and Dawihl, 1929, give the following results for solutions simultaneously saturated with thorium phosphate sulphate and thorium sulfate on the one hand and with thorium phosphate on the other at 45°.

Gms. per 100 gms. sat. sol.			Solid Phase
ThO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	SO <sub>3</sub>	
0.59	0.72	13.0	Th(SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O + ThSO <sub>4</sub> ·HPO <sub>4</sub> ·4H <sub>2</sub> O
0.71	0.73	15.1	" + "
0.65	0.77	21.4	" + "
0.26	2.1	6.29	Th <sub>3</sub> (PO <sub>4</sub> ) <sub>4</sub> + "
2.5	6.8	10.8	" + "
2.9	7.6	11.2	" + "

THORIUM PYROPHOSPHATE  $\text{ThP}_2\text{O}_7$ 

P0

SOLUBILITY IN DILUTE HYDROCHLORIC ACID SOLUTIONS AT 20°  
(Moeller and Schweitzer, 1948)

Radioactive  $\text{P}_2\text{O}_7^{-4}$  was added to an excess of  $\text{Th}^{+4}$  and the precipitated  $\text{ThP}_2\text{O}_7$  was washed and dried. Samples were shaken with acid for 36 hours and then filtered off. The radioactive count in solution was taken as a measure of the solubility. The data below were read from the curve given by the authors.

Normality of HCl:	0.10	0.20	0.30
Moles $\text{ThP}_2\text{O}_7$ per liter:	$2.2 \times 10^{-5}$	$3.5 \times 10^{-5}$	$5.0 \times 10^{-5}$

THORIUM HYPOPHOSPHATE  $\text{ThP}_2\text{O}_6$ 

P0

SOLUBILITY IN AQUEOUS HYDROCHLORIC ACID SOLUTIONS AT 25°  
(Moeller and Quinty, 1952)

Normality of HCl:	1.00	2.00	4.00	6.00
Moles $\text{ThP}_2\text{O}_6$ per liter	0.000025	0.000047	0.000165	0.000210

SOLUBILITY OF THORIUM HYPOPHOSPHATE IN VARIOUS SOLUTIONS AT 25°  
(Spitzer, 1917)

## Solid phase Th

Aq. Solvent	Gm. $\text{ThO}_2$ per liter	Aq. Solvent	Gm. $\text{ThO}_2$ per liter
Aq. 1.0 n $\text{HNO}_3$	0.012	Aq. 1.0 n $\text{H}_2\text{SO}_4$	0.053
Aq. 1.0 n HCl	0.024	Aq. 1.0 n $\text{K}_2\text{CO}_3$	0.250

THORIUM SULFATE  $\text{Th}(\text{SO}_4)_2$ 

S0

SOLUBILITY IN WATER  
(Roozeboom, 1890; Demarcay, 1883)

t°	Gms. $\text{Th}(\text{SO}_4)_2$ per 100 Gms. $\text{H}_2\text{O}$		Solid Phase
0	0.74 (R)	0.88 (D)	$\text{Th}(\text{SO}_4)_2 \cdot 9\text{H}_2\text{O}$
10	0.98	1.02	"
20	1.38	1.25	"
30	1.995	1.85	"
40	2.998	2.83	"
50	5.22 (51°)	4.86	"
55	6.76	6.5±	"
0	1.0		$\text{Th}(\text{SO}_4)_2 \cdot 8\text{H}_2\text{O}$
	(Cont.)		

## Th THORIUM

## SOLUBILITY IN WATER--Cont.

R = Roozeboom, 1890      D = Demarcay, 1883

t°	Gms. Th(SO <sub>4</sub> ) <sub>2</sub> per 100 gms. H <sub>2</sub> O		Solid Phase
15	1.38		Th(SO <sub>4</sub> ) <sub>2</sub> ·8H <sub>2</sub> O
25	1.85		"
30	2.4 <sup>a</sup>		"
44	3.71		"
0	1.50 (R)		Th(SO <sub>4</sub> ) <sub>2</sub> ·6H <sub>2</sub> O
15	1.63		"
30	2.45		"
45	3.85		"
60	6.64		"
17		9.41 (D)	Th(SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
40	4.04 (R)	4.5 (35°D)	"
50	2.54	1.94 (55°)	"
60	1.63	-	"
70	1.09	1.32 (75°)	"
95	-	0.71	"

Additional results for the 8H<sub>2</sub>O and the 9H<sub>2</sub>O salt, in fair agreement with the above, are given by Wyruboff (1901).

<sup>a</sup>Caven, 1932

## SOLUBILITY OF THORIUM SULFATE IN AQUEOUS SOLUTIONS OF SULFURIC ACID

Results at 25°

(Data of Wirth, 1912)			(Data of Barre, 1912)	
Normality of Aq. H <sub>2</sub> SO <sub>4</sub>	Gms. Th(SO <sub>4</sub> ) <sub>2</sub> per 100 Gms. Sat. Sol.		Gms. per 100 Gms. H <sub>2</sub> O	
		Solid Phase	H <sub>2</sub> SO <sub>4</sub>	Th(SO <sub>4</sub> ) <sub>2</sub>
0	1.593	Th(SO <sub>4</sub> ) <sub>2</sub> ·9H <sub>2</sub> O	0	1.722
1.1	1.831	"	1.072	1.919
2.16	1.488	"	1.941	2.017
4.32	0.8751	"	2.821	2.060
6.68	0.4312	"	3.843	2.061
9.68	0.1045	Th(SO <sub>4</sub> ) <sub>2</sub> ·8H <sub>2</sub> O	5.212	2.035
10.89	0.0636	"	8.055	1.863
15.15	0.0308	Th(SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O	10.105	1.702

## SOLUBILITY OF THORIUM SULFATE IN AQUEOUS SOLUTIONS OF SULFURIC ACID--Cont.

Results at 30°

(Koppel and Holtkamp, 1910)

Gms.			Gms.		
Wt. %	Th(SO <sub>4</sub> ) <sub>2</sub>		Wt. %	Th(SO <sub>4</sub> ) <sub>2</sub>	
H <sub>2</sub> SO <sub>4</sub>	per 100		H <sub>2</sub> SO <sub>4</sub>	per 100	
Solvent	Gms.	Solid Phase	Solvent	Gms.	Solid Phase
Sat. Sol.			Sat. Sol.		
0	2.152	Th(SO <sub>4</sub> ) <sub>2</sub> ·8H <sub>2</sub> O	15.03	1.484	Th(SO <sub>4</sub> ) <sub>2</sub> ·8H <sub>2</sub> O
0.466	2.055	"	23.64	0.7196	"
0.72	2.085	"	32.68	0.3364	"
1.468	2.267	"	37.80	0.0777	Th(SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
2.983	2.311	"	43.28	0.0213	"
4.38	2.367	"	45.69	0.0047	"
4.97	2.323	"	74	0.1208	"
9.95	1.961	"	80.5	0	"

Results at 20° and at the Boiling Point

(Koppel and Holtkamp, 1910)

t°	Wt. % H <sub>2</sub> SO <sub>4</sub> in Solvent	Gms. Th(SO <sub>4</sub> ) <sub>2</sub> per 100 Gms. Sat. Sol.	Solid Phase
20	5	1.722	Th(SO <sub>4</sub> ) <sub>2</sub> ·8H <sub>2</sub> O
20	15	0.9752	"
20	25	0.3838	"
20	40	0.0103	Th(SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
b. pt.	5	0.7407	Th(SO <sub>4</sub> ) <sub>2</sub> ·8H <sub>2</sub> O
b. pt.	10	0.4808	"
b. pt.	15	0.3882	"

SOLUBILITY OF THORIUM SULFATE IN AQUEOUS SOLUTIONS OF HYDROCHLORIC  
ACID AND OF NITRIC ACID AT 30°

(Koppel and Holtkamp, 1910)

In Aq. Hydrochloric AcidIn Aq. Nitric Acid

Gms. Th(SO <sub>4</sub> ) <sub>2</sub> per 100 Gms. Sat. Sol.			Gms. Th(SO <sub>4</sub> ) <sub>2</sub> per 100 Gms. Sat. Sol.		
Wt. % HCl in Solvent	Sat. Sol.	Solid Phase	Wt. % HCl in Solvent	Sat. Sol.	Solid Phase
0	2.15	Th(SO <sub>4</sub> ) <sub>2</sub> ·8H <sub>2</sub> O	0	2.15	Th(SO <sub>4</sub> ) <sub>2</sub> ·8H <sub>2</sub> O
4.55	3.541	"	5.17	3.68	"
6.95	3.431	"	10.04	4.20	"
12.14	2.811	"	16.68	4.84	"
15.71	2.360	"	21.99	4.47	"
18.33	2.199	"	28.33	3.96	"
20	2.110	Th(SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O	28.51	3.88	"
20	2.141	"	33.17	3.34	Th(SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
23.9	1.277	"	38.82	2.51	"

# Th THORIUM

## SOLUBILITY OF THORIUM SULFATE IN AQUEOUS SOLUTIONS OF POTASSIUM SULFATE (Barre, 1911)

Results at 16°			Results at 75°		
Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 Gms. H <sub>2</sub> O		
K <sub>2</sub> SO <sub>4</sub>	Th(SO <sub>4</sub> ) <sub>2</sub>		K <sub>2</sub> SO <sub>4</sub>	Th(SO <sub>4</sub> ) <sub>2</sub>	
0	1.39	Th(SO <sub>4</sub> ) <sub>2</sub> ·9H <sub>2</sub> O	0	0.9248	
0.424	1.667	Th(SO <sub>4</sub> ) <sub>2</sub> ·K <sub>2</sub> SO <sub>4</sub> ·4H <sub>2</sub> O	0.865	1.137	
1.004	2.193	"	1.167	1.173	
1.152	3.191	"	1.172	1.121	
1.224	2.514	"	1.270	0.907	
1.283	2.222	"	1.296	0.495	
1.348	1.706	"	1.852	0.297	
1.378	1.637	Th(SO <sub>4</sub> ) <sub>2</sub> ·2K <sub>2</sub> SO <sub>4</sub> ·2H <sub>2</sub> O	3.117	0.201	
1.487	0.870	"	4.659	0.256	
1.844	0.370	"	5.348	0.170	
3.092	0.070	"	5.932	0.123	
5.040	0.027	Th(SO <sub>4</sub> ) <sub>2</sub> ·3 <sup>1</sup> / <sub>2</sub> K <sub>2</sub> SO <sub>4</sub>	7.177	0.031	
4.825	0.003	"	9.706	0.022	

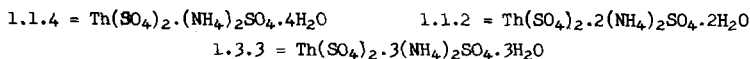
## SOLUBILITY OF THORIUM SULFATE IN AQUEOUS SOLUTIONS OF:

### Ammonium Sulfate at 16° (Barre, 1911)

Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Th(SO <sub>4</sub> ) <sub>2</sub>	
2.13	3.361	Th(SO <sub>4</sub> ) <sub>2</sub> ·9H <sub>2</sub> O
4.80	5.269	"
10.02	8.947	"
16.56	13.330	" + 1.1.4
28	10.359	1.1.4
35.20	9.821	" + 1.2.2
45.14	6.592	1.2.2
49.05	5.750	"
52.88	4.583	1.3.3
69.74	1.653	"

### Lithium Sulfate at 25° (Barre, 1912)

Gms. per 100 Gms. H <sub>2</sub> O	
Li <sub>2</sub> SO <sub>4</sub>	Th(SO <sub>4</sub> ) <sub>2</sub>
0	1.722
2.57	4.13
4.93	6.20
6.98	7.95
9.23	9.68
11.13	11.05
13.18	12.54
16.12	14.52
20.49	16.92
25.18	18.87



More recent determinations upon the system thorium sulfate, ammonium sulfate and water at 25° by Rosenheim and Zickermann, 1932, will be found under ammonium sulfate.

(Cont'd)

Sodium Sulfate at 16°  
(Barre, 1910, 1911)

Solid Phase  $\text{Th}(\text{SO}_4)_2 \cdot \text{Na}_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$  throughout.

Gms. per 100 Gms. $\text{H}_2\text{O}$		Gms. per 100 Gms. $\text{H}_2\text{O}$	
$\text{Na}_2\text{SO}_4$	$\text{Th}(\text{SO}_4)_2$	$\text{Na}_2\text{SO}_4$	$\text{Th}(\text{SO}_4)_2$
1.094	1.743	5.79	2.136
1.960	2.387	9.35	1.379
2.98	3.962	12.24	1.169
4.11	3.375	15.36	1.048

THORIUM THALLIUM SULFATE  $2\text{Th}(\text{SO}_4)_2 \cdot 7\text{Tl}_2\text{SO}_4 \cdot 3\text{H}_2\text{O}$

SO

SOLUBILITY OF THORIUM THALLIUM SULFATE IN WATER  
(Fernandez, 1925)

t°	Gm. $\text{ThO}_2$ per 100 cc. $\text{H}_2\text{O}$	t°	Gm. $\text{ThO}_2$ per 100 cc. $\text{H}_2\text{O}$	t°	Gm. $\text{ThO}_2$ per 100 cc. $\text{H}_2\text{O}$
0	0.280	40	0.584	80	0.712
10	0.340	50	0.658	90	0.690
20	0.415	60	0.696	100	0.630
30	0.500	70	0.714		

SOLUBILITY OF ANHYDROUS THORIUM SULFATE IN PURE METHYL ALCOHOL  
(Gibson, Driscoll and Jones, 1929)

t°	Gms. $\text{Th}(\text{SO}_4)_2$ per 100 gms. $\text{CH}_3\text{OH}$
15	0.029
25	0.024
35	0.019
45	0.014
55	0.010

THORIUM SELENITE  $\text{Th}(\text{SeO}_3)_2$

SeO

The Ksp is  $1.35 \times 10^{-20}$ . (Krylov and Chukhlantsev, 1957.)

THORIUM SELENATE  $\text{Th}(\text{SeO}_4)_2 \cdot 9\text{H}_2\text{O}$

SeO

100 gms.  $\text{H}_2\text{O}$  dissolve 0.498 gm.  $\text{Th}(\text{SeO}_4)_4$  at 0° and 1.972 gms. at 100°. (Cleve, 1885.)

## Ti TITANIUM

## Ti TITANIUM

The percentage of titanium in mercury at 20°, determined by filtering an amalgam of the metal through a sintered glass filter, was found by Irvin and Russell, 1932, to be less than  $1 \times 10^{-5}$ .

A review of the solubility of various metals and non-metals in titanium is given by Kornilov, 1954.

The systems Ti-C, Ti-N, Ti-B and Ti-Be were studied by Ehrlich, 1949.

## Br TITANIUM TETRABROMIDE

Determinations of the reciprocal solubility of titanium tetrabromide and sulfur dioxide, determined by the synthetic method, are given by Bond and Crone, 1934.

## CH TITANIUM SALICYLATES

(Results of Sudarikov and Smirnov, 1956 at 20°)

A = titanium sodium salicylate  $\text{Ti}(\text{HOC}_6\text{H}_4\text{COO})_2 \cdot \text{Na}(\text{HOC}_6\text{H}_4\text{COO}) \cdot 3\text{H}_2\text{O}$

B = titanium ammonium salicylate  $\text{Ti}(\text{HOC}_6\text{H}_4\text{COO})_2 \cdot \text{NH}_4(\text{HOC}_6\text{H}_4\text{COO}) \cdot 3\text{H}_2\text{O}$

Salt	Solvent	Gms. Ti per liter	Salt	Solvent	Gms. Ti per liter
A	H <sub>2</sub> O	0.50	B	NH <sub>4</sub> salicylate	0.72
A	Na salicylate (50 g./l.)	2.54	B	100 g./l.	
B	NH <sub>4</sub> NO <sub>3</sub> 500 g./l.	0.01	B	" 50 g./l.	0.42
			B	Ethanol	16.62
			B	Acetone	0.93

## Cl TITANIUM TETRACHLORIDE $\text{TiCl}_4$

100 gms. sat. solution of titanium tetrachloride in selenium oxychloride ( $\text{SeOCl}_2$ ) contains 0.75 gm.  $\text{TiCl}_4$  at 25°. (Wise, 1923.)

Melting point data are given for  $\text{TiCl}_4$  and the following:

Naphthalene (1), propionitrile (2)(6), benzonitrile (2)(6), p-tolunitrile (2), trinitrotoluene (3), nitrobenzene (4), chlorobenzene (4), o-nitrotoluene (4), bromobenzene (4), 1,3,4 nitroxytol (4), m-dinitrobenzene (4)(6), m-dinitrotoluene (4), trinitrotoluene (4), carbon tetrachloride (5), sulfur dioxide (7), methyl acetate (8), ethyl acetate (8), propyl acetate (8), butyl acetate (8), isobutyl acetate (8), isoamyl acetate (8), ethyl formate (8), butyl formate (8), isobutyl

formate, isoamyl formate (8), n-butyl chloroacetate (8), isobutyl chloroacetate (8), isoamyl chloroacetate (8), ethyl propionate (8), ethylbutyrate (8).

(1) Pushin, 1948a, (2) Pushin, Ristic, Parchmenko, and Ubovic, 1942, (3) Pushin, et al., 1947, (4) Pushin, Nikolic, Radojein, and Voropcnova, 1942, (5) Nasu, 1933, (6) Herzel and Demmer, 1932, (7) Bond and Stephens, 1929, (8) Lysenko, Osipov and Akopov, 1956.

Melting point data are given for:

$TiCl_4 + MgCl_2$	(Komarek and Herasymenko, 1958)
$TiCl_4 + FeCl_3$	(Saheki and Funaki, 1957) (Morozov and Toptygin, 1957)
$TiCl_4 + NaCl$	(Komarek and Herasymenko, 1958a)
$TiCl_4 + FeCl_3 + NaCl$	(Morozov and Toptygin, 1957)
$TiCl_4 + FeCl_3 + AlCl_3$	(Morozov and Toptygin, 1957)
$TiCl_4 + CH_3Cl, + CH_2Cl_2, + CHCl_3, + C_2H_5Cl,$	(Lefgworth,
$+ i-C_3H_7Cl, + C_2H_4Cl_2$	Plesch and Rigbi, 1958)
$TiCl_4 + CCl_4$	(Sackmann, 1955)

#### TITANIUM POTASSIUM HEXAFLUORIDE $TiK_2F_6$

F

100 cc. sat. solution of titanium potassium hexa fluoride in aq. 0.125 n hydrofluoric acid contain 0.0483 gm. mols.  $TiK_2F_6$  at 20°. (V. Hevesy, Christiansen and Berglund, 1925.)

#### TITANIUM DIOXIDE $TiO_2$

0

Mironov and Odnosevtsev, 1957, estimate the  $K_{sp}$  of  $Ti(OH)_4$  to be  $7.94 \times 10^{-54}$  by potentiometric titrations.

#### THE SYSTEM TITANIUM DIOXIDE - SULFURIC ACID - WATER AT 25° (Reinders and Kies, 1940)

This system was studied further by Pamfilov and Khudyakova, 1949. Only the dehydrate could be isolated with certainty.

Gms. per 100 gms. Sat. Sol.			Gms. per 100 gms. Sat. Sol.		
$H_2SO_4$	$TiO_2$	Solid Phase	$H_2SO_4$	$TiO_2$	Solid Phase
10.2	0.54	$TiO_2 \cdot nH_2O$	38.1	3.1	$TiO_2 \cdot nH_2O + TiO_2 \cdot SO_3 \cdot 2H_2O$
19.2	0.44	"	41.4	2.09	$TiO_2 \cdot SO_3 \cdot 2H_2O$
34.4	2.26	"	44.6	0.90	"
32.6	26.7m	$TiO_2 \cdot SO_3 \cdot 2H_2O$	50.1	.09	"
32.6	22.9m	"	61.1	.04	"
32.4	12.6m	"	70.2	.57	"
33.9	8.6m	"	77.4	5.1	"
			78.3	10.4	"

m = metastable



## Tl THALLIUM

The system was studied at 100° by Sagawa (quoted by Reinders and Kies), 1936 who found the stable solid phases to be  $\text{TiO}_2 \cdot n\text{H}_2\text{O}$ ,  $\text{TiO}_2 \cdot \text{SO}_3 \cdot \text{H}_2\text{O}$ ,  $2\text{TiO}_2 \cdot 3\text{SO}_3 \cdot 5\text{H}_2\text{O}$ ,  $\text{TiO}_2 \cdot 4\text{SO}_3 \cdot 4.5\text{H}_2\text{O}$ , and  $\text{TiO}_2 \cdot 4\text{SO}_3 \cdot 2\text{H}_2\text{O}$ . The saturated solution in equilibrium with  $\text{TiO}_2 \cdot n\text{H}_2\text{O}$  and  $\text{TiO}_2 \cdot \text{SO}_3 \cdot \text{H}_2\text{O}$  contains 0.32%  $\text{TiO}_2$  and 41.9%  $\text{H}_2\text{SO}_4$ .

### SOLUBILITY OF TITANIUM OXIDE IN AQUEOUS SOLUTION OF ALKALIS (Auger, 1923)

The temperature is not stated and the manner in which the determinations were made is not clearly described.

Solvent	Gm. $\text{TiO}_2$ per liter	Solvent	Gm. $\text{TiO}_2$ per liter
Aq. 10 % NaOH	0.02-0.025	Aq. 12 % $\text{KHCO}_3$	0.50
Aq. 36 % NaOH	0.06-0.10	Aq. 25 % $\text{KHCO}_3$	2.75
Aq. 10 % KOH	0.30-0.45	Aq. saturated $\text{KHCO}_3$	7.00
Aq. 10 % KOH	0.70-0.90	Aq. 30 % $\text{K}_2\text{CO}_3$	0.02
Aq. 10 % $\text{NaHCO}_3$	0.25	Aq. saturated $\text{K}_2\text{CO}_3$	0.30

Data for the system  $\text{TiO}_2 - \text{H}_2\text{O} - \text{NaCl}$  showing the formation of  $\text{H}_2\text{TiO}_3$  and  $\text{H}_2\text{Ti}_2\text{O}_5$  are given by Kasimov, 1956.

6.9%  $\text{TiO}_2$  dissolve in cryolite at 1000°C. (Hayakawa and Kido, 1952.)

## BO THALLIUM BORATES $\text{TlBO}_2$ , $\text{Tl}_3\text{BO}_2$ and $\text{Tl}_4\text{B}_2\text{O}_5$

Freezing-point data, for the system  $\text{Tl}_2\text{O} + \text{B}_2\text{O}_3$ , which show the formation of the above three compounds are given by Canneri and Morelli, 1922.

## Br THALLIUM BROMIDE $\text{TlBr}$

### SOLUBILITY OF THALLIUM BROMIDE IN WATER

The results of Kohlrausch, 1908; Noyes, 1890; and Osborg, 1926, were plotted and the following results taken from the curve. The results above 100° are by Benrath, Gjeddebo, Schiffers and Wunderlich, 1937.

t°	Gms. $\text{TlBr}$ per liter sat. sol.	Solid Phase	t°	Gms. $\text{TlBr}$ per liter sat. sol.	Solid Phase
0	0.22	$\text{TlBr}$	162	1.73	$\text{TlBr}$
10	0.32	"	215	3.09	"
20	0.48	"	258	4.45	"
25	0.57	"	269	6.2	"
30	0.68	"	294	7.27	"
40	0.97	"	414	85.5	"
50	1.32	"	421	92.0	"
70	2.50	"	457m.pt.	100.0	"

SOLUBILITY OF THALLIUM BROMIDE IN AQUEOUS SALT SOLUTIONS AT 20°  
(Sirucek and Viktorin, 1939)

- Moles TlBr per 1000 gms. of Water  $\times 10^3$  -

Moles Salt per 1000 gms. of Water	NaNO <sub>3</sub>	Ba(NO <sub>3</sub> ) <sub>2</sub>	K <sub>2</sub> SO <sub>4</sub>	Mg.(C <sub>6</sub> H <sub>5</sub> SO <sub>3</sub> ) <sub>2</sub>	Br
0.0	1.6465	1.644 <sup>a</sup>	-	-	
.002	-	-	1.719	-	
.0025	1.685	-	-	1.726	
.005	1.717	1.788	-	1.775	
.01	1.755	1.868	1.874	1.847	
.02	1.827	1.967	-	-	
.03	1.881	2.042	2.069	1.985	
.05	-	2.160	-	2.071	
.1	2.130	-	-	-	
.15	2.265	-	-	-	

<sup>a</sup>Böttger, 1903

Moles Salt per 1000 gms. of Water	MgSO <sub>4</sub>	p-ClC <sub>6</sub> H <sub>4</sub> SO <sub>3</sub> Na	Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	Tl <sub>2</sub> SO <sub>4</sub>
0.001	-	-	-	-	0.961
.002	1.738	-	-	1.737	-
.0024	-	-	1.826	-	-
.003	-	-	-	-	0.484
.0042	-	-	1.887	-	-
.005	1.820	-	-	1.822	-
.0075	1.863	-	-	1.884	-
.008	-	-	1.736	-	0.232
.01	1.907	-	2.025	1.923	-
.02	2.027	-	-	2.065	-
.025	-	1.820	-	-	-
.04	2.180	-	-	-	-
.05	-	-	-	2.345	-
.053	-	1.905	-	-	-
.09	-	1.983	-	-	-
.1	-	2.019	-	-	-
.15	-	2.080	-	-	-

SOLUBILITY OF THALLOUS BROMIDE IN AQUEOUS SOLUTIONS AT 25°  
(Keefer and Reiber, 1941a)

Results are expressed in Moles per 1000 gms. H<sub>2</sub>O.

KNO <sub>3</sub>	TlBr	Alanine	TlBr	Glycine	KNO <sub>3</sub>	TlBr
0.0	2.013 $\times 10^{-3}$	0.0249	2.033 $\times 10^{-3}$	0.0249	-	2.032 $\times 10^{-3}$
0.00502	2.100	.0498	2.052	.0499	-	2.059
.01003	2.163	.0749	2.070	.0500	0.05035	2.480
.01505	2.207	.1000	2.090	.0501	.1009	2.674
.02008	2.250	-	-	.0750	-	2.078
.02510	2.287	-	-	.1001	-	2.105
.05025	2.432	-	-	.1003	.0505	2.522
.07545	2.543	-	-	.1004	.1011	2.718
.1007	2.637	-	-	.1504	-	2.145
				.2010	-	2.193

# TI THALLIUM

## SOLUBILITY OF THALLIUM BROMIDE IN AQUEOUS SOLUTIONS OF THALLIUM NITRATE AT 68.5° (Noyes, 1890)

Gms. Mols. per Liter		Gms. per Liter	
TlNO <sub>3</sub>	TlBr	TlNO <sub>3</sub>	TlBr
0	0.00869	0	2.469
0.0163	0.00410	4.336	2.469
0.0294	0.00289	7.820	0.821
0.0955	0.00148	25.400	0.420

100 gms. liquid sulfur dioxide (SO<sub>2</sub>) dissolve 0.017 gm. TlBr at 0°. Br (Jander and Ruppolt, 1937.)

Freezing-point data for mixtures of TlBr + TlCl, TlBr + TlI and TlCl + TlI are given by Monkemeyer (1906). Results for TlCl + SnCl<sub>2</sub> and TlCl + ZnCl<sub>2</sub> are given by Korreng (1914). Results for TlBr + TlNO<sub>3</sub> are given by Rostkowsky (1929). For TlBr + ZnSO<sub>4</sub> see Luzhnaya and Vereshchetina (1956).

Data for TlBr - TlCl also see Favorskii, 1940. For TlCl + TlI see Tutte and Egli, 1946.

## Br THALLI-THALLO BROMIDES TlBr, TlBr<sub>2</sub>, [TlBr<sub>6</sub>]Tl<sub>3</sub>, [TlBr<sub>4</sub>]Tl

### SOLUBILITY OF THALLI-THALLO BROMIDES IN WATER (Benrath, 1924)

Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
TlBr <sub>3</sub>	TlBr		TlBr <sub>3</sub>	TlBr	
Results at 30°			Results at 50°		
0.0	0.073	TlBr(white)	0.0	0.159	TlBr(white)
0.233	0.91	"	0.478	0.210	"
1.147	0.204	"	0.651	0.251	"
1.556	0.272	"	0.934	0.285	"
1.990	0.356	[TlBr <sub>6</sub> ]Tl <sub>3</sub> (red)	1.352	0.398	"
2.293	0.315	"	1.695	0.500	"
2.851	0.380	"	1.701	0.542	"
3.490	0.379	"	1.992	0.670	"
3.865	0.448	"	2.351	0.669	[TlBr <sub>6</sub> ]Tl <sub>3</sub> (red)
4.163	0.435	[TlBr <sub>4</sub> ]Tl(yellow)	3.082	0.680	"
5.062	0.425	"	3.591	0.738	"
6.980	0.415	"	4.110	0.879	"
9.241	0.403	"	4.251	0.926	[TlBr <sub>4</sub> ]Tl(yellow)
11.917	0.349	"	4.763	0.901	"
14.596	0.364	"	5.286	0.891	"
15.721	0.389	"	6.632	0.880	"
			8.511	0.874	"
			10.256	0.883	"
			13.056	0.851	"
			15.554	0.941	" (Cont.)

## SOLUBILITY OF THALLI-THALLO BROMIDES IN WATER--Cont.

Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
TlBr <sub>3</sub>	TlBr		TlBr <sub>3</sub>	TlBr	
<u>Results at 80°</u>					
6.020	2.801	TlBr(white)	8.234	3.741	TlBr(white)
6.211	2.972	[TlBr <sub>6</sub> ]Tl <sub>3</sub> (red)	8.980	4.520	[TlBr <sub>6</sub> ]Tl <sub>3</sub> (red)
7.515	3.250	"	9.54	4.995	[TlBr <sub>4</sub> ]Ti(yellow)
8.014	3.193	[TlBr <sub>4</sub> ]Ti(yellow)			

TlBr - TlI mixed crystals in the mole ratio 44:56 dissolve in water to the extent of 0.05 gm./100 ml. (Greenland, 1952.)

THALLIUM BROMATE TlBrO<sub>3</sub>

BrO

## SOLUBILITY IN WATER

t°	Gms. TlBrO <sub>3</sub> per liter Sat. Sol.	Reference
19.9	3.463	Noyes and Abbot, 1895
20	3.303	Gross and Kahn, 1955
25	4.034	Suzuki, 1952
39.75	7.355	Noyes and Abbot, 1895

SOLUBILITY OF THALLIUM BROMIDE IN AQUEOUS SALT SOLUTIONS AT 25°  
(Suzuki, 1952)Moles TlBrO<sub>3</sub> per liter

Moles salt per liter of solvent	KNO <sub>3</sub> added	TlNO <sub>3</sub>	KBrO <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>	Ba(NO <sub>3</sub> ) <sub>2</sub>	Tl <sub>2</sub> SO <sub>4</sub>
0.0	0.01215	-	-	-	-	-
0.01	0.01270	0.00849	0.00845	0.01366	0.01368	0.00685
0.02	0.01315	0.00641	0.00640	0.01472	0.01448	0.00476
0.05	0.01410	0.00367	0.00364	0.01688	0.01658	0.00176
0.1	0.01540	0.00233	0.00278	0.01948	0.01800	0.00204
0.2	0.01738	0.00152	0.00139	0.02280	0.02140	-
0.5	0.02138	-	-	0.02955	-	-
1.0	0.02778	-	-	-	-	-

## TI THALLIUM

### SOLUBILITY OF $\text{TlBrO}_3$ IN AQUEOUS SOLUTIONS OF ORGANIC SOLVENTS AT 20° (Gross and Kahn, 1955)

Moles per Liter		Moles per Liter		Moles per Liter		Moles per Liter	
Ethanol	$\text{TlBrO}_3$	Acetone	$\text{TlBrO}_3$	Urea	$\text{TlBrO}_3$	Glykokoll	$\text{TlBrO}_3$
0.0	0.009951	0.146	0.009681	0.100	0.01010	0.0322	0.01007
0.086	0.009767	0.297	0.009384	0.201	0.0123	0.0642	0.01022
0.173	0.009588	0.838	0.008388	0.301	0.0138	0.0963	0.01038
0.341	0.009253						

## CH THALLIUM FORMATE $\text{TlCO}_2\text{H}$

Freezing point data and the solubility of thallium formate in water up to 60° are reported by Taft and Horsley, 1942. The densities, conductivities, viscosities, and surface tensions of dilute solutions were also determined.

## THALLIUM METHIONATE $\text{Ti}_2[\text{CH}_2(\text{SO}_3)_2]$

100 gms.  $\text{H}_2\text{O}$  dissolve 6.42 gms.  $\text{Ti}_2[\text{CH}_2(\text{SO}_3)_2]$  at 25°. (Backer and Terpstra, 1929.)

## THALLIUM CHLORMETHIONATE $\text{Ti}_2\text{CH}_3\text{Cl}(\text{SO}_3)_2$

100 gms.  $\text{H}_2\text{O}$  dissolve 0.1438 gm. mols.  $\text{Ti}_2\text{CH}_3\text{Cl}(\text{SO}_3)_2$  at 25°. (Backer, 1930.)

## THALLOUS METHOXIOE AND ETHOXIDE

### SOLUBILITY OF EACH SEPARATELY IN ALCOHOL AND BENZENE AT 25° (Sidgwick and Sutton, 1930)

Compound	Formula	Solvent	Gms. Compound per 100 gms. solvent
Thallos methoxide	$\text{TlOCH}_3$	$\text{CH}_3\text{OH}$	1.703
Thallos methoxide	$\text{TlOCH}_3$	$\text{C}_6\text{H}_6$	3.160
Thallos ethoxide	$\text{TlOC}_2\text{H}_5$	$\text{C}_2\text{H}_5\text{OH}$	9.108

Results for the solubility of several thallium derivatives of beta-di ketones and beta ketonic esters in n hexane at 27° are given by Menzies and Walker, 1936.

THALLIUM ACETATE  $\text{TlCH}_3\text{COO}$ 

CH

100 gms. liquid sulfur dioxide ( $\text{SO}_2$ ) dissolve 7.5 gms.  $\text{TlCH}_3\text{COO}$  at  $0^\circ$ .

THALLIUM TRIFLUOROACETATE  $\text{CF}_3\text{COOTl}$ 

SOLUBILITY IN VARIOUS SOLVENTS  
(Swarts, 1939)

Water	$20.5^\circ$	86.7% (d. $\approx 2.85$ )
alcohol	$20^\circ$	88%
benzene	$16^\circ$	1.6%
	$59.6^\circ$	2 liquids + 1 solid in equilibrium
	$60^\circ$	$\left\{ \begin{array}{l} \text{liquid I} = 83.3\% \text{ CF}_3\text{COOTl} \\ \text{liquid II} = 9.7\% \text{ CF}_3\text{COOTl} \end{array} \right.$

THALLIUM HYDROGEN TARTRATE  $\text{TlHC}_4\text{H}_4\text{O}_6$ 

SOLUBILITY OF THALLOUS HYDROGEN TARTRATE IN  
AQUEOUS UREA AND DIOXANE SOLUTIONS  
(Pedersen, 1941)

In Aqueous Dioxane at $18.00^\circ$		In Aqueous Urea at $17.85^\circ$	
Moles Dioxane per liter of Solvent	Moles $\text{TlHC}_4\text{H}_4\text{O}_6$ per liter Sat. Sol.	Moles Urea per liter of Solvent	Moles $\text{TlHC}_4\text{H}_4\text{O}_6$ per liter Sat. Sol.
0.000	0.02480	0.000	0.02471
.200	.02357	.250	.02580
.400	.02233	.500	.02693
.600	.02114	.750	.02809
.800	.02001	1.000	.02927

# TI THALLIUM

## CH THALLIUM MANDELATE (Racemic) $\text{TlC}_8\text{H}_7\text{O}_3$

THE SYSTEM RACEMIC THALLIUM MANDELATE - RACEMIC MANDELIC  
ACID - WATER AT 25°  
(Rose and Morrison, 1956)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{C}_8\text{H}_8\text{O}_3$	$\text{TlC}_8\text{H}_7\text{O}_3$		$\text{C}_8\text{H}_8\text{O}_3$	$\text{TlC}_8\text{H}_7\text{O}_3$	
0.0	7.8	$\text{TlC}_8\text{H}_7\text{O}_3$	20.9	5.8	1.1
1.0	8.1	"	24.0	6.0	"
1.9	8.5	"	22.6	6.0	" + $\text{C}_8\text{H}_8\text{O}_3$
2.8	9.5	" + 1.1	20.4	4.7	$\text{C}_8\text{H}_8\text{O}_3$
3.7	8.2	1.1	18.8	3.1	"
4.8	7.1	"	17.7	1.6	"
9.1	5.7	"	17.2	0.6	"
12.2	5.3	"	17.0	0.4	"
16.0	5.4	"	16.95	0.0	"

1.1 =  $\text{TlC}_8\text{H}_7\text{O}_3 \cdot \text{C}_8\text{H}_8\text{O}_3$

## CH THALLIUM MANDELATE (Levo) $\text{TlC}_8\text{H}_7\text{O}_3$

THE SYSTEM LEVO THALLIUM MANDELATE - LEVO MANDELIC ACID - WATER AT 25°

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{C}_8\text{H}_8\text{O}_3$	$\text{TlC}_8\text{H}_7\text{O}_3$		$\text{C}_8\text{H}_8\text{O}_3$	$\text{TlC}_8\text{H}_7\text{O}_3$	
5.2	60.1	1.1	29.2	28.8m	$\text{C}_8\text{H}_8\text{O}_3$
3.8	52.2	"	23.0	22.0m	"
3.1	36.4	"	21.2	20.8m	"
4.5	18.1	"	17.8	16.7m	"
5.9	16.2	"	15.3	13.7	"
10.0	13.7	"	11.4	6.5	"
18.3	14.6m	"	10.4	2.4	"
19.4	17.0	" + $\text{C}_8\text{H}_8\text{O}_3$	10.1	0.0	"

m = metastable      1.1 =  $\text{TlC}_8\text{H}_7\text{O}_3 \cdot \text{C}_8\text{H}_8\text{O}_3$

THALLIUM PICRATE  $\text{TlOC}_6\text{H}_2(\text{NO}_2)_3$ 

CH

SOLUBILITY IN WATER  
(Rabe, 1901)

t°	Gms. $\text{TlOC}_6\text{H}_2(\text{NO}_2)_3$ per 100 Gms.	Solid Phase	t°	Gms. $\text{TlOC}_6\text{H}_2(\text{NO}_2)_3$ per 100 Gms.	Solid Phase
	H <sub>2</sub> O			H <sub>2</sub> O	
0	0.135	Monoclinic Red	45	1.04	Triclinic Yellow
18	0.36	"	47	1.10	"
30	0.575	"	50	1.205	"
40	0.825	"	60	1.73	"
47	1.14	"	70	2.43	"

100 gms. H<sub>2</sub>O simultaneously sat. with both salts dissolve:

0.132 gm.	$\text{C}_6\text{H}_2(\text{NO}_2)_3\text{OTl}$	+ 0.36 gm.	$\text{C}_6\text{H}_2(\text{NO}_2)_3\text{OK}$	at 0°.	
0.352 gm.	"	+ 0.44 gm.	"	at 15°.	
0.38 gm.	"	+ 0.23 gm.	"	at 20°.	(Rabe, 1901)

THALLIUM PICRATE  $\text{Tl}[\text{OC}_6\text{H}_2(\text{NO}_2)_3]$ SOLUBILITY OF THALLIUM PICRATE IN AQUEOUS SALT SOLUTIONS AT 25°  
(Otake, 1949)

(Moles per liter)

$\text{KNO}_3$	TlP	$\text{K}_2\text{SO}_4$	TlP	$\text{K}_2\text{C}_2\text{O}_4$	TlP	$\text{Ba}(\text{NO}_3)_2$	TlP
0.0	0.01112	0.00199	0.01160	0.00104	0.01131	0.00214	0.01159
.00106	.01123	.00527	.01214	.00516	.01220	.00524	.01210
.00499	.01158	.01257	.01328	.01103	.01325	.01176	.01342
.01000	.01202	.05076	.01528	.09463	.01592	.05269	.01576
.05000	.01335	.10017	.01775	.34357	.01988	.10012	.01790
.10028	.01443			1.01483	.02045	.37021	.02559
.50000	.01765						
.98507	.02105						

SOLUBILITY OF THALLIUM PICRATE IN METHYL ALCOHOL  
(Rabe, 1901)

t°	Gms. $\text{TlOC}_6\text{H}_2(\text{NO}_2)_3$ per 100 Gms.	Solid Phase	t°	Gms. $\text{TlOC}_6\text{H}_2(\text{NO}_2)_3$ per 100 Gms.	Solid Phase
	CH <sub>3</sub> OH			CH <sub>3</sub> OH	
0	0.39	Monoclinic Red	45	1.195	Triclinic Yellow
18	0.59	"	48	1.265	"
25	0.70	"	50	1.325	"
30	0.795	"	53	1.41	"
35	0.90	"	57	1.54	"
40	1.02	"	60	1.65	"
45	1.17	"	65	1.84	"
47	1.265	"			



# Tl THALLIUM

## CH THALLIUM (III) 8-HYDROXYQUINOLATES

The  $K_{sp} = 4 \times 10^{-33}$  (Pyatnitskii and Kostyshina, 1957)  
 $= 6.3 \times 10^{-38}$  (Borrel and Paris, 1952)

### THALLIUM TRIPHENYL $Tl(C_6H_5)_3$

SOLUBILITIES AT 20°  
 (Strohmeier and Humpfer, 1957)

Benzene	63.7 gms. per liter	Ethyl ether	78.8 gms. per liter
Dioxane	142 gms. per liter	Chloroform	262 gms. per liter
Heptane	1.98 gms. per liter		

THALLIUM OLEATE  $C_8H_7CH:CH(CH_2)_7COOTl$  (m.pt. 83°)

THALLIUM PALMITATE  $CH_3(CH_2)_{14}COOTl$  (m.pt. 115°-117°)

THALLIUM STEARATE  $CH_3(CH_2)_{16}COOTl$  (m.pt. 119°)

THALLIUM LAURATE  $C_{12}H_{23}O_2Tl$  (m.pt. 125°-126°)

THALLIUM MYRISTATE  $C_{14}H_{27}O_2Tl$  (m.pt. 120°-123°)

SOLUBILITY OF EACH SEPARATELY IN WATER AND IN 96% ETHYL ALCOHOL  
 (Holde and Selim, 1925)

The numerical results are not given but only small scale diagrams, from which the following approximate values were read.

t°	Solubility in Water			Solubility in 96% Alcohol		
	Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
	Tl Oleate	Tl Palmitate	Tl Stearate	Tl Oleate	Tl Palmitate	Tl Stearate
15	0.04	0.015	0.005	2.2	0.35	0.1
20	0.05	0.025	0.006	2.5	0.4	0.1
25	0.06	0.030	0.008	2.75	0.5	0.1
30	0.07	0.035	0.010	3.05	0.6	0.1
35	-	-	-	3.75	0.75	0.1
40	0.09	0.045	0.020	7.5	1.0	0.1
45	-	-	-	15.0	1.35	0.15
50	0.11	0.055	0.030			0.25
60	0.15	0.07	0.050			0.75
70	0.20	-	0.075			
80	0.30	-	0.110			

100 gms. sat. solution of thallium oleate in aqueous 50% alcohol contain 0.92 gms. of the salt at 15°. (Holde and Selim, 1925.)

100 gms. sat. sol. of thallium laurate in aqueous 50% ethyl alcohol contain 1.51 gms.  $C_{12}H_{23}O_2Tl$  at 15°. (Halde and Takehara, 1925.)

100 gms. sat. sol. of thallium myristate in aqueous 50% ethyl alcohol contain 0.53 gm.  $C_{14}H_{27}O_2Tl$  at 15°. (Halde and Takehara, 1925.)

SOLUBILITY OF THALLIUM SALTS OF FATTY ACIDS, EACH DETERMINED SEPARATELY,  
IN ACETONE, ETHER AND IN 96 PERCENT ETHYL ALCOHOL  
(Canneri and Bigalli, 1936)

	Gms. per 100 cc. of solvent						
t°	Tl Laurate	Tl Myristate	Tl Palmitate	Tl Stearate	Tl Oleate	Tl Arachinate	
	<u>In Anhydrous Acetone</u>						
5	0.026	0.028	0.022	0.036	0.023	0.024	CH
11	0.029	0.031	0.024	0.054	0.026	0.028	
19	0.038	0.035	0.028	0.078	0.029	0.032	
28	0.065	0.048	0.036	0.143	0.078	0.039	
	<u>In Anhydrous Ethyl Ether</u>						
5	0.011	0.028	0.010	0.019	0.128	0.007	
12.2	0.024	0.041	0.027	0.059	0.353	0.022	
15.4	0.042	0.048	0.036	0.119	0.684	0.038	
21	0.057	0.054	0.045	0.138	1.983	0.047	
24.5	0.079	0.071	0.057	0.203	3.460	0.079	
30	0.088	0.078	0.068	0.235	8.150	0.101	
	<u>In 96% Ethyl Alcohol</u>						
15	-	0.559	-	-	-	0.202	
21	-	0.910	-	-	-	0.186	
26	-	1.272	-	-	-	0.244	
30	-	2.001	-	-	-	0.361	
40	-	3.456	-	-	-	0.546	
45	-	4.921	-	-	-	0.796	

# THALLIUM CYANIDE TlCN and Double Cyanides

CN

SOLUBILITY IN WATER  
(Fronmüller, 1878)

Cyanide and Formula	Gms. Salt per 100 Gms. H <sub>2</sub> O
Tl Cyanide, TlCN	16.8 at 28.5°
Tl Cobalti Cyanide $Tl_3Co(CN)_6$	3.6 at 0°; 5.86 at 9.5°; 10.04 at 19.5°.
Tl Zinc Cyanide $2TlCN \cdot Zn(CN)_2$	8.7 at 0°; 15.2 at 14°; 29.6 at 31°.
Tl Ferro Cyanide $Tl_4Fe(CN)_6 \cdot 2H_2O$	0.37 at 18°; 3.93 at 101°. (Lamy.)

100 gms. liquid sulfur dioxide dissolve 0.012 gm. TlCN at 0°.  
(Jander and Ruppolt, 1937.)

# Tl THALLIUM

## SCN THALLIUM THIOCYANATE TlSCN

### SOLUBILITY IN WATER AND IN AQUEOUS SALT SOLUTIONS (Böttger, 1903; Noyes, 1890; Noyes and Abbott, 1895)

One liter sat. aq. solution contains 3.154 gms. TlSCN at 20°, 3.905 gms. at 25°, and 7.269 gms. at 39.75° Suzuki, 1952 reports the Ksp at 25° to be  $1.70 \times 10^{-4}$ .

t°	Gms. Mols. per Liter		Gms. per Liter	
	Salt	TlSCN	Salt	TlSCN
In aqueous salt solution of thallium bromate TlBrO <sub>2</sub> (excess):				
39.75	0.01496	0.0221	4.966	5.793 (N. & A.)
In aqueous salt solution of thallium nitrate TlNO <sub>3</sub> :				
25	0.0227	0.00852	6.04	2.233 (N.)
25	0.0822	0.00406	21.88	1.064
In aqueous salt solution of potassium thiocyanate, KSCN:				
25	0.0227	0.0083	2.208	2.176 (N.)

### SOLUBILITY OF THALLIUM THIOCYANATE IN GELATIN SOLUTIONS AT 40° (Eversole and Thomas, 1943)

The addition of a gelatin was found to increase the water solubility of the salt and the effect is about the same whether iso-electric gelatin (pH  $\approx$  4.7) or cationic (HAc added until pH  $\approx$  3.6) or ionic (NaOH added pH  $\approx$  6) gelatin was used. Results are in grams per 1000 gms. of water.

pH $\approx$ 4.7		pH $\approx$ 3.6		pH $\approx$ 6	
Gelatin	TlCNS	Gelatin	TlCNS	Gelatin	TlCNS
0.0	7.39	23.17	8.14	23.01	7.93
22.30	7.82	44.03	8.58	43.25	8.39
45.20	8.35	63.03	9.17	64.12	8.77
66.58	8.58				

The solubility of thallous thiocyanate in solutions of egg albumin at 25° was determined by Eversole and Bjork, 1939.

100 gms. liquid sulfur dioxide dissolve 0.024 gm. TlSCN at 0°.  
(Jander and Ruppolt, 1937.)

THALLIUM CARBONATE  $Tl_2CO_3$ 

CO

SOLUBILITY IN WATER  
(Crookes, 1864; Lamy, 1863)

t°:	15.5°	18°	62°	100°	100.8°
Gms. $Tl_2CO_3$ per 100 gms. $H_2O$	4.2(C.)	5.23	12.85	27.2(C.)	22.4

The  $K_{sp}$  (activity product) of  $Tl_2CO_3$  is  $1.25 \times 10^{-4}$  (Saegusa, 1950)

100 gms. liquid sulfur dioxide dissolve 0.01 gm.  $Tl_2CO_3$  at 0°.  
(Jander and Ruppolt, 1937.)

Fusion-point data for  $Tl_2CO_3 + TlNO_3$  are given by Broun, 1933.

THALLIUM OXALATE  $Tl_2C_2O_4$ 

CO

One liter of saturated aqueous solution contains 15.77 gms.  $Tl_2C_2O_4$  at 20°, and 18.69 gms. at 25°. (Bottger, 1903; Abegg and Spencer, 1905.)

## SOLUBILITY OF THALLIUM OXALATE AT 25° IN AQUEOUS SOLUTIONS OF:

Thallium Nitrate (Abegg and Spencer)				Potassium Oxalate (Abegg and Spencer)			
Mol. Concentration		Grams per Liter		Mol. Concentration		Grams per Liter	
$TlNO_3$	$Tl_2C_2O_4$	$TlNO_3$	$Tl_2C_2O_4$	$K_2C_2O_4$	$Tl_2C_2O_4$	$K_2C_2O_4$	$Tl_2C_2O_4$
0.0	0.03768	0.00	18.69	0.0498	0.0351	8.281	17.42
0.04114	0.0264	10.95	13.10	0.0996	0.03565	16.57	17.69
0.0799	0.0195	21.26	9.68	0.2467	0.0390	41.02	19.36
0.1597	0.01235	42.51	6.128	0.4886	0.04506	81.25	22.37
				0.9785	0.05536	162.6	27.48

# TI THALLIUM

## CI THALLIUM CHLORIDE TlCl

### SOLUBILITY IN WATER

A = average of older determinations of Noyes, 1892; Böttger, 1903; Kohlrausch, 1904; Hepperling; Crooke; Lamy.

B = Berkeley, 1904

C = average of recent determinations of Osborg, 1926; Butler and Hiscocks, 1926; Randall and Chang, 1928; Benrath and Ammer, 1929; Failey, 1932, 1932a, 1933.

D = Recent results of Federov and Cheu, 1957

The results for temperatures above 100° are by Benrath, Gjedebø, Schiffrers and Wunderlich, 1937.

t°	Gms. per liter sat. sol.				Above 100°:	
	A	B	C	D	t°	Gms. TlCl per liter sat. sol.
0	2.1	1.7	1.61	1.60		
9.54	2.27 <sup>k</sup>	-	-	-		
10	2.5	2.4	2.40	-	144	4.2
17.7	3.05 <sup>k</sup>	-	-	-	177	6.67
20	3.3	3.4	3.25	-	205	9.0
25	3.86	4.0	3.80	3.90	234	12.3
25.75	3.97 <sup>k</sup>	-	-	-	303	21.1
30	4.2	4.6	-	-	338	26.4
40	5.2	6.0	-	-	364	30 - 86
50	6.3	8.0	7.83	8.00	367	91.5
60	8	10.2	-	-	381	96.2
75	-	-	-	14.48	430 m.pt.	100.0
80	12	16	-	-		
100	18	24.1 (99.3°)	-	-		

### SOLUBILITY OF THALLI-THALLO CHLORIDES IN WATER AT 35° (Benrath, 1924)

Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
TlCl <sub>3</sub>	TlCl		TlCl <sub>3</sub>	TlCl	
0.0	0.051	TlCl(white)	74.401	0.770	[TlCl <sub>6</sub> ]Tl <sub>3</sub> (yellow)
0.169	0.373	[TlCl <sub>6</sub> ]Tl <sub>3</sub> (yellow)	88.510	1.021	"
0.823	0.265	"	118.875	1.536	"
2.173	0.237	"	144.782	2.272	"
2.872	0.232	"	157.161	2.695	"
3.566	0.216	"	160.502	2.917	"
4.444	0.236	"	163.291	2.887	[TlCl <sub>4</sub> ]Tl(white)
8.723	0.237	"	166.434	2.826	"
15.097	0.272	"	172.971	2.779	"
28.109	0.244	"	197.997	2.653	"
39.940	0.314	"			

SOLUBILITY OF THALLI-THALLO CHLORIDES IN WATER  
AT SEVERAL TEMPERATURES  
(Benrath, 1924)

Gms. per 100 gms. H <sub>2</sub> O			Gms. per 100 gms. H <sub>2</sub> O		
TlCl <sub>3</sub>	TlCl	Solid Phase	TlCl <sub>3</sub>	TlCl	Solid Phase
<u>Results at 45°</u>			<u>Results at 55°--Cont.</u>		
0.0	0.070	TlCl(white)	120.601	3.006	[TlCl <sub>6</sub> ]Tl <sub>3</sub> (yellow)
0.214	0.496	[TlCl <sub>6</sub> ]Tl <sub>3</sub> (yellow)	155.838	5.412	"
1.875	0.405	"	157.413	5.587	"
4.954	0.356	"	163.985	6.215	"
20.184	0.426	"	167.913	6.669	"
39.561	0.495	"	177.163	6.687	[TlCl <sub>4</sub> ]Tl(white)
65.597	0.803	"	183.968	6.612	"
90.693	1.187	"	201.022	6.578	"
117.654	1.976	"	214.579	6.493	"
144.840	3.115	"	<u>Results at 70°</u>		
156.167	3.771	"			
166.853	4.424	"			
171.000	4.400	[TlCl <sub>4</sub> ]Tl(white)	178.31	10.356	[TlCl <sub>6</sub> ]Tl <sub>3</sub> (yellow)
195.820	4.361	"	187.16	10.580	[TlCl <sub>4</sub> ]Tl(white)
209.542	4.302	"	<u>Results at 80°</u>		
<u>Results at 55°</u>					
0.0	0.092	TlCl(white)	179.82	15.291	[TlCl <sub>6</sub> ]Tl <sub>3</sub> (yellow)
0.291	0.678	[TlCl <sub>6</sub> ]Tl <sub>3</sub> (yellow)	225.37	16.013	"
1.327	0.593	"	245.20	15.920	[TlCl <sub>4</sub> ]Tl(white)
4.458	0.586	"	<u>Results at 90°</u>		
26.501	0.532	"			
40.512	0.698	"	287.41	20.085	[TlCl <sub>6</sub> ]Tl <sub>3</sub> (yellow)
88.845	1.995	"	290.83	19.876	[TlCl <sub>4</sub> ]Tl(white)

One liter of water dissolves 2.7 gms. thallo thallic chloride  
3TlCl·TlCl<sub>3</sub> at 15°-17°, and 35 gms. at 100°. (Crookes, 1864; Lamy;  
Hebberling.)

SOLUBILITY OF THALLIUM CHLORIDE AT 25° IN AQUEOUS SOLUTIONS OF:

<u>Acetic Acid</u> (Hill, 1917)			<u>Nitric Acid</u> (Hill and Simmons, 1909)		
Normality of Aq. CH <sub>3</sub> COOH	TlCl per Liter		Normality of Aq. HNO <sub>3</sub>	d <sub>25</sub> of Sat. Sol.	TlCl per Liter
	Gm.	Equiv.			Gms. Gm. Equiv.
0	3.8515	0.016085	0	0.996	3.951 0.0165
0.0501	3.8375	0.016027	0.4977	1.0184	5.937 2.475
0.0958	3.8326	0.016006	1.0046	1.0359	6.882 2.875
0.263	3.7503	0.015662	2.0452	1.0705	8.143 3.401
0.524	3.6539	0.015258	4.0170	1.1362	9.925 4.145

# TI THALLIUM

One liter of  $2\frac{1}{2}$  per cent aqueous ammonia dissolves 0.761 gm.  $TlCl$ .  
 One liter of  $6\frac{1}{2}$  per cent aqueous ammonia dissolves 0.758 gm.  $TlCl$ .  
 (Long, 1888.)

## SOLUBILITY OF THALLIUM CHLORIDE IN AQUEOUS SALT SOLUTIONS AT $25^{\circ}$ (Noyes, 1890; Noyes and Abbott, 1895; Geffcken, 1904)

	Aqueous Salt Solution	G. Mols. per Liter		Gms. per Liter	
		Salt	$TlCl$	Salt	$TlCl$
Cl	Ammonium Nitrate $NH_4NO_3$	0	0.01612	0	3.861 (G.)
	"	0.5	0.02587	40.02	6.209
	"	1	0.03121	80.05	7.473
	"	2	0.03966	160.10	9.497
	Barium Chloride $BaCl_2$	0.0283	0.00857	5.895	2.052 (N.)
	"	0.1468	0.00323	30.59	0.773
	Cadmium Sulfate $CdSO_4$	0.030	0.0206	6.255	4.933 (N.)
	"	0.0787	0.0254	16.41	6.081
	"	0.1574	0.0309	32.82	7.399
	Hydrochloric Acid $HCl$	0.0283	0.00836	1.032	2.002 (N.)
	"	0.0560	0.00565	2.043	1.353
	"	0.1468	0.00316	5.357	0.757
	Lithium Nitrate $LiNO_3$	0.5	0.02542	34.53	6.085 (G.)
	"	1	0.03035	69.07	7.266
	"	2	0.03785	138.14	9.063
	"	3	0.04438	207.21	10.630
	Potassium Chlorate $KClO_3$	0.5	0.0237	61.28	5.674 (G.)
	Potassium Nitrate $KNO_3$	0.015	0.0170	1.517	4.070 (N.)
	"	0.030	0.0179	3.033	4.286
	"	0.0787	0.0192	7.775	4.597
	"	0.1574	0.0212	15.920	5.076
	"	0.5	0.0257	50.55	6.153 (G.)
	"	1	0.0308	101.11	7.375
	"	2	0.0390	202.22	9.340
	Sodium Acetate $CH_3COONa$	0.015	0.0168	1.231	4.023 (N.)
	"	0.030	0.0172	2.462	4.118
	"	0.0787	0.0185	6.46	4.430
	"	0.1574	0.0196	12.92	4.693
	Sodium Nitrate $NaNO_3$	0.5	0.02564	42.50	6.139 (G.)
	"	1	0.03054	85.01	7.313
	"	2	0.03851	170.02	9.221
	"	3	0.04544	255.03	10.88
	"	4	0.05128	340.12	12.28
	Sodium Chlorate $NaClO_3$	0.5	0.02320	53.25	5.555 (G.)
	"	1	0.02687	106.5	6.433
	"	2	0.03060	213	7.326
	"	3	0.03303	319.5	7.909
	"	4	0.03850	426	9.215
	Thallium Bromate $TlBrO_3$ (at $39.75^{\circ}$ )	0.01567	0.01959	5.201	4.690 (N. & A.)
	Thallium Nitrate $TlNO_3$	0.0283	0.0083	7.518	1.987 (N.)
	"	0.0560	0.00571	14.89	1.368
	"	0.1468	0.00332	39.05	0.795
	Thallium Sulfate $Tl_2SO_4$	0.0283	0.00886	14.27	2.121 (N.)
	"	0.0560	0.00624	28.23	1.494
	Thallium Thiocyanate $TlSCN$	0.0107	0.0119	2.802	2.849 (N.)
	Thallium Thiocyanate $TlSCN$ (at $39.75^{\circ}$ )	0.02149	0.01807	5.632	4.326 (N. & A.)

Note.— In the case of the results for thallium bromate and thallium thiocyanate at  $39.75^{\circ}$ , the solutions were saturated with respect to these salts as well as with respect to thallium chloride.

SOLUBILITY OF THALLIUM CHLORIDE IN AQUEOUS SOLUTIONS OF SALTS AT 25°  
(Bray and Winninghoff, 1911)

Solvent			Saturated Solution		
Salt Present	Gms. Salt per Liter	d <sub>25</sub> of Aq. Solvent	Gms. Salt per Liter	d <sub>25</sub> of Sat. Sol.	Gms. Equiv. TlCl per Liter
None	-	-	-	0.9994	0.01607
KNO <sub>3</sub>	0.02001	0.9973	0.020	1.0009	0.01716
KNO <sub>3</sub>	0.05000	0.9992	0.04997	1.0028	0.01826
KNO <sub>3</sub>	0.10005	1.0023	0.39998	1.0063	0.01961
KNO <sub>3</sub>	0.3002	1.0145	0.3000	1.0194	0.02313
KNO <sub>3</sub>	1.0005	1.0568	0.9996	1.0632	0.03072
K <sub>2</sub> SO <sub>4</sub>	0.01997	0.9975	0.01996	1.0012	0.01779
K <sub>2</sub> SO <sub>4</sub>	0.05000	0.9995	0.04996	1.0037	0.01942
K <sub>2</sub> SO <sub>4</sub>	0.1000	1.0030	0.09989	1.0074	0.02137
K <sub>2</sub> SO <sub>4</sub>	0.3000	1.0167	0.29966	1.0221	0.02600
K <sub>2</sub> SO <sub>4</sub>	1.0000	1.0628	0.9986	1.0698	0.03416
Tl <sub>2</sub> SO <sub>4</sub>	0.0200	1.0007	0.01999	1.0028	0.01034
Tl <sub>2</sub> SO <sub>4</sub>	0.0500	1.0076	0.04999	1.0090	0.006772
Tl <sub>2</sub> SO <sub>4</sub>	0.1000	1.0191	0.09997	1.0200	0.004679

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SOLUBILITY OF THALLOUS CHLORIDE IN AQUEOUS SOLUTIONS OF SALTS  
(Butler and Hiscocks, 1926)

Constant agitation was employed and equilibrium was approached from above and from below. The thallium was determined by titration with standard permanganate except in cases where thallos salts were used in the solvent.

Salt	Mols. salt per liter	d <sub>4</sub> <sup>t°</sup> of Sat. Sol.	Mols. TlCl per liter	Salt	Mols. salt per liter	d <sub>4</sub> <sup>t°</sup> of Sat. sol.	Mols. TlCl per liter
Results at 0°				Results at 25°			
None (=water)	1.0014	0.00670		None (=water)	1.0004	0.01607	
KNO <sub>3</sub>	0.05	1.0039	0.00787	KCl	0.05	1.003	0.00586
"	0.20	1.0155	0.00955	"	0.10	1.0033	0.00387
"	0.50	1.0349	0.01184	"	0.20	1.0063	0.00258
"	1.00	1.0661	0.01472	"	0.50	1.0203	0.00176
ZnSO <sub>4</sub>	0.05	1.0105	0.00875	TlNO <sub>3</sub>	0.05	1.0078	0.00615
"	0.10	1.0188	0.00979	"	0.10	1.0202	0.00413
"	0.30	1.0674	0.01214	"	0.20	1.0399	0.00300
"	0.5994	1.1015	0.01423	KNO <sub>3</sub>	0.05	1.0038	0.01826
La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	0.01	1.0063	0.00746	"	0.20	1.0138	0.02151
"	0.015	1.0088	0.00805	"	0.50	1.0327	0.02556
"	0.02	1.0110	0.00828	"	1.00	1.0619	0.03030
"	0.025	1.0135	0.00845				

(Cont.)



# TI THALLIUM

## SOLUBILITY OF THALLOUS CHLORIDE IN AQUEOUS SOLUTIONS OF SALTS--Cont.

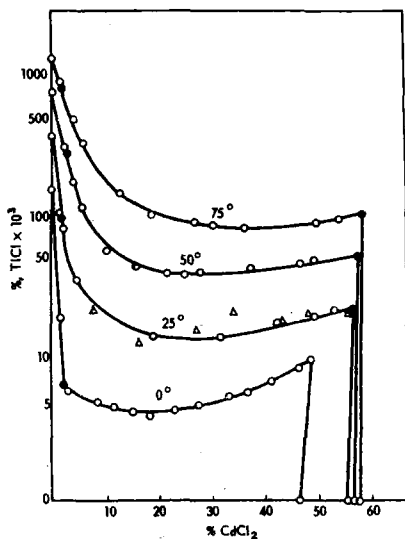
	Mols. salt per liter	d <sup>t°</sup> of Sat. Sol.	Mols. TlCl per liter		Mols. salt per liter	d <sup>t°</sup> of Sat. Sol.	Mols. TlCl per liter
Salt				Salt			
<u>Results at 25°--Cont.</u>				<u>Results at 50°</u>			
Cl	Tl <sub>2</sub> SO <sub>4</sub>	0.025	1.0098	0.00680	None (=Water)	0.9950	0.03265
	"	0.05	1.0186	0.00463	KCl	0.05	0.9943
	ZnSO <sub>4</sub>	0.05	1.0097	0.01801	"	0.10	0.9957
	"	0.10	1.0184	0.01836	"	0.20	0.9996
	"	0.30	1.0515	0.01913	"	0.50	1.0121
	"	0.5994	1.0993	0.01937	TlNO <sub>3</sub>	0.10	1.0131
	La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	0.01	1.0055	0.01801	"	0.20	1.0321
	"	0.015	1.0079	0.01836	Tl <sub>2</sub> SO <sub>4</sub>	0.025	1.0012
	"	0.02	1.0098	0.01913	"	0.05	1.0140
	"	0.025	1.0122	0.01937	KNO <sub>3</sub>	0.05	0.9989
					"	0.20	1.0088
					"	0.50	1.0273
				"	1.00	1.0571	
				ZnSO <sub>4</sub>	0.05	1.0046	
				"	0.10	1.0249	
				"	0.30	1.0459	
				"	0.5994	1.0952	

## SOLUBILITY OF THALLIUM CHLORIDE IN AQUEOUS SOLUTIONS OF SALTS WITH A COMMON ION AT 25° (Noyes, 1892)

Aqueous Solution of:		Gms. Added Salt per Liter	Gms. Dissolved TlCl per Liter	Aqueous Solution of:		Gms. Added Salt per Liter	Gms. Dissolved TlCl per Liter
Water alone		0	0.01612	MgCl <sub>2</sub>		0.025	0.00904
NH <sub>4</sub> Cl		0.025	0.00877	"		0.050	0.00618
"		0.05	0.00593	"		0.10	0.00413
"		0.20	0.00271	"		0.20	0.00275
BaCl <sub>2</sub>		0.05	0.00620	MnCl <sub>2</sub>		0.025	0.00898
"		0.10	0.00425	"		0.05	0.00617
CdCl <sub>2</sub>		0.025	0.01040	"		0.10	0.00412
"		0.05	0.00780	"		0.20	0.00286
"		0.10	0.00578	KCl		0.025	0.00872
"		0.20	0.00427	"		0.05	0.00593
CaCl <sub>2</sub>		0.025	0.00899	"		0.10	0.00399
"		0.05	0.00624	"		0.20	0.00265
"		0.10	0.00417	"		0.80	0.00170
"		0.20	0.00284	NaCl		0.025	0.00869
CuCl <sub>2</sub>		0.025	0.00905	"		0.05	0.00592
"		0.05	0.00614	"		0.10	0.00395
"		0.10	0.00422	"		0.20	0.00271
"		0.20	0.00291	TlClO <sub>3</sub>		0.025	0.00897
HCl		0.025	0.00869	"		0.025	0.00894
"		0.05	0.00585	TlNO <sub>3</sub>		0.025	0.00883
"		0.10	0.00384	"		0.05	0.00626
"		0.20	0.00254	"		0.10	0.00423

## THE SYSTEM THALLIUM CHLORIDE - CADMIUM CHLORIDE - WATER

Federov and Chen, 1957 reported the system at 0°, 25°, 50° and 75° graphically as shown.



Cl

○ Federov and Chen, 1957

Δ Benrath and Ammer, 1929

## Compositions of invariant solutions

t°	Wt. %		Solid Phase
	TlCl	CdCl <sub>2</sub>	
0	0.020	2.10	TlCl + TlCl·CdCl <sub>2</sub>
25	0.085	2.86	"
50	0.299	2.84	"
75	0.802	2.85	"
0	0.010	47.42	TlCl·CdCl <sub>2</sub> + CdCl <sub>2</sub> ·2 <sup>1</sup> / <sub>2</sub> H <sub>2</sub> O
25	0.024	54.68	"
50	0.051	57.83	TlCl·CdCl <sub>2</sub> + CdCl <sub>2</sub> ·H <sub>2</sub> O
75	0.106	58.60	"

# Tl THALLIUM

(Results of Benrath and Ammer, 1929)

Gms. per 100 gms. H <sub>2</sub> O			Gms. per 100 gms. H <sub>2</sub> O		
TlCl	CdCl <sub>2</sub>	Solid Phase	TlCl	CdCl <sub>2</sub>	Solid Phase
0.376	0.0	TlCl	0.033	52.96	TlCl·CdCl <sub>2</sub>
0.024	9.27	TlCl·CdCl <sub>2</sub>	0.034	76.16	"
0.016	19.27	"	0.041	93.70	"
0.019	23.60	"	0.043	99.25	"
0.023	37.59	"	0.052	125.02	"
			0.0	131.5	CdCl <sub>2</sub>

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SOLUBILITY OF THALLIUM CHLORIDE AT 25° IN AQUEOUS SOLUTIONS OF:  
(Benrath and Ammer, 1929)

The solid phase is TlCl in all cases.

<u>Barium Chloride</u>		<u>Calcium Chloride</u>		<u>Strontium Chloride</u>	
Gms. per 100 gms. H <sub>2</sub> O		Gms. per 100 gms. H <sub>2</sub> O		Gms. per 100 gms. H <sub>2</sub> O	
BaCl <sub>2</sub>	TlCl	CaCl <sub>2</sub>	TlCl	SrCl <sub>2</sub>	TlCl
2.0	0.070	5.0	0.040	5.0	0.042
5.0	0.043	18.5	0.060	10.0	0.040
10.0	0.041	28.3	0.109	20.0	0.045
18.0	0.044	41.28	0.154	30.0	0.062
25.0	0.044	45.30	0.203	40.0	0.074
30.0	0.063	67.77	0.488	50.0	0.098
36.32	0.086	88.67	0.875	53.4	0.134

THE SYSTEM THALLIUM CHLORIDE - MERCURIC CHLORIDE - WATER AT 25°  
(Benrath and Ammer, 1929)

Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
HgCl <sub>2</sub>	TlCl		HgCl <sub>2</sub>	TlCl	
0.037	0.289	TlCl	2.146	0.065	TlCl·HgCl <sub>2</sub>
0.072	0.270	"	3.748	0.059	"
0.291	0.144	"	4.691	0.057	"
1.303	0.091	TlCl·HgCl <sub>2</sub>	6.346	0.034	"
1.561	0.078	"	7.218	0.0	HgCl <sub>2</sub>

THE SYSTEM THALLIUM CHLORIDE - MAGNESIUM CHLORIDE - WATER AT 25°  
(Benrath and Ammer, 1929)

Gms. per 100 gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 gms. H <sub>2</sub> O		Solid Phase
MgCl <sub>2</sub>	TlCl		MgCl <sub>2</sub>	TlCl	
0.58	0.091	TlCl	30.0	0.076	TlCl
2.78	0.053	"	38.75	0.146	"
5.50	0.045	"	40.28	0.137	3TlCl·MgCl <sub>2</sub>
11.69	0.033	"	44.47	0.085	"
17.19	0.040	"	51.41	0.020	"
20.00	0.055	"	54.15	0.007	"

THE SYSTEM THALLIUM CHLORIDE - ZINC CHLORIDE - WATER AT 25°  
(Benrath and Ammer, 1929)

Gms. per 100 gms. H <sub>2</sub> O			Gms. per 100 gms. H <sub>2</sub> O		
ZnCl <sub>2</sub>	TlCl	Solid Phase	ZnCl <sub>2</sub>	TlCl	Solid Phase
0.0	0.376	TlCl	160.9	4.67	3TlCl·ZnCl <sub>2</sub>
1.11	0.04	"	163.7	5.49	2TlCl·ZnCl <sub>2</sub>
2.52	0.007	"	229.9	12.11	"
11.15	0.059	"	246.0	18.52	"
37.55	0.186	"	303.1	33.59	"
76.40	0.780	3TlCl·ZnCl <sub>2</sub>	323.7	42.31	"
92.47	0.950	"	332.7	49.31	"
126.00	1.97	"	354.4	30.00	"
138.1	2.49	"	367.3	22.97	"
145.8	3.75	"	390.4	0.0	ZnCl <sub>2</sub>

Cl

SOLUBILITY OF THALLIUM CHLORIDE AT 25° IN AQUEOUS SOLUTIONS OF:  
(Randall and Chang, 1928)

Magnesium Sulfate				Lanthanum Nitrate			
Gm. Mols. per 1000 gms. H <sub>2</sub> O		Gm. Mols. per 1000 gms. H <sub>2</sub> O		Gm. Mols. per 1000 gms. H <sub>2</sub> O		Gm. Mols. per 1000 gms. H <sub>2</sub> O	
MgSO <sub>4</sub>	TlCl	MgSO <sub>4</sub>	TlCl	La(NO <sub>3</sub> ) <sub>3</sub>	TlCl	La(NO <sub>3</sub> ) <sub>3</sub>	TlCl
0.000	0.01611	0.06259	0.02214	0.005215	0.01740	0.04180	0.02129
0.01708	0.01920	0.1291	0.02504	0.008808	0.01778	0.08166	0.02433
0.03364	0.02042	0.1994	0.02641	0.02024	0.01946	0.1970	0.02697
0.04384	0.02106	0.3529	0.02878				

SOLUBILITY OF THALLIUM CHLORIDE IN AQUEOUS SALT SOLUTIONS AT 20°  
(Viktorin and Sirucek, 1939)

Concentrations are in moles per 1000 gms. H<sub>2</sub>O

NaSO <sub>4</sub>	TlCl	NaNO <sub>3</sub>	TlCl	MgSO <sub>4</sub>	TlCl
0.0	0.01376	0.005	0.01406	0.005	0.01466
.005	.01462	.01	.01428	.01	.01524
.01	.01523	.02	.01470	.02	.01610
.03	.01702	.05	.01567	.04	.01722
		.1	.01681		

SOLUBILITY OF THALLIUM CHLORIDE IN AQUEOUS SOLUTIONS  
OF ZINC SULFATE AT 25°  
(LeMer and Goldman, 1929)

Gm. Mols. per liter		Gm. Mols. per liter	
ZnSO <sub>4</sub>	TlCl	ZnSO <sub>4</sub>	TlCl
0.05	0.02059	0.30	0.02770
0.10	0.02279	0.5994	0.03203

# TI THALLIUM

## SOLUBILITY OF THALLIUM CHLORIDE IN MIXTURES OF ORGANIC SOLVENTS AND WATER AT 25° (Black and Garrett, 1943)

		- % H <sub>2</sub> O by Volume -					
		100	80	60	40	20	0
<u>Ethylene Glycol + Water:</u>							
Mole Fraction Glycol:	0.0	0.073	0.177	0.326	0.564	1.000	
Density:	0.997	1.025	1.053	1.077	1.096	1.110	
Moles TlCl per 1000 gms. Solvent:	0.01617	.01340	.01116	.00944	.00792	.00644	

Cl

### Dioxane + Water:

Mole Fraction Dioxane:	0.0	0.052	0.121	0.257	0.474	1.000	
Density:	0.997	1.015	1.028	1.035	1.035	1.027	
Moles TlCl per 1000 gms. Solvent:	.01617	.00924	.00415	.00139	.00073	.00031	

### Morpholine + Water:

Mole Fraction Morpholine:	0.0	0.050	0.121	0.240	0.457	1.000	
Density:	0.997	1.011	1.027	1.034	1.030	0.996	
Moles TlCl per 1000 gms. Solvent:	.01617	.01125	.00680	.00278	.00101	.00020	

## SOLUBILITY OF THALLIUM CHLORIDE IN GLYCINE SOLUTIONS AT 25° (Lee and Luh, 1948)

The data do not lie on a very smooth curve.

Moles Glycine per 1000 gms. H <sub>2</sub> O	Moles TlCl per 1000 gms. Sat. Sol.	Moles Glycine per 1000 gms. H <sub>2</sub> O	Moles TlCl per 1000 gms. Sat. Sol.
0.0	0.01594	0.6169	0.01820
.3619	.01798	.7978	.01913
.3849	.01777	.8008	.01953
.6060	.01788		

SOLUBILITY OF THALLIUM CHLORIDE IN  
ETHANOL - POTASSIUM CHLORIDE SOLUTIONS AT 25°  
(Hogge and Garrett, 1941)

Moles per 1000 gms. Solvent		Density 25° 4°	Moles per 1000 gms. Solvent		Density 25° 4°
KCl	TlCl	Sat. Sol.	KCl	TlCl	Sat. Sol.
<u>Results in 10% Ethanol</u>			<u>Results in 30% Ethanol</u>		
0.0	0.01166	0.9827	0.0	58.55 x 10 <sup>-4</sup>	0.9496
.02043	.05845	.9825	.01061	29.47	.9496
.05108	.003376	.9834	.02647	17.06	.9500
.1023	.002300	.9854	.05293	11.39	.9512
.2051	.001627	.9905	.1057	8.097	.9532
.3084	.001371	.9946	.1589	6.959	.9552
.5111	.001142	1.0158	.2658	6.009	.9591
1.0515	.001117	1.0259	.5361	5.49	.9694
2.195	.001416	1.0617	1.093	6.62	.9909

Results in 40% Ethanol

0.0	40.58 x 10 <sup>-4</sup>	0.9337	.2157	4.238	.9423
.01071	16.62	.9342	.3246	4.006	.9467
.02145	10.01	.9342	.5440	4.18	.9558
.05369	6.653	.9351	1.108	5.20	.9774
.1075	5.064	.9377			

Results in 51.25% Ethanol

0.0	25.71 x 10 <sup>-4</sup>	0.9076	0.0	17.93 x 10 <sup>-4</sup>	0.8882
.01654	6.126	.9081	.01409	3.612	.8886
.03310	4.285	.9086	.02819	2.636	.8889
.08295	3.049	.9108	.05637	2.078	.8903
.1476	2.706	.9133	.09318	1.875	.8921
.1662	2.678	.9141	.1414	1.789	.8934
.1848	2.623	.9145	.1698	1.826	.8961
.3705	2.703	.9234	.2839	1.867	.8992
.7510	3.385	.9372	.3760	1.991	.9028
			.4715	2.141	.9065

Results in 60% Ethanol

SOLUBILITY OF THALLIUM CHLORIDE IN  
POTASSIUM CHLORIDE - ETHYLENE GLYCOL SOLUTIONS AT 25°  
(Black and Garrett, 1943)

- Moles per 1000 grams of Solvent -

In 20 Wt. % Glycol		In 40 Wt. % Glycol		In 60 Wt. % Glycol	
KCl	TlCl	KCl	TlCl	KCl	TlCl
0.0	0.01340	0.0	0.01116	0.0	0.00944
.0196	.00761	.0190	.00616	.0178	.00496
.0391	.00507	.0381	.00409	.0355	.00351
.0783	.00410	.0762	.00281	.0710	.00221
.0978	.00371	.0952	.00239	.0888	.00199
.5253	.00135	.1904	.00180	.1775	.00135
.7879	.00124	.4759	.00123	.4437	.00108
1.0501	.00110	.7615	.00054	.7099	.00065
		1.1423	.00051	1.0649	.00050

(Contd)

# TI THALLIUM

## SOLUBILITY OF THALLIUM CHLORIDE IN POTASSIUM CHLORIDE - ETHYLENE GLYCOL SOLUTIONS AT 25°--Cont.

- Moles per 1000 grams of Solvent -

	In 80 Wt. % Glycol		In 100% Ethylene Glycol	
	KCl	TlCl	KCl	TlCl
	0.0	0.00792	0.0	0.00644
	.0184	.00368	.0181	.00284
	.0367	.00274	.0362	.00203
	.0724	.00154	.0725	.00128
	.0918	.00124	.0906	.00110
	.1834	.00084	.1812	.00054
	.4589	.00051	.4530	.00015
	.7341	.00026		

Cl

## SOLUBILITY OF THALLIUM CHLORIDE IN AQUEOUS SOLUTIONS OF AMINO ACIDS AT 25° (Failey, 1933)

Aqueous Solvent		Gm. Mol. TlCl per liter
Amino Acid	Gm. Mols. per liter	
Glycylglycine	0.2	0.01835
Glycine	0.2	0.01725
α Alanine	0.2	0.01703
Urea	0.2	0.01642
Diketo piperazine	0.1	0.01602
α Amino n Butyric Acid	0.1	0.01648
" " " "	0.2	0.01688
" " iso " "	0.2	0.01679
" " n Valeric "	0.1	0.01627
" " " "	0.2	0.01633

## SOLUBILITY OF THALLIUM CHLORIDE IN AQUEOUS SOLUTIONS OF GLYCINE ALONE AND IN PRESENCE OF ACID AND BASE AT 25° (Failey, 1933)

Gm. Mols. per 1000 gms. H <sub>2</sub> O		Gm. Mols. TlCl per 1000 gms. H <sub>2</sub> O	Gm. Mols. per 1000 gms. H <sub>2</sub> O		Gm. Mols. TlCl per 1000 gms. H <sub>2</sub> O
Glycine	HNO <sub>3</sub> or NaOH		Glycine	HNO <sub>3</sub> or NaOH	
0.00	-	0.01617	0.10	0.025 NaOH	0.01810
0.010	-	0.01623	0.10	0.050 NaOH	0.01902
0.030	-	0.01634	0.10	0.075 NaOH	0.01978
0.050	-	0.01648	0.10	0.100 NaOH	0.02051
0.100	-	0.01678	-	0.025 HNO <sub>3</sub>	0.01734
0.200	-	0.01745	-	0.050 HNO <sub>3</sub>	0.01821
0.10	0.025 HNO <sub>3</sub>	0.01794	-	0.075 HNO <sub>3</sub>	0.01887
0.10	0.050 HNO <sub>3</sub>	0.01868	-	0.100 HNO <sub>3</sub>	0.01945
0.10	0.075 HNO <sub>3</sub>	0.01925	-	0.025 NaOH	0.01777
0.10	0.100 HNO <sub>3</sub>	0.01979	-	0.050 NaOH	0.01986
			-	0.075 NaOH	0.01995
			-	0.100 NaOH	0.02086

SOLUBILITY OF THALLIUM CHLORIDE IN AQUEOUS SOLUTIONS  
OF EDESTIN NITRATE AT 25°  
(Failey, 1932a)

Per 1000 gms. H <sub>2</sub> O of sat. sol.			Per 1000 gms. H <sub>2</sub> O of sat. sol.		
Gms.	Gm.	Gm.	Gms.	Gm.	Gm.
Edestin	Mol. HNO <sub>3</sub>	Mol. TlCl	Edestin	Mol. HNO <sub>3</sub>	Mol. TlCl
0.0	0.025	0.01734	0.0	0.050	0.01821
4.5	0.025	0.01763	5.2	0.050	0.01842
13.4	0.025	0.01802	10.1	0.050	0.01861
13.8	0.025	0.01827	24.2	0.050	0.01953
30.1	0.025	0.01924	28.1	0.050	0.01971
34.7	0.025	0.01948	45.9	0.050	0.02131
48.8	0.025	0.02043			

CI

SOLUBILITY OF THALLIUM CHLORIDE IN GELATIN SOLUTIONS AT 40°  
(Eversole and Thomas, 1943)

Addition of gelatin increases the aqueous solubility of the salt. Isoelectric (pH  $\approx$  4.7), positive (HAc added until pH  $\approx$  3.6), and negative (NaOH added until pH  $\approx$  6) gelatin all showed about the same effect.

Grams per 1000 gms. of Water

pH $\approx$ 4.7		pH $\approx$ 3.6		pH $\approx$ 6	
Gelatin	TlCl	Gelatin	TlCl	Gelatin	TlCl
0.0	6.12	19.70	6.35	20.33	6.41
25.13	6.31	41.65	6.57	43.30	6.80
44.89	6.34	65.40	6.60	64.42	6.97
70.74	6.74				

SOLUBILITY OF THALLOUS CHLORIDE IN PROTEIN SOLUTIONS  
(Stone and Failey, 1933)

The results below are for solutions of isoelectric, electrolyte-free protein solutions. Additional determinations were made with these and other proteins in which the ionic strength of the solutions was varied.

Gms. Egg Albumin per 1000 gms. H <sub>2</sub> O	Moles TlCl per 1000 gms. H <sub>2</sub> O	Gms. Hemoglobin per 1000 gms. H <sub>2</sub> O	Moles TlCl per 1000 gms. H <sub>2</sub> O
5.61	0.01622	10.79	0.01620
11.13	.01624	15.16	.01631
19.31	.01640	22.77	.01638
29.63	.01646	26.85	.01648
39.14	.01647	31.03	.01657
47.49	.01667		

The solubility of thallos chloride in solutions of egg albumin at 25° was determined by Eversole and Bjork, 1939.

One liter of 90% alcohol dissolves 0.0038 gm. TlCl. (Long, 1888.)



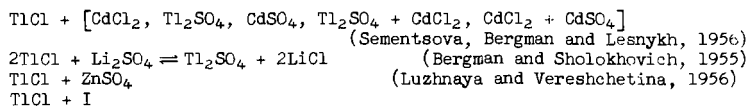
## TI THALLIUM

One liter of 50 per cent alcohol dissolves 0.027 gm.  $\text{TlCl}$ . (Long, 1888.)

100 gms. methyl alcohol ( $\text{CH}_3\text{OH}$ ) dissolve 0.000029 gm. equiv.  $\text{TlCl}$  at  $25^\circ$ . (Buckley and Hartley, 1929.)

100 gms. liquid sulfur dioxide ( $\text{SO}_2$ ) dissolve 0.007 gm.  $\text{TlCl}$  at  $0^\circ$ . (Jander and Ruppolt, 1937.)

Melting points have been determined for:



## ClO THALLIUM CHLORATE $\text{TlClO}_3$

### SOLUBILITY IN WATER (Muir, 1876)

	$0^\circ$	$20^\circ$	$50^\circ$	$80^\circ$	$100^\circ$
Gms. $\text{TlClO}_3$ per 100 gms. $\text{H}_2\text{O}$ :	2	3.92	12.67	36.65	57.31

One liter sat. aq. solution contains 38.51 gms.  $\text{TlClO}_3$  at  $20^\circ$ . (Noyes and Farrel, 1911.)

One liter of aqueous solution, saturated with both salts, contains 30.4 gms.  $\text{TlClO}_3$  + 34.43 gms.  $\text{Ti}_2\text{SO}_4$  at  $20^\circ$ . (Noyes and Farrel, 1911.)

### SOLUBILITY OF MIXED CRYSTALS OF THALLIUM CHLORATE AND POTASSIUM CHLORATE IN WATER AT $10^\circ$ (Roozeboom, 1891)

NOTE.--Solutions of the two salts were mixed in different proportions and allowed to crystallize, such amounts being taken that not more than one or two grams would separate from one liter.

Gms. per 1000 cc. Solution		Mg. Mols. per 1000 cc. Solution		Sp. Gr. of Solutions	Mols. per cent $\text{KClO}_3$ in Mixed Crystals
$\text{TlClO}_3$	$\text{KClO}_3$	$\text{TlClO}_3$	$\text{KClO}_3$		
25.637	-	89.14	-	1.0210	0
19.637	6.884	68.27	56.15	1.0222	2
12.001	26.100	41.73	212.89	1.0278	12.61
9.036	40.064	31.42	326.79	1.0338	25.01
7.885	46.497	27.42	379.26	1.0359	36.30 - 97.93
7.935	46.535	27.60	379.57	1.0360	
6.706	46.410	23.32	378.55	1.0357	
6.723	47.109	23.37	384.25	1.0363	
4.858	47.312	16.89	385.91	1.0345	99.62
2.769	47.134	9.63	384.46	1.0330	99.67
-	49.925	-	407.22	1.0330	100

SOLUBILITY OF MIXED CRYSTALS OF THALLIUM CHLORATE AND POTASSIUM  
CHLORATE IN WATER AT DIFFERENT TEMPERATURES  
(Quoted by Rabe, 1902)

100 gms. H<sub>2</sub>O dissolve 2.8 gms. TlClO<sub>3</sub> + 3.3 gms. KClO<sub>3</sub> at 0°.  
 " H<sub>2</sub>O dissolve 10 gms. TlClO<sub>3</sub> + 1.5 gms. KClO<sub>3</sub> at 15°.  
 " H<sub>2</sub>O dissolve 12.67 gms. TlClO<sub>3</sub> + 16.2 gms. KClO<sub>3</sub> at 50°.  
 " H<sub>2</sub>O dissolve 57.3 gms. TlClO<sub>3</sub> + 48.2 gms. KClO<sub>3</sub> at 100°.

THALLIUM PERCHLORATE TlClO<sub>4</sub>

ClO

## SOLUBILITY IN WATER

(Carlson, 1910)			(Noonan, 1948)		
t°	Sp. Gr. Sat. Sol.	Gms. TlClO <sub>4</sub> per 100 Gms. H <sub>2</sub> O	t°	Gms. TlClO <sub>4</sub> per 100 gms. H <sub>2</sub> O	
0	1.060	6.00	5	6.71	
10	1.075	8.04	15	10.36	
30	1.146	19.72		(10) <sup>a</sup>	
50	1.251	39.62	25	15.5	
70	1.430	65.32	35	22.5	
80	1.520	81.49	100	(166.6) <sup>a</sup>	

<sup>a</sup>Roscoe, 1866

SOLUBILITY OF THALLIUM PERCHLORATE IN WATER AND DEUTERIUM OXIDE  
(Noonan, 1948)

	Moles TlClO <sub>4</sub> per 100 moles of Solvent			
	5°	15°	25°	35°
H <sub>2</sub> O	0.3978	0.615	0.921	1.337
91.6% D <sub>2</sub> O	-	-	0.763	1.129
99.7% D <sub>2</sub> O	0.304	0.488	-	-
100% D <sub>2</sub> O	0.304	0.488	0.748	1.110

100 gms. liquid sulfur dioxide (SO<sub>2</sub>) dissolve 0.013 gm. TlClO<sub>4</sub> at  
0°. (Jander and Ruppolt, 1937.)

THALLIUM CHROMATE Tl<sub>2</sub>CrO<sub>4</sub>

CrO

100 gms. H<sub>2</sub>O dissolve 0.03 gm. Tl<sub>2</sub>CrO<sub>4</sub> at 60°, and 0.2 gm. at 100°.  
(Browning and Hutchins, 1900.)

1 liter of aq. 31 per cent KOH solution dissolves 18 gms. Tl<sub>2</sub>CrO<sub>4</sub>.  
(Lepierre and Lachland, 1891.)

## Tl THALLIUM

### SOLUBILITY OF THALLIUM CHROMATE IN WATER AND IN AQUEOUS SOLUTIONS AT 20° (Moser and Brukl, 1926)

Constant agitation was employed for securing saturation.

	Solvent	Gms. $Tl_2CrO_4$ per liter sat. sol.
CrO	Water	0.0427
	Aq. 60% Ethyl Alcohol	0.0092
	Aq. 70% Ethyl Alcohol	0.0080
	Aq. 80% Ethyl Alcohol	0.0072
	Aq. 96% Ethyl Alcohol	0.0060
	Aq. 2% $NH_3$ + 1% $K_2CrO_4$	0.0100
	Aq. 2% $NH_3$ + 2% $K_2CrO_4$	0.0095
	Aq. 5% $NH_3$ + 2% $K_2CrO_4$	0.0142
	Aq. 10% $NH_3$ + 2% $K_2CrO_4$	0.0205
	Aq. 2% $NH_3$ + 4% $K_2CrO_4$ + 10% Alcohol	0.0060

Reaction in the system  $Tl_2CrO_4$  + MgO at 300° was studied by Montignie, 1941a.

### THALLIUM TRICHROMATE $Tl_2Cr_3O_{10}$

One liter of  $H_2O$  dissolves 0.35 gm. thallium trichromate,  $Tl_2Cr_3O_{10}$ , at 15°, and 2.27 gms. at 100°. (Crookes, 1864.)

## F THALLIUM FLUORIDE TlF

100 gms.  $H_2O$  dissolve 80 gms. TlF at 15°. (Büchner, 1865.)

## I THALLIUM IODIDE TlI

### SOLUBILITY IN WATER

Average results from Böttger, 1903; Kohlrausch, 1904-05, 1908; Werther; Crookes, 1864; Lamy; Heberling; Jones and Schumb, 1921; Davies and Robinson, 1937.

$t^\circ$	Gms. TlI per liter	$t^\circ$	Gms. TlI per liter
0	0.02	40	0.15
10	0.036	60	0.35
18	0.056	80	0.70
20	0.06	100	1.20
25	0.08		

## THALLIUM IODIDE TlI

SOLUBILITY OF THALLIUM IODIDE IN AQUEOUS SALT SOLUTIONS AT 20°  
(Viktorin and Sirucek, 1939)

Moles Salt per 1000 gms. of Water	Moles TlI per 1000 gms. of Water x 10 <sup>4</sup>					
	NaNO <sub>3</sub>	MgSO <sub>4</sub>	Ba(NO <sub>3</sub> ) <sub>2</sub>	p-Cl <sub>6</sub> H <sub>4</sub> SO <sub>3</sub> Na	(NH <sub>4</sub> ) <sub>2</sub> ·SO <sub>4</sub>	Na <sub>2</sub> SO <sub>4</sub>
0.0	1.901	-	-	-	-	-
.001	-	1.988	-	-	2.064	-
.005	1.999	-	2.103	-	2.225	2.130
.0075	-	2.191	-	-	-	-
.01	-	-	-	2.040	-	2.268
.011	-	-	-	-	2.390	-
.02	-	2.375	2.312	-	-	-
.025	-	-	-	-	-	2.512
.04	2.254	2.553	-	-	-	-
.05	-	-	2.502	-	-	-
.06	-	-	-	-	-	2.819
.075	-	-	-	2.317	-	-
.10	2.508	-	-	-	-	-
.15	-	-	-	2.458	-	-
.16	2.684	-	-	-	-	-

EQUILIBRIUM IN THE SYSTEMS THALLOUS IODIDE - IODINE - BENZENE AND  
THALLOUS IODIDE - IODINE - TOLUENE AT 6°  
(Foote and Fleischer, 1940)

With Toluene		With Benzene	
Wt. % I <sub>2</sub> in Solution	Solid Phase	Wt. % I <sub>2</sub> in Solution	Solid Phase
0.044	TlI + Tl <sub>6</sub> I <sub>8</sub>	0.038	TlI + Tl <sub>6</sub> I <sub>8</sub>
.17	Tl <sub>6</sub> I <sub>8</sub>	.18	Tl <sub>6</sub> I <sub>8</sub>
.74	"	.36	"
1.51	"	.75	"
1.75	"	1.40	"
1.81	"	1.43	"
2.28	Tl <sub>6</sub> I <sub>8</sub> + TlI <sub>3</sub>	1.57	"
2.97	TlI <sub>3</sub>	1.98	Tl <sub>6</sub> I <sub>8</sub> + TlI <sub>3</sub>
9.40	"	3.07	TlI <sub>3</sub>
10.12	TlI <sub>3</sub> + I <sub>2</sub>	8.27	"
		8.63	TlI <sub>3</sub> + I <sub>2</sub>

100 gms. liquid sulfur dioxide (SO<sub>2</sub>) dissolve 0.06 gm. TlI at 0°.  
(Jander and Ruppolt, 1937.)

Data for the temperatures of solidification of mixtures of TlI and TlNO<sub>3</sub> are given by Van Eyk (1901).

Reaction in the system TlI + MgO at 300° was studied by Montignie, 1941a.

# TI THALLIUM

## IO THALLIUM IODATE $TlIO_3$

### SOLUBILITY IN WATER

$t^\circ$	Gms. $TlIO_3$ per liter sat. sol.	Reference
0	0.246	Bell and George, 1953
18	0.536	Pederson, 1941
20	0.578	Böttger, 1903
25	0.695	Failley, 1946
	0.698	Failley, 1933a
	0.688	Friedman and LaMer, 1931
	0.698	LaMer and Goldman, 1931
	0.701	Keefer and Rieber, 1941a
	0.696	Bell and George 1953
40	1.152	Bell and George, 1953

### SOLUBILITY OF THALLIUM IODATE IN AQUEOUS SALT SOLUTIONS AT $25^\circ$ (LaMer and Goldman, 1929)

Concentration of Aq. salt sol. in Gm. Mols. per liter	Gm. Mols. $TlIO_3$ per liter sat. sol.	Concentration of Aq. salt sol. in Gm. Mols. per liter	Gm. Mols. $TlIO_3$ per liter sat. sol.
$H_2O$ alone	0.001819 (1)	0.01 $NaNO_3$	0.002456
0.001 $K_2SO_4$	0.001912	0.0333 $Na_2SO_4$	0.002543
0.002 "	0.001958	0.05 "	0.002740
0.005 "	0.002075	0.005 $MgSO$	0.002668
0.010 "	0.002193	0.01 "	0.002172
0.013 "	0.002252	0.025 "	0.002387
0.020 "	0.002513	0.05 "	0.002640
0.0333 "	0.002544	0.05 "	0.002625 (1)
0.05 "	0.002747	0.01 $KCl$	0.002005
0.064 "	0.002877	0.02 "	0.002107
0.15 "	0.003520	0.05 "	0.002335
0.25 "	0.004028	0.10 "	0.002625
0.50 "	0.005128	0.0333 $MgCl_2$	0.002544
0.01 $KNO_3$	0.001987	0.05 "	0.002744
0.02 "	0.002079	0.05 "	0.002755 (1)
0.05 "	0.002270	0.10 $NaCl$	0.002620
0.10 "	0.002492	0.0333 $Mg(NO_3)_2$	0.002459
0.30 "	0.003126	0.05 "	0.002621
0.50 "	0.003673	0.05 $ZnSO_4$	0.002789
1.00 "	0.004821	0.05 $CdSO_4$	0.002798 (1)
		0.05 $CdCl_2$	0.002708 (1)

(1) Results in a later paper by Friedman and LaMer, 1931.

SOLUBILITY OF THALLOUS IODATE IN AQUEOUS ELECTROLYTES  
(Bell and George, 1953)

In Aqueous  $K_2SO_4$

<u>At 0°</u>		<u>At 25°</u>		<u>At 40°</u>	
Millimoles per liter		Millimoles per liter		Millimoles per liter	
$K_2SO_4$	$TlIO_3$	$K_2SO_4$	$TlIO_3$	$K_2SO_4$	$TlIO_3$
0.0	0.650	0.0	1.838	0.0	3.043
4.48	.732	1.98	1.948	2.46	3.241
9.87	.782	4.53	2.044	6.75	3.465
15.84	.827	9.52	2.177	13.76	3.709
21.52	.861	18.44	2.349	20.70	3.895
32.83	.921	28.61	2.486	30.59	4.108

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In Aqueous KCl

<u>At 0°</u>		<u>At 25°</u>		<u>At 40°</u>	
Millimoles per liter		Millimoles per liter		Millimoles per liter	
KCl	$TlIO_3$	KCl	$TlIO_3$	KCl	$TlIO_3$
5.71	0.697	4.90	1.930	5.81	3.196
14.12	0.738	12.57	2.025	15.39	3.380
24.83	0.778	25.65	2.158	30.44	3.595
40.59	0.831	40.81	2.266	48.92	3.805
51.74	0.853	54.22	2.359	57.38	3.881

In Aqueous KOH

<u>At 0°</u>		<u>At 25°</u>		<u>At 40°</u>	
Millimoles per liter		Millimoles per liter		Millimoles per liter	
KOH	$TlIO_3$	KOH	$TlIO_3$	KOH	$TlIO_3$
4.91	0.690	3.00	1.915	5.60	3.212
10.38	0.721	5.36	1.951	10.66	3.333
20.38	0.761	8.10	1.989	21.43	3.514
35.70	0.809	15.40	2.070	36.18	3.745
49.83	0.844	19.76	2.121	50.07	3.905
71.16	0.896	33.04	2.233	69.72	4.121
93.53	0.943	47.79	2.353	88.46	4.313
		65.93	2.455		
		89.10	2.608		

(Cont.)

# TI THALLIUM

## SOLUBILITY OF THALLOUS IODATE IN AQUEOUS ELECTROLYTES--Cont.

### In Aqueous KSCN

At 0°		At 25°		At 40°	
Millimoles per liter		Millimoles per liter		Millimoles per liter	
KSCN	TlIO <sub>3</sub>	KSCN	TlIO <sub>3</sub>	KSCN	TlIO <sub>3</sub>
4.63	0.693	4.09	1.927	5.54	3.188
5.04	0.699	18.31	2.100	15.63	3.383
10.03	0.730	31.62	2.232	32.29	3.620
16.95	0.758	45.00	2.346	45.05	3.772
23.64	0.787	55.90	3.885	46.46	
24.80	0.794				

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### In Aqueous K<sub>4</sub>Fe(CN)<sub>6</sub>

At 0°		At 25°		At 40°	
Millimoles per liter		Millimoles per liter		Millimoles per liter	
K <sub>4</sub> Fe(CN) <sub>6</sub>	TlIO <sub>3</sub>	K <sub>4</sub> Fe(CN) <sub>6</sub>	TlIO <sub>3</sub>	K <sub>4</sub> Fe(CN) <sub>6</sub>	TlIO <sub>3</sub>
0.519	0.763	0.504	2.053	0.486	3.304
1.094	0.840	1.386	2.307	0.942	3.505
1.721	0.901	2.343	2.502	1.488	3.694
2.291	0.955	3.767	2.740	2.328	3.970
4.011	1.051	6.132	3.036	3.859	4.326

### In Aqueous NaF at 25°

Millimoles per liter	
NaF	TlIO <sub>3</sub>
4.83	1.919
10.34	1.972
22.57	2.070
33.88	2.125
46.46	2.185

## SOLUBILITY OF THALLIUM IODATE IN AQUEOUS SOLUTIONS OF SODIUM SALTS AT 25° (Failey, 1933a)

Conc. of aq. salt sol. in Gm. Mols. per liter	Gm. Mols. TlIO <sub>3</sub> per liter sat. sol.	Conc. of aq. salt sol. in Gm. Mols. per liter	Gm. Mols. TlIO <sub>3</sub> per liter sat. sol.
H <sub>2</sub> O alone	0.001843	0.005 Na <sub>2</sub> C <sub>12</sub> O <sub>12</sub>	0.004980
0.0001 Na <sub>2</sub> C <sub>12</sub> O <sub>12</sub> (1)	0.001967	0.01 "	0.006184
0.0002 "	0.002092	0.02 NaCl	0.002118
0.0005 "	0.002426	0.04 "	0.002277
0.001 "	0.002901	0.10 "	0.002629
0.002 "	0.003636	0.01 NaOH	0.002003

(1) Sodium mellitate

The author also gives results at 25° for the solubility of thallium iodate in aqueous 0.001 and 0.02 normal solutions of sodium mellitate to which various amounts of a third salt have been added.

SOLUBILITY OF THALLIUM IODATE IN AQUEOUS SOLUTIONS OF AMINO ACIDS AT 25°  
(Failey, 1933)

Conc. of Aq. Amino Acid Sol. in Gm. Mols. per liter	Gm. Mols. TlIO <sub>3</sub> per liter sat. sol.	Conc. of Aq. Amino Acid Sol. in Gm. Mols. per liter	Gm. Mols. TlIO <sub>3</sub> per liter sat. sol.
H <sub>2</sub> O alone	0.001843	0.20 Sarcosine	0.001993
0.20 Glycylglycine	0.002282	0.10 αAmino n Butyric Acid	0.001966
0.025 Glycine	0.001875	0.2 " "	0.001971
0.05 "	0.001907	0.025 Di methyl Glycine	0.001859
0.10 "	0.001917	0.05 " " "	0.001873
0.15 "	0.002033	0.10 " " "	0.001901
0.20 "	0.002098	0.20 " " "	0.001957
0.025 αAlanine	0.001872	0.05 αAmino iso Butyric Acid	0.001874
0.05 "	0.001907	0.10 " " "	0.001901
0.10 "	0.001963	0.15 " " "	0.001934
0.20 "	0.002084	0.20 " " "	0.001956
0.025 βAlanine	0.001863	0.10 αAmino n Valeric Acid	0.001895
0.05 "	0.001884	0.20 " " "	0.001939
0.10 "	0.001919	0.025 Urea	0.001845
0.15 "	0.001964	0.05 "	0.001851
0.20 "	0.002001	0.10 "	0.001861
0.05 Sarcosine	0.001880	0.15 "	0.001876
0.10 "	0.001917	0.20 "	0.001891
0.15 "	0.001954	0.10 Diketopiperzine	0.001844

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SOLUBILITY OF THALLIUM IODATE IN AQUEOUS SOLUTIONS OF  
ETHYL ALCOHOL AT 25°  
(La Mer and Goldman, 1931)

d. of sat. sol.	Wt. % C <sub>2</sub> H <sub>5</sub> OH in aq. solvent	Gm. Mol. TlIO <sub>3</sub> per liter sat. sol.	d. of sat. sol.	Wt. % C <sub>2</sub> H <sub>5</sub> OH in aq. solvent	Gm. Mol. TlIO <sub>3</sub> per liter sat. sol.
0.99718	0.0	0.001841	0.9478	31.61	0.000297
0.9894	4.25	0.001416	0.9304	40.51	0.000135
0.9780	11.56	0.000915	0.9167	46.91	0.000083
0.9644	21.37	0.000504	-	94.71	trace



# Tl THALLIUM

## SOLUBILITY OF THALLIUM IODATE IN AQUEOUS ALKANE DISULFONATE SOLUTIONS AT 25° (Stone, 1940)

The solvent salts had the general formula  $\text{NaO}_3\text{S}(\text{CH}_2)_x\text{SO}_3\text{Na}$ .  
Results are in moles  $\text{TlIO}_3$  per liter  $\times 10^{-6}$ . The solubility of  $\text{TlIO}_3$  in  
water was  $1833 \times 10^{-6}$  moles per liter.

x	Molarity of Solvent Salt Solution					
	0.0200	0.0100	0.0050	0.0020	0.0010	0.0005
1	2300	2138	2036	1937	1897	1867
2	2220	2094	2009	1927	1887	1868
3	2216	2094	2007	1924	1890	1868
4	2207	2093	2003	1921	1891	1860
5	2198	2079	1997	1915	1884	1860
6	2196	2084	1995	1920	1890	1860
10	2176	2071	1994	1924	1885	1861
14	2135	2054	1977	--	1873	1856

## SOLUBILITY OF THALLOUS IODATE IN AQUEOUS UREA AND DIOXANE SOLUTIONS (Pederson, 1941)

17.85°			18.00°	
Moles Urea per 1000 ml. Solvent	Moles $\text{TlIO}_3$ per 1000 ml. Sat. Sol.		Moles Dioxane per 1000 ml. Solvent	Moles $\text{TlIO}_3$ per 1000 ml. Sat. Sol.
0.000	$1.410 \times 10^{-3}$		0.000	$1.417 \times 10^{-3}$
.250	1.467		.250	1.315
.500	1.526		.500	1.213
.750	1.586		.750	1.117
1.000	1.644			

## SOLUBILITY OF THALLOUS IODATE IN AQUEOUS GLYCINE AND ALANINE SOLUTIONS AT 25° (Keefer and Rieber, 1941a)

Moles $\text{TlIO}_3$ per 1000 gms. $\text{H}_2\text{O}$ with:	Moles Glycine or Alanine per 1000 gms. $\text{H}_2\text{O}$				
	0.0	0.0498	0.1000	0.1503	0.2010
Glycine	.001850	.001909	.001976	.002037	.002103
Alanine	.001850	.001896	.001947	.001999	.002043

SOLUBILITY OF THALLIUM IODATE IN AQUEOUS SOLUTIONS OF  
SODIUM SALTS OF BENZENE CARBOXYLIC ACIDS AT 25°  
(Failey, 1946)

S = Solubility of  $\text{TlIO}_3 \times 10^6$  in moles per liter. Concentrations of the solvent salts are in moles per liter.

Sodium Benzoate:	0.0	0.02	0.05	0.10	0.20		
S:	1834	2057	2228	2429	2723		
" o-Phthalate:	.001333	.002667	.00667	.01333	.03333	0.667	
S:	1930	2005	2172	2377	2798	3287	
" m-Phthalate:	.00667	.01333	.03333	.0667			
S:	2053	2171	2401	2655			
" p-Phthalate:	.00667	.01333	.03333	.0667			
S:	2046	2156	2373	2613			
" Trimesate:	.003333	.00667	.01667	.03333			
S:	2069	2189	2416	2661			
Sodium Benzene penta							
Carboxylate:	.0001067	.0002666	.000533	.001334	.002666		
S:	1908	2029	2212	2636	3123		
Sodium							
Pyromellitate:	.0004	.0008	.002	.004	.010	.0120	
S:	1944	2029	2214	2458	2818	3224	

Data are also given for the solubility of thallium iodate in solutions containing a fixed concentration of one of the above salts with varying amounts of  $\text{NaCl}$ ,  $\text{MgCl}_2$ , or  $\text{NaNO}_3$  in addition.

THALLIUM NITRIDE  $\text{TlN}_3$ 

N

SOLUBILITY OF THALLIUM NITRIDE IN WATER  
(Curtius and Rissom, 1898; Suzuki, 1952)

t°	Gm. $\text{TlN}_3$ per 100 gms. sat. sol.	Solid Phase
0	0.171	$\text{TlN}_3$
5	0.196	"
16	0.30	"
25	0.365 (S.)	"

# TI THALLIUM

## NO THALLIUM NITRITE $\text{TiNO}_2$

### SOLUBILITY OF THALLIUM NITRITE IN WATER (Ferrari and Colls, 1937)

t°	d. of sat. sol.	Gms. $\text{TiNO}_2$ per 100 gms. sat. sol.	t°	d. of sat. sol.	Gms. $\text{TiNO}_2$ per 100 gms. sat. sol.
0	1.1471	15.15	50		55.10
5	1.1811	18.43	55	1.9611	61.60
10	1.2383	22.44	60	2.2600	68.40
15	1.2627	25.30	65	2.7080	77.50
20	1.2942	28.75	71	-	86.19
25	1.3601	32.10	78	-	91.49
30	1.4193	34.73	89	-	94.45
35	1.5061	39.95	98	-	95.78
40	1.5771	45.53	110	-	97.42
45	1.6751	49.85	182 m. pt.		100.00

## NO THALLIUM NITRATE $\text{TiNO}_3$

### SOLUBILITY IN WATER (Berkeley, 1904; see also Etard, 1894; Crookes; Lamy)

t°	Gms. $\text{TiNO}_3$ per 100 Gms.		t°	Gms. $\text{TiNO}_3$ per 100 Gms.	
	Solution	Water		Solution	Water
0	3.76	3.91	60	31.55	46.2
10	5.86	6.22	70	41.01	69.5
20	8.72	9.55	80	52.6	111.0
30	12.51	14.3	90	66.66	200.0
40	17.33	20.9	100	80.54	414.0
50	23.33	30.4	105	85.59	594.0

Solid phase  $\text{TiNO}_3$  rhombic

The following results by Chang and Tseng, 1950 are considerably higher than those above, but equilibrium was approached from supersaturation only.

t°	Gms. $\text{TiNO}_3$ per 100 Gms. $\text{H}_2\text{O}$	t°	Gms. $\text{TiNO}_3$ per 100 Gms. $\text{H}_2\text{O}$
5	6.87	30	20.3
10	9.05	35	24.6
15	10.86	40	30.0
20	13.33	45	37.2
25	16.58	50	47.7

SOLUBILITY OF THALLIUM NITRATE IN DEUTERIUM OXIDE SOLUTIONS  
(Noonan, 1948)

t°	Moles TlNO <sub>3</sub> per 100 moles of Solvent			
	90.86% D <sub>2</sub> O	91.59% D <sub>2</sub> O	92.36% D <sub>2</sub> O	100% D <sub>2</sub> O
5	-	-	0.263	0.258
15	-	-	.415	.407
25	-	-	.638	.622
28.37	0.739	-	-	.722
30.11	.793	-	-	.775
35.0	-	0.961	-	.941

Results of Chang and Tseng, 1950, differing from those of Noonan; obtained by equilibrating solutions that had been heated with the salt. NO

t°	Mole % D <sub>2</sub> O in solvent	Moles TlNO <sub>3</sub> per 1000 gms. solvent	t°	Mole % D <sub>2</sub> O in solvent	Moles TlNO <sub>3</sub> per 1000 gms. solvent
5	98.4	0.144	30	95.6	0.434
10	98.4	0.190	35	93.3	0.535
15	94.0	0.232	40	93.7	0.648
20	94.0	0.286	45	98.0	0.802
25	95.6	0.356	50	98.0	1.027

100 gms. H<sub>2</sub>O dissolve 43.5 gms. TlNO<sub>3</sub> + 104.2 gms. KNO<sub>3</sub> at 58°. (Rabe, 1902.)

The freezing-point curve for the system thallium nitrate + thallium nitrite shows that a continuous series of mixed crystals is formed. (Cuttica, 1920.)

Melting points in the system TlNO<sub>3</sub> - Ca(NO<sub>3</sub>)<sub>2</sub> are given by Protzenko and Belova, 1957.

THALLIUM (I) HYDROXIDE TlOH

OH

SOLUBILITY IN WATER  
(Bahr, 1911)

t°	d. of Sat. Sol.	Mols. TlOH per Liter	Gms. TlOH per Liter	t°	Mols. TlOH per Liter	Gms. TlOH per Liter
0	1.231	1.151	254.4	44.5	2.442	539.8
18.5	1.317	1.554	343.4	54.1	2.940	649.7
29	1.342	1.803	398.5	64.6	3.601	795.8
32.1	1.377	1.861	411.2	78.5	4.673	1033
36	1.417	2.075	458.6	90	5.705	1261
40	1.446	2.240	495	99.2	6.708	1483

The solutions were stirred by means of a current of hydrogen. The solid phase is the same at all temperatures.

# TI THALLIUM

## OH THALLIUM (III) HYDROXIDE $Tl(OH)_3$

### SOLUBILITY IN WATER AT 25°

$K_{sp} [Tl^{+++}] [OH^-]^3$	$= 1.0 \times 10^{-45}$	(Schindler, 1957, 1958)
$K_{sp}$	$= 6.3 \times 10^{-46}$	(Suzuki, 1951)
Solubility	$= 1.3 \times 10^{-9}$ moles/liter	(Oka, 1940)

### SOLUBILITY OF THALLIC HYDROXIDE IN AQUEOUS SOLUTIONS OF PERCHLORIC ACID AND OF SULFURIC ACID AT 25° (Sherrill and Haas, 1936)

Results for Aqueous Perchloric Acid		Results for Aqueous Sulfuric Acid	
Wt. formality per liter		Wt. formality per liter	
$HClO_4$	$Tl(OH)_3$	$H_2SO_4$	$Tl(OH)_3$
0.5246	0.00221	0.1590	0.001255
0.9912	0.01485	0.2084	0.002753
1.4943	0.04424	0.2871	0.006880
1.9297	0.08881	0.4676	0.02402
		0.5267	0.03294
		0.6215	0.05038

Fusion-point data for  $Tl_2O + V_2O_5$  are given by Canneri, 1928.

## PO THALLIUM HYPOPHOSPHITE $TlH_2PO_2$

### SOLUBILITY OF THALLIUM HYPO PHOSPHITE IN WATER (Ferrari and Colla, 1937)

t°	Gms. $TlH_2PO_2$ per 100 gms. sat. sol.	Solid Phase	t°	d. of sat. sol.	Gms. $TlH_2PO_2$ per 100 gms. sat. sol.	Solid Phase
- 7	43.68	Ice	0	2.538	77.69	$TlH_2PO_4$
-12	56.91	"	10	2.688	79.90	"
-17	63.63	"	20	2.827	81.53	"
-25e	-	" + $TlH_2PO_2$	25	2.900	83.80	"
-23	70.93	$TlH_2PO_2$	35	3.049	86.32	"
-17	72.37	"	50	3.260	90.64	"
- 9.5	74.42	"	65	-	93.28	"
- 6.0	75.51	"	77	-	95.74	"
			100	-	98.62	"
			110m.pt.	-	100.00	"

e = eutectic

THALLIUM PHOSPHATE (ortho)  $Tl_3PO_4$ 

PO

One liter of sat. aqueous solution contains 4.97 gms.  $Tl_3PO_4$  at 15° and 6.71 gms. at 100°. (Crookes, 1864.)

THALLIUM PERRHENATE  $TlReO_4$ 

ReO

SOLUBILITY OF THALLIUM PER RHENATE IN WATER  
(Noddack and Noddack, 1931)

t°	Gms. $TlReO_4$ per liter sat. sol.	Solid Phase	t°	Gms. $TlReO_4$ per liter sat. sol.	Solid Phase
20.3	1.6	$TlReO_4$	42	5.8	$TlReO_4$
21.5	1.7	"	93	15.4	"
24.8	2.1	"			

THALLIUM SULFIDE  $Tl_2S$ 

S

One liter of sat. aqueous solution contains 0.215 gm.  $Tl_2S$  at 20°. (Böttger, 1903.)

The  $K_{sp}$  is  $7 \times 10^{-20}$  at 25°. (Goates, Gordon and Faux, 1952.)

The results of Moser and Behr, 1924, and of Bruner and Zawadski, 1909, 1910, upon the solubility of thallous sulfide in water are critically reviewed and recalculated by Kolthoff, 1931, and by Ravitz, 1936, in connection with similar results upon other methal sulfides.

1000 cc. aq. 0.01 normal  $H_2SO_4$  saturated with  $H_2S$  at 1 atmosphere pressure, dissolve 1.451 gms.  $Tl_2S$  at 20°. (Moser and Behr, 1924.)

A study of the systems  $TlNO_3 - Na_2S - H_2O$  and  $TlCl_2H_2O_2 - Na_2S - H_2O$  only the sulfide  $Tl_2S$  is obtained. In the system  $TlNO_3 - Pb(NO_3)_2 - Na_2S - H_2O$  the mixed sulfide  $Tl_2S \cdot PbS$  is formed. (Nanobashvili, Shelia and Ivanitskaya, 1957.)

A diagram and discussion of the fusion points of  $Tl_2S + S$ ,  $Tl_2S + Se$  and  $Tl_2S + Te$  are given by Pelabon, 1907.

THALLIUM SULFITE  $Tl_2SO_3$ 

SO

100 gms.  $H_2O$  dissolve 3.34 gms.  $Tl_2SO_3$  at 15.5°. (Seubert and Elten, 1892.)

100 gms. liquid sulfur dioxide ( $SO_2$ ) dissolve 0.242 gm.  $Tl_2SO_3$  at 0°. (Jander and Ruppolt, 1937.)

# Tl THALLIUM

## SO THALLIUM SULFATE $Tl_2SO_4$

### SOLUBILITY IN WATER

Berkeley, 1904; Tutton, 1907 (a); Cohen, de Meester and Moesveld, 1924 (b); Ricci and Fischer, 1952 (c); Hill, Smith and Ricci, 1940. See also Crookes; Lamy; Noyes and Farrel, 1911; Noyes and Stewart, 1911.

t°	Gms. $Tl_2SO_4$ per 100 Gms.		t°	Gms. $Tl_2SO_4$ per 100 Gms.	
	Solution	Water		Solution	Water
0	2.63	2.70	50	8.44	9.21
6.5	-	3.36a		8.44b	-
10	3.57	3.70	60	9.89	10.92
12	-	4.3a		9.79b	-
20	4.64	4.87	70	11.31	12.74
25	5.222c	-	80	12.77	14.61
	5.212d	-	90	14.19	16.53
30	5.80	6.16	99	15.57	18.45
	5.83b	-	100	-	19.14a

<sup>c</sup>density = 1.046

<sup>d</sup>density = 1.064

### Results above 100°

(Benrath, Gjedebo, Schiffers and Wunderlich, 1937)

t°	Gms. $Tl_2SO_4$ per 100	t°	Gms. $Tl_2SO_4$ per 100	t°	Gms. $Tl_2SO_4$ per 100
	gms. sat. sol.		gms. sat. sol.		gms. sat. sol.
116	17.7	173	25.5	271	34.4
130	18.8	188	27.0	359	37 - 76
146	21.5	208	29.0	365	78.8
153	22.4	225	31.2	380	85.7
167	28.8	241	32.4	632 m.pt.	100.0

### SOLUBILITY OF THALLIUM SULFATE IN WATER AT 30° AND UNDER HIGH PRESSURES (Cohen, Voller and Moesveld, 1923)

Pressure in atmospheres	1	500	1000	1500
Gms. $Tl_2SO_4$ per 100 gms. sat. sol.	5.83	7.48	9.03	10.50

### SOLUBILITY OF THALLIUM OXIDE ( $Tl_2O_3$ ) IN AQUEOUS SOLUTIONS OF SULFURIC ACID AT 25°

(Meyer, 1923; Meyer and Wilk, 1924)

Constant agitation in a thermostat was employed.

% $H_2SO_4$	Gms. per 100 cc. Aq. Sulfuric Acid		
	$Tl_2O_3$	$Tl(OH)SO_4 \cdot 2H_2O$	$HTl(SO_4)_2 \cdot 4H_2O$
20	16.2	25.2	-
40	9.8	15.2	-
50	2.52	-	2.9
70	0.30	-	0.61

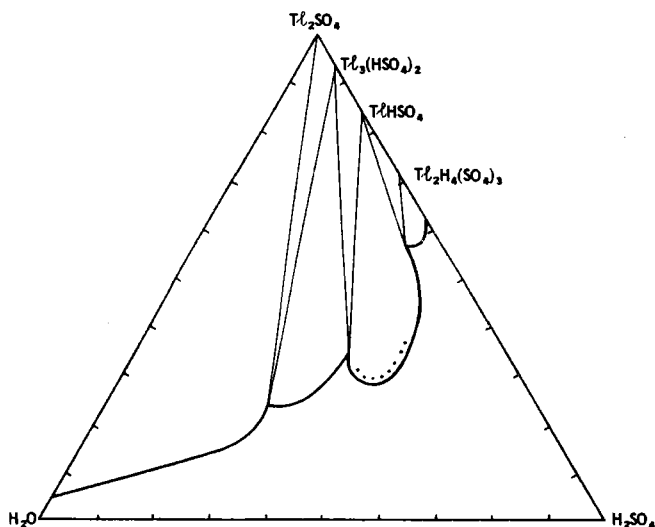
(Cont)

The diagram given by the authors contains three branches, corresponding respectively to the solubility of  $Tl_2O_3$  in dilute sulfuric acid and of the two sulfates,  $Tl(OH)SO_4 \cdot 2H_2O$  and  $HTl(SO_4)_2 \cdot 4H_2O$ , in stronger acid. The existence of the basic salt  $Tl(OH)SO_4 \cdot 2H_2O$  requires a concentration of at least 10%  $H_2SO_4$ . The space diagram but not the numerical data is given for determinations at temperatures between  $20^\circ$  and  $95^\circ$ .

SOLUBILITY OF THALLIUM SULFATE IN AQUEOUS SOLUTIONS OF SULFURIC  
ACID AT  $25^\circ$

(D'Ans and Fritsche, 1909)

Mols. per 1000 Gms. Sat. Sol.		Solid Phase	Mols. per 1000 Gms. Sat. Sol.		Solid Phase	SO
$H_2SO_4$	$Tl_2SO_4$		$H_2SO_4$	$Tl_2SO_4$		
0	0.103	$Tl_2SO_4$	4.89	0.59	$TlHSO_4$	
2.99	0.46	" + $Tl_2H(SO_4)_2$	4.92	0.66	"	
4.25	0.61	$Tl_3H(SO_4)_2 + TlHSO_4$	4.78	0.75	"	
4.55	0.56	$TlHSO_4$	4.26	1.01	"	
4.79	0.55	"	4.03	1.08	"	



The System  $Tl_2SO_4 - H_2SO_4 - H_2O$  at  $25^\circ$

Results of Urazov and Bashilova, 1955. These data generally agree with and extend those of D'Ans and Fritsche, above. D'Ans data are plotted as a series of dots.



# Tl THALLIUM

## FREEZING POINTS OF $Tl_2SO_4$ IN $H_2SO_4$ (Gillespie and Oubridge, 1956)

Molality of $Tl_2SO_4$ in $H_2SO_4$ :	0.0	0.02	0.05	0.10
Freezing point: ( $^{\circ}C$ )	10.365 $^{\circ}$	10.000 $^{\circ}$	9.328 $^{\circ}$	8.170 $^{\circ}$

## SOLUBILITY OF THALLIUM SULFATE IN AQUEOUS SOLUTIONS AT 25 $^{\circ}$ (Noyes and Stewart, 1911)

Solvent		Saturated Solution				
Salt present	Formula Wts. Salt per Liter	Formula Wts. Salt per Liter	Formula Wts. $Tl_2SO_4$ per Liter	$d_{25}$ of Sat. Sol.	Gms. Salt per Liter	Gms. $Tl_2SO_4$ per Liter
$TlNO_3$	0.0994	0.0996	0.08365	-	26.51	42.17
$Na_2SO_4$	0.04995	0.0497	0.1080	1.0531	7.062	54.44
$Na_2SO_4$	0.20	0.1988	0.1173	1.0754	28.25	59.13
$NaHSO_4$	0.1015	0.1010	0.1161	1.0596	12.12	58.53
$H_2SO_4$	0.04967	0.0494	0.1172	1.0540	4.878	59.09
$H_2SO_4$	0.09933	0.0987	0.1249	1.0604	9.747	62.95

## SO THALLI-THALLO SULFATE $Tl_2SO_4 \cdot Tl_2(SO_4)_2$

### SOLUBILITY OF THALLI-THALLO SULFATE IN AQUEOUS 16.36% SULFURIC ACID (Benrath and Espenschied, 1922)

$t^{\circ}$	Gms. $Tl_2SO_4 \cdot Tl_2(SO_4)_2$ per 100 gms. sat. sol.	$t^{\circ}$	Gms. $Tl_2SO_4 \cdot Tl_2(SO_4)_2$ per 100 gms. sat. sol.
48.5	17.26	61.0	16.89
55.2	16.69	65.5	16.23
60.5	16.89	83.5	15.35

The density of the aqueous  $H_2SO_4$  was 1.115. Below 48 $^{\circ}$  the ratio of  $Tl(1)$  and  $Tl(3)$  in the solution is no longer 1:1 as required for the double salt.

100 gms.  $H_2O$  simultaneously sat. with both salts dissolve:

4.74 gms.  $Tl_2SO_4$  + 10.3 gms.  $K_2SO_4$  at 15 $^{\circ}$ .  
 11.5 gms.  $Tl_2SO_4$  + 16.4 gms.  $K_2SO_4$  at 62 $^{\circ}$ .  
 18.52 gms.  $Tl_2SO_4$  + 26.2 gms.  $K_2SO_4$  at 100 $^{\circ}$ .

(Rabe, 1902)

## THALLIUM DOUBLE SULFATES

50

SOLUBILITY IN WATER AT 25°  
(Locke, 1902)

Double Sulfate	Formula	Salt per 100 cc. H <sub>2</sub> O	
		Gms. Anhydrous	Gms. Mols.
Tl Copper Sulfate	Tl <sub>2</sub> Cu(SO <sub>4</sub> ) <sub>2</sub> ·6H <sub>2</sub> O	8.1	0.0122
Tl Nickel Sulfate	Tl <sub>2</sub> Ni(SO <sub>4</sub> ) <sub>2</sub> ·6H <sub>2</sub> O	4.61	0.007
Tl Zinc Sulfate	Tl <sub>2</sub> Zn(SO <sub>4</sub> ) <sub>2</sub> ·6H <sub>2</sub> O	8.6	0.0129

## THALLIUM ALUMS

50

SOLUBILITY IN WATER AT 25°  
(Locke, 1901)

Alum	Formula	Salt per 100 Grams H <sub>2</sub> O		
		Gms. Anhydrous	Gms. Hydrated	Gm. Mols.
Tl Aluminum Alum	TlAl(SO <sub>4</sub> ) <sub>2</sub> ·12H <sub>2</sub> O	7.5	11.78	0.0177
Tl Vanadium Alum	TlV(SO <sub>4</sub> ) <sub>2</sub> ·12H <sub>2</sub> O	25.6	43.31	0.0573
Tl Chromium Alum	TlCr(SO <sub>4</sub> ) <sub>2</sub> ·12H <sub>2</sub> O	10.48	16.38	0.0212
Tl Iron Alum	TlFe(SO <sub>4</sub> ) <sub>2</sub> ·12H <sub>2</sub> O	36.15	64.6	0.0799

THE SYSTEM THALLIUM SULFATE ZINC SULFATE WATER  
(Benrath, 1931)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
TlSO <sub>4</sub>	ZnSO <sub>4</sub>		TlSO <sub>4</sub>	ZnSO <sub>4</sub>	
<u>At 0°</u>					
0.81	26.81	ZnSO <sub>4</sub> ·7H <sub>2</sub> O + 1.1.6	2.32	39.58	ZnSO <sub>4</sub> ·6H <sub>2</sub> O+1.1.6
2.74	0.97	Tl <sub>2</sub> SO <sub>4</sub> + "	2.64	37.16	1.1.6
			3.2	33.6	"
			3.91	28.2	"
			4.39	22.66	"
1.37	34.69	ZnSO <sub>4</sub> ·7H <sub>2</sub> O + 1.1.6	6.12	9.97	"
1.73	26.36	1.1.6	6.82	7.30	"
4.68	2.04	" + Tl <sub>2</sub> SO <sub>4</sub>	8.34	4.48	" + Tl <sub>2</sub> SO <sub>4</sub>
<u>At 17.6°</u>					

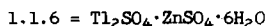
1.1.6 = Tl<sub>2</sub>SO<sub>4</sub>·ZnSO<sub>4</sub>·6H<sub>2</sub>O

(Cont.)

# Tl THALLIUM

## THE SYSTEM THALLIUM SULFATE-ZINC SULFATE-WATER--Cont.

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
Tl <sub>2</sub> SO <sub>4</sub>	ZnSO <sub>4</sub>	Solid Phase	Tl <sub>2</sub> SO <sub>4</sub>	ZnSO <sub>4</sub>	Solid Phase
At 64.5°			At 100°		
2.93	41.07	ZnSO <sub>4</sub> ·H <sub>2</sub> O	3.55	37.10	ZnSO <sub>4</sub> ·H <sub>2</sub> O
5.66	40.04	" + 1.1.6	11.97	34.58	" + 1.1.6
6.35	38.30	1.1.6	24.5	31.3	Tl <sub>2</sub> SO <sub>4</sub>
8.57	34.45	"	23.7	12.11	Tl <sub>2</sub> SO <sub>4</sub>
10.85	21.39	"			
14.71	10.43	" + Tl <sub>2</sub> SO <sub>4</sub>			
13.95	8.77	Tl <sub>2</sub> SO <sub>4</sub>			



## SOLUBILITY OF THALLIUM SULFATE IN GELATIN SOLUTIONS AT 40° (Eversole and Thomas, 1943)

Addition of gelatin usually increases the aqueous solubility of the salt. Isoelectric (pH  $\approx$  4.7), positive (HAc added until pH  $\approx$  3.6), and negative (NaOH added until pH  $\approx$  6) gelatin all showed about the same effect.

### Grams per 1000 gms. of Water

pH $\approx$ 4.7		pH $\approx$ 3.6		pH $\approx$ 6	
Gelatin	Tl <sub>2</sub> SO <sub>4</sub>	Gelatin	Tl <sub>2</sub> SO <sub>4</sub>	Gelatin	Tl <sub>2</sub> SO <sub>4</sub>
0.0	76.0	22.49	75.6	21.71	76.3
20.78	76.1	48.23	74.9	45.88	77.0
46.52	77.5	67.20	74.5	65.16	77.9
63.80	78.9				

The solubility of thallous sulfate in solutions of egg albumin at 25° was determined by Eversole and Bjork, 1939.

100 gms. liquid sulfur dioxide (SO<sub>2</sub>) dissolve 0.021 gm. Tl<sub>2</sub>SO<sub>4</sub> at 0°. (Jander and Ruppolt, 1937.)

Melting points are given for Tl<sub>2</sub>SO<sub>4</sub> + CdSO<sub>4</sub>, Tl<sub>2</sub>SO<sub>4</sub> + CdCl<sub>2</sub>, Tl<sub>2</sub>SO<sub>4</sub> + CdSO<sub>4</sub> + CdCl<sub>2</sub> by Sementsova, 1936.

THALLIUM SELENATE  $Tl_2SeO_4$ 

SeO

## SOLUBILITY IN WATER

t°	Gms. $Tl_2SeO_4$ per 100 Gms. $H_2O$	Authority
9.3	2.13	(Tutton, 1907)
12	2.4	(Tutton, 1907)
20	2.8	(Glauser, 1910)
80	8.5	(Glauser, 1910)
100	10.86	(Tutton, 1907)

The system  $Tl_2O_3 + SeO_3 + H_2O$  at 25° is described by Meyer and Wilk, 1924, but numerical data are not given. It is stated that the curve is almost identical with that of selenium sulfate but the transition point is at 45%  $H_2SeO_4$  instead of at 40%.

## THALLIUM VANADATES

VO

SOLUBILITY IN WATER  
(Carnelly, 1873; Liebig, 1860)

		Gms. Vanadate per 100 Gms. $H_2O$	
		At 15°	At 100°
Thallium meta vanadate	$TlVO_3$	0.087 (11°)	0.21
Thallium ortho vanadate	$Tl_3VO_3$	1	1.74
Thallium pyro vanadate	$Tl_4V_2O_7$	0.20 (14°)	0.26
Thallium vanadate	$Tl_{12}V_5O_{26}$	0.107	0.29

THULIUM OXALATE  $Tm_2(C_2O_4)_3 \cdot 8H_2O$  (?  $10H_2O$ )

100 cc. aq. 20% methylamine oxalate dissolve approx 4.082 gms. thulium oxalate.

100 cc. aq. 20% ethylamine oxalate dissolve approx. 5.728 gms. thulium oxalate.

100 cc. aq. 20% triethylamine oxalate dissolve approx. 1.340 gms. thulium oxalate. (Grant and James, 1917.)

THULIUM BROMONITROBENZENE SULFONATE  $Tm(C_6H_3Br.NO_2.SO_3, 1.4.2)_3 \cdot 12H_2O$ 

100 gms. sat. solution in water contain 6.379 gms. of the anhydrous salt at 25°. (Katz and James, 1913.)

## U URANIUM

## U URANIUM

The percentage solubility of uranium in mercury at 20°, determined by filtering an amalgam of the metal through a sintered glass filter, was found by Irvin and Russell, 1932, to be less than  $1 \times 10^{-5}$ .

Less than 0.05 wt. % uranium dissolves in metallic sodium at 97.8°. (Douglas, 1954.)

## AsO URANIUM DOUBLE ARSENATES

### SOLUBILITY PRODUCT CONSTANTS (Chukhlantsev and Sharova, 1956)

Measurements made in dilute  $H_2SO_4 + HNO_3$  at pH 2.05 - 5.30.

				Ksp
$[UO_2^{++}]$	$[NH_4^+]$	$[AsO_4^{=}]$	=	$1.71 \times 10^{-24}$
$[UO_2^{++}]$	$[K^+]$	$[AsO_4^{=}]$	=	$2.52 \times 10^{-23}$
$[UO_2^{++}]$	$[Na^+]$	$[AsO_4^{=}]$	=	$1.35 \times 10^{-22}$
$[UO_2^{++}]$	$[Li^+]$	$[AsO_4^{=}]$	=	$1.52 \times 10^{-19}$
$[UO_2^{++}]$	$[HAsO_4^{-}]$		=	$3.17 \times 10^{-11}$

## CH URANYL FORMATE $UO_2(HCOO)_2$

### SOLUBILITY IN WATER

(Solid phase is a monohydrate)

15° 7.2 gms.  $UO_2(HCOO)_2$  per 100 cc. sat. sol. (Courtois, 1914)

### SOLUBILITY OF URANYL FORMATE IN AQUEOUS SOLUTIONS OF FORMIC ACID AT 25° (Colani, 1929)

The solutions were kept in darkness during the period of saturation. When uranyl formate is dissolved in water or dilute solutions of formic acid, a precipitate of basic formate separates after a short time. This increases in solubility with increase in concentration of formic acid until the neutral formate is formed. This latter then decreases in solubility with increase in the concentration of formic acid.

SOLUBILITY OF URANYL FORMATE IN AQUEOUS SOLUTIONS OF  
FORMIC ACID AT 25°---Cont.

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
UO <sub>2</sub>	HCOOH		UO <sub>2</sub>	HCOOH	
0.076	0.012	UO <sub>3</sub> ·2H <sub>2</sub> O·UO <sub>2</sub> (HCOO) <sub>2</sub> ·H <sub>2</sub> O	4.12	20.16	UO <sub>2</sub> (HCOO) <sub>2</sub> ·H <sub>2</sub> O
0.368	0.285	"	2.52	31.57	"
0.759	0.806	"	1.15	44.85	"
1.07	1.33	"	0.765	50.67	"
3.06	4.88	"	0.325	61.23	"
4.87	8.23	"	0.116	72.29	"
6.05	10.87 (1)	" + UO <sub>2</sub> (HCOO) <sub>2</sub> ·H <sub>2</sub> O	0.058	85.86	"
5.71	12.33	UO <sub>2</sub> (HCOO) <sub>2</sub> ·H <sub>2</sub> O	0.057	93.93	"

(1) This result corresponds to 7.99 gms. UO<sub>2</sub>(HCOO)<sub>2</sub>·H<sub>2</sub>O per 100 gms. sat. solution at 25°.

URANYL ACETATE UO<sub>2</sub>(CH<sub>3</sub>COO)<sub>2</sub>

CH

SOLUBILITY IN WATER

(Solid phase is a dihydrate)

17°      7.73 gms. per 100 cc. sat. sol.      (Courtois, 1914.)

SOLUBILITY OF URANYL ACETATE IN AQUEOUS SOLUTIONS OF ACETIC ACID AT 25°  
(Colani, 1927a)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
UO <sub>2</sub>	CH <sub>3</sub> COOH		UO <sub>2</sub>	CH <sub>3</sub> COOH	
0.549	0.270	2.1	3.11	30.70	UO <sub>2</sub> (CH <sub>3</sub> COO) <sub>2</sub> ·2H <sub>2</sub> O
0.883	0.499	"	2.88	36.9	"
1.11	0.618	"	2.65	41.1	"
1.28	0.747	"	2.36	46.4	"
2.07	1.20	"	1.87	56.7	"
4.12	2.32	" + 1.1.3	1.38	65.9	"
4.47	2.49	1.1.3	0.831	77.4	"
4.39	2.64 (1)	" + UO <sub>2</sub> (CH <sub>3</sub> COO) <sub>2</sub> ·2H <sub>2</sub> O	0.858	79.9	" + 1.2.1
4.54	2.87	UO <sub>2</sub> (CH <sub>3</sub> COO) <sub>2</sub> ·2H <sub>2</sub> O	0.645	81.6	1.2.1
4.07	4.55	"	0.405	88.2	"
3.79	11.3	"	0.306	97.8	"
3.30	24.8	"			

2.1 = 2(UO<sub>2</sub>)(OH)<sub>2</sub>·UO<sub>2</sub>(CH<sub>3</sub>COO)<sub>2</sub>; 1.2.1 = UO<sub>2</sub>(CH<sub>3</sub>COO)<sub>2</sub>·2CH<sub>3</sub>COOH·H<sub>2</sub>O;  
1.1.3 = UO<sub>2</sub>(OH)<sub>2</sub>·UO<sub>2</sub>(CH<sub>3</sub>COO)<sub>2</sub>·3H<sub>2</sub>O.

(1) This results corresponds to 7.24 gm. UO<sub>2</sub>(CH<sub>3</sub>COO)<sub>2</sub>·2H<sub>2</sub>O and 0.39 gm. free acetic acid per 100 gms. sat. solution.

# U URANIUM

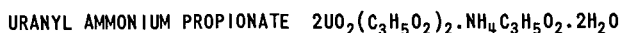
## CH URANYL PROPIONATE, BUTYRATE, VALERATE

SOLUBILITY OF EACH SEPARATELY IN WATER  
(Courtois, 1914)

		t°	Gms. Anhydrous Cmpd. per liter sat. sol.
Uranyl Formate	$\text{UO}_2(\text{HCOO})_2 \cdot \text{H}_2\text{O}$	15	72.0
Uranyl Acetate	$\text{UO}_2(\text{CH}_3\text{COO})_2 \cdot 2\text{H}_2\text{O}$	17	77.3
Uranyl Propionate	$\text{UO}_2(\text{C}_2\text{H}_5\text{COO})_2 \cdot 2\text{H}_2\text{O}$	19	84.8
Uranyl <u>n</u> Butyrate	$\text{UO}_2(\text{C}_3\text{H}_7\text{COO})_2 \cdot 2\text{H}_2\text{O}$	17	105.3
Uranyl Iso "	"	20	42.5
Uranyl <u>n</u> Valerate	$\text{UO}_2(\text{C}_4\text{H}_9\text{COO})_2 \cdot 2\text{H}_2\text{O}$	14	37.2

100 gms. methyl alcohol dissolve 0.74 gm. anhydrous uranyl acetate at 15° and 0.83 gm. at 66° (b.pt.).

100 gms. acetone dissolve 2.37 gms. anhydrous uranyl acetate at 15°. (Henstock, 1934.)

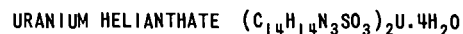


100 gms. aq. solution contain 16.48 gms.  $2\text{UO}_2(\text{C}_3\text{H}_5\text{O}_2)_2 \cdot \text{NH}_4\text{C}_3\text{H}_5\text{O}_2$  at 29.8°.

100 gms. aq. solution contain 2.362 gms.  $\text{UO}_2(\text{C}_3\text{H}_5\text{O}_2)_2 + 0.82$  gm.  $\text{KC}_3\text{H}_5\text{O}_2$  at 29.4°, atomic relation, 1:1.29. (Rimbach, 1904.)



The double salt is decomposed by water at ordinary temperatures and the solution gets richer in uranyl butyrate. The solubility at 29.4° in water containing  $\text{KC}_4\text{H}_7\text{O}_2$  is 2.10 gms.  $\text{UO}_2(\text{C}_4\text{H}_7\text{O}_2)_2 + 0.38$  gm.  $\text{KC}_4\text{H}_7\text{O}_2$  per 100 gms. solution. The atomic relation being 1:0.64. (Rimbach, 1904.)



1000 cc.  $\text{H}_2\text{O}$  dissolve 0.30 gm. hydrated uranium helianthate at 20-25°. (Stark and Dehn, 1918.)

Data for the extraction of  $\text{UO}_2^{++}$  from aqueous solutions containing various organic compounds have been reported:

Organic Compound	Solvent System (+ $\text{H}_2\text{O}$ )	t°	Reference	
0-hydroxybenzoic acid 3,5-dinitrobenzoic acid cinnamic acid	methyl isobutyl ketone chloroform	25	Hok-Bernstrom, 1956	
acetylacetone	benzene	25	Rydberg and Rydberg, 1955	
0-hydroxybenzoic acid methoxybenzoic acid,	hexone	25	Hok-Bernstrom 1956a	
5,7-dichloro, 5,7-dibromo, 5,7-diiodo, 5 chloro-7-iodo 8-hydroxyquinolates	chloroform	25	Dyrssen, Dyrssen and Johansson, 1956	CH
cupferron	ether	--	Furman, Mason and Pekola, 1949	
cupferron 8 hydroxyquinoline	chloroform, hexone	--	Dyrssen and Dahlberg, 1953	

In a saturated solution in dioxane, the mole fraction of uranium 8-hydroxyquinolate is 0.00051. (Charles and Freiser, 1951.)

#### URANYL FERROCYANIDE $(\text{UO}_2)_2\text{Fe}(\text{CN})_6$

CN

A saturated solution in water contains  $8.0 \times 10^{-5}$  gm. ions  $\text{UO}_2^{++}$ . (Tananaev, Glushkova and Seifer, 1956.)

#### URANYL CARBONATE $\text{UO}_2\text{CO}_3$

CO

#### SOLUBILITY IN SODIUM CARBONATE SOLUTIONS AT 26° (Blake, et al., 1956)

Solid phase  $\text{UO}_2\text{CO}_3$

Moles per liter sat. sol.

Moles per liter sat. sol.

$\text{Na}_2\text{CO}_3$	$\text{UO}_2\text{CO}_3$	$d_{25}^\circ$	$\text{Na}_2\text{CO}_3$	$\text{UO}_2\text{CO}_3$	$d_{25}^\circ$
0.094	0.087	1.029	0.755	0.742	1.257
0.189	0.174	1.061	0.943	0.886	1.314
0.377	0.338	1.121	1.13	1.09	1.373
0.566	0.521	1.188	1.41	1.35	1.421



# U URANIUM

## CO URANYL AMMONIUM CARBONATE $\text{UO}_2\text{CO}_3 \cdot 2(\text{NH}_4)_2\text{CO}_3$

### SOLUBILITY IN WATER (Girolitti and Vecchiarelli, 1905)

A large excess of the double carbonate was agitated with water at constant temperature and the clear saturated solutions analyzed.

t°	Gms. per 100 Gms. Sat. Sol.			Mol. Ratio		
	U	CO <sub>2</sub>	NH <sub>3</sub>	U	CO <sub>2</sub>	NH <sub>3</sub>
18.6	2.71	1.54	0.795	1	3.08	4.10
36.5	3.09	2.29	1.188	1	4.01	5.35
48.3	3.03	2.71	1.35	1	4.95	6.35
62	-	3.17	1.62	-	-	-
87.3	3.95	3.96	2.027	1	5.42	7.15

Theoretical molecular ratio for  $\text{UO}_2\text{CO}_3 \cdot 2(\text{NH}_4)_2\text{CO}_3 = 1:3:4$ .

Thus at the lower temperature, the composition of the dissolved salt is very near the ratio corresponding to the formula.

The author calculates that 6.04 gms. of  $\text{UO}_2\text{CO}_3 \cdot 2(\text{NH}_4)_2\text{CO}_3$  are contained in 100 gms. of the sat. solution at 18.6° (a recalculation from the U value, 2.71, indicates that this figure should be 5.26 gms.).

## URANYL CAMPHO CARBONATE $\text{UO}_2(\text{C}_{11}\text{H}_{15}\text{O}_3)_2$

### SOLUBILITY OF URANYL CAMPHO CARBONATE IN SEVERAL SOLVENTS (Picon, 1931)

Gms. UO <sub>2</sub> (C <sub>11</sub> H <sub>15</sub> O <sub>3</sub> ) <sub>2</sub> per liter sat. sol.			Gms. UO <sub>2</sub> (C <sub>11</sub> H <sub>15</sub> O <sub>3</sub> ) <sub>2</sub> per liter sat. sol.		
Solvent	t°		Solvent	t°	
Ethyl Ether	7	22.4	Benzene	7	79.1
Acetone	7	13.5	Chloroform	7	61.0
Ethyl Acetate	7	52.6	Olive Oil	15	5.84

## CO URANYL OXALATE $\text{UO}_2 \cdot \text{C}_2\text{O}_4$

### SOLUBILITY OF URANYL OXALATE IN WATER (Colani, 1925)

t°	11.0	15.0	20.0	50.0	75.0	100.0
Gms. $\text{UO}_2\text{C}_2\text{O}_4$ per 100 gms. sat. sol.	0.45	0.47	0.50	1.00	1.65	3.06

The solid phase was  $\text{UO}_2 \cdot \text{C}_2\text{H}_4 \cdot 3\text{H}_2\text{O}$  in all cases.

100 gms.  $\text{H}_2\text{O}$  dissolve 0.7401 gm.  $\text{UO}_2\text{C}_2\text{O}_4 \cdot 3\text{H}_2\text{O}$  at  $25^\circ$ . (Dittrich, 1899.)

SOLUBILITY OF URANYL OXALATE IN AQUEOUS SOLUTIONS OF ACIDS  
(Colani, 1925)

In Aqueous HCl at  $11^\circ$

Gms. per 100 gms. sat. sol.	
HCl	$\text{UO}_2\text{C}_2\text{O}_4$
3.60	1.14
8.20	2.00
11.49	2.91
14.99	4.90
17.65	8.82

CO

In Aqueous Oxalic Acid at  $15^\circ$

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{H}_2\text{C}_2\text{O}_4$	$\text{UO}_2\text{C}_2\text{O}_4$	Solid Phase	$\text{H}_2\text{C}_2\text{O}_4$	$\text{UO}_2\text{C}_2\text{O}_4$	Solid Phase
1.40	1.56	$\text{UO}_2 \cdot \text{C}_2\text{O}_4 \cdot 3\text{H}_2\text{O}$	7.49	1.55	$\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$
2.66	1.86	"	7.55	1.20	"
4.12	2.02	"	7.56	0.78	"
5.18	2.09	"	7.48	0.39	"
7.33	2.19	"	7.46	0.00	"

In Aqueous Phosphoric Acid  
at  $20^\circ$

Gms. per 100 gms. sat. sol.	
$\text{H}_2\text{PO}_4$	$\text{UO}_2\text{C}_2\text{O}_4$
0.77	2.10
1.51	3.56
2.67	5.66
4.94	9.25
8.75	15.14
15.76	25.74

In Aqueous Sulfuric Acid at  $20^\circ$

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
$\text{H}_2\text{SO}_4$	$\text{UO}_2\text{C}_2\text{O}_4$	$\text{H}_2\text{SO}_4$	$\text{UO}_2\text{C}_2\text{O}_4$
0.00	0.50	15.07	3.85
0.82	0.85	19.88	4.93
2.59	1.34	25.58	5.98
3.05	1.61	27.31	6.46
5.53	2.04	29.67	7.49

Results in oxalic acid solutions up to  $70^\circ$  are given by Bol'shakov, Korovin, Plyushehev and Ermakova, 1957.

# U URANIUM

## SOLUBILITY OF URANYL OXALATE IN AQUEOUS NITRIC ACID SOLUTIONS AT 20°

Results in reasonable agreement with each other.

(Colani, 1925)

(Amphlett and Davidge, 1952)

	Gms. per 100 gms. sat. sol.		Wt. % HNO <sub>3</sub> in Solvent	Wt. % UO <sub>2</sub> C <sub>2</sub> O <sub>4</sub> in Sat. Sol.	Solid Phase
	HNO <sub>3</sub>	CO <sub>2</sub> C <sub>2</sub> O <sub>4</sub>			
CO	1.84	0.79	15.1	1.63	UO <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·3H <sub>2</sub> O
	5.34	1.19	26.8	1.88	"
	12.14	1.56	27.9	1.87	"
	17.60	1.76	35.8	2.19	UO <sub>2</sub> C <sub>2</sub> O <sub>4</sub>
	21.47	1.88	41.5	2.68	"
	31.00	2.28	42.0	2.84	"
			46.5	3.48	"
			58.9	4.04	"

## THE SYSTEM URANYL OXALATE - POTASSIUM OXALATE - WATER

(Colani, 1916a)

### Results at 15°

Gms. per 100 Gms. Sat. Sol.		Solid Phase
UO <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	
0.47	0	UO <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·3H <sub>2</sub> O
1.34	0.42	" + K <sub>2</sub> (UO <sub>2</sub> ) <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> ·4H <sub>2</sub> O
3.89	1.83	K <sub>2</sub> (UO <sub>2</sub> )(C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub> ·3 <sup>1</sup> / <sub>2</sub> H <sub>2</sub> O + "
3.76	1.85	" + K(UO <sub>2</sub> ) <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>5</sub> ·10H <sub>2</sub> O
0.10	24.30	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O + "
0	24.09	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O

### Results at 50°

Gms. per 100 Gms. Sat. Sol.		Solid Phase
UO <sub>2</sub> P <sub>2</sub> O <sub>4</sub>	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	
1	0	UO <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·3H <sub>2</sub> O
3.45	1.11	" + K <sub>2</sub> (UO <sub>2</sub> ) <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> ·4H <sub>2</sub> O
9.82	4.83	K <sub>2</sub> (UO <sub>2</sub> )(C <sub>2</sub> O <sub>4</sub> ) <sub>2</sub> + "
9.59	5.61	" + K(UO <sub>2</sub> ) <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>5</sub> ·10H <sub>2</sub> O
1.22	32.65	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O + "
0	32.75	K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O

SOLUBILITY OF URANYL OXALATE IN AQUEOUS SODIUM OXALATE AT 25°  
(Dittrich, 1899)

Gms. $\text{Na}_2\text{C}_2\text{O}_4$ per 100 cc. Solution	Gms. $\text{UO}_2 \cdot \text{C}_2\text{O}_4 \cdot 3\text{H}_2\text{O}$ per 100 cc. Sat. Solution
0.6706	2.0126
0.3353	0.9867
0.2235	0.6059

THE SYSTEM URANYL OXALATE - AMMONIUM OXALATE - WATER  
(Colani, 1917)

Gms. per 100 Gms. Sat. Sol.

CO

$\text{UO}_2\text{C}_2\text{O}_4$        $(\text{NH}_4)_2\text{C}_2\text{O}_4$

Solid Phase

Results at 15°

0.47	0	$\text{UO}_2\text{C}_2\text{O}_4 \cdot 3\text{H}_2\text{O}$
7.19	2.14	" + $(\text{NH}_4)_2(\text{UO}_2)_3(\text{C}_2\text{O}_4)_3 \cdot 3\text{H}_2\text{O}$
8.78	2.99	$(\text{NH}_4)_2(\text{UO}_2)(\text{C}_2\text{O}_4)_3 \cdot 2\text{H}_2\text{O}$ + "
9.66	6.43	" + $(\text{NH}_4)_2\text{C}_2\text{O}_4 \cdot \text{H}_2\text{O}$
0	3.69	$(\text{NH}_4)_2\text{C}_2\text{O}_4 \cdot \text{H}_2\text{O}$

Results at 50°

1	0	$\text{UO}_2 \cdot \text{C}_2\text{O}_4 \cdot 3\text{H}_2\text{O}$
5.11	1.36	" + $(\text{NH}_4)_2(\text{UO}_2)_3(\text{C}_2\text{O}_4)_3$
19.89	8.52	$(\text{NH}_4)_2(\text{UO}_2)(\text{C}_2\text{O}_4)_2$ + "
23.82	15.90	" + $(\text{NH}_4)_2\text{C}_2\text{O}_4 \cdot \text{H}_2\text{O}$
0	9.36	$(\text{NH}_4)_2\text{C}_2\text{O}_4 \cdot \text{H}_2\text{O}$

Two determinations at 75° are also given.

URANIUM OXALATE  $\text{U}(\text{C}_2\text{O}_4)_2$

SOLUBILITY OF URANIUM OXALATE IN AQUEOUS ACIDS AT 25°  
(Grinberg, Petrzhak and Evteen, 1958; Grinberg and Petrzhak, 1956)

	Gms. $\text{U}(\text{C}_2\text{O}_4)_2 \cdot 6\text{H}_2\text{O}$ per liter sat. sol.					
Normality of acid:	0	0.1	0.25	0.5	1.0	1.5
$\text{H}_2\text{SO}_4$	0.050	0.041	-	0.143	0.195	-
$\text{HNO}_3$	-	0.027	0.038	0.056	0.096	0.141
$\text{HCl}$	-	-	-	-	0.085	-
$\text{HClO}_4$	-	0.023	-	0.046	0.076	-
$\text{HC}_2\text{H}_3\text{O}_2$	-	0.020	-	0.027	0.032	-
$\text{H}_2\text{CO}_3$	(0.030)	-	-	-	-	-

URANYL CHLORIDE  $\text{UO}_2\text{Cl}_2 \cdot 3\text{H}_2\text{O}$

CI

100 gms.  $\text{H}_2\text{O}$  dissolve 320 gms.  $\text{UO}_2\text{Cl}_2$  at 18°. (Mylius and Dietz, 1901.) The densities and molar volumes of dilute uranyl chloride solutions at 25° were determined by Karistinski and Lipilina, 1948.

SOLUBILITY OF URANYL AMMONIUM CHLORIDE, URANYL TETRA METHYL AMMONIUM CHLORIDE, URANYL TETRA ETHYL AMMONIUM CHLORIDE, URANYL CAESIUM CHLORIDE, URANYL RUBIDIUM CHLORIDE, AND URANYL POTASSIUM CHLORIDE IN WATER  
(Rimbach, 1904)

Formula	t°	Gms. per 100 Gms. Sat. Sol.	Atomic Relation in Sol.	Solid Phase
UO <sub>2</sub> Cl <sub>2</sub> .2NH <sub>4</sub> Cl.2H <sub>2</sub> O	15	40.67 UO <sub>2</sub> + 3.51 NH <sub>4</sub> + 19.15Cl	1UO <sub>2</sub> :1.59NH <sub>4</sub> :3.59Cl	1 Mol. double salt + 0.4 Mol. NH <sub>4</sub> Cl
UO <sub>2</sub> Cl <sub>2</sub> .2N(CH <sub>2</sub> ) <sub>4</sub> Cl	29.8	19.85 " + 10.44 Cl <sub>2</sub> = 41.24 <sup>a</sup>	1UO <sub>2</sub> :4.02Cl	Double Salt
	80.7	20.23 " + 10.52 Cl <sub>2</sub> = 41.91 <sup>a</sup>	1UO <sub>2</sub> :3.98Cl	"
UO <sub>2</sub> Cl <sub>2</sub> .2N(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> Cl	27.1	15.02 " + 7.81 Cl <sub>2</sub> = 37.15 <sup>b</sup>	1UO <sub>2</sub> :3.97Cl	"
	80.7	15.12 " + 7.78 Cl <sub>2</sub> = 37.23 <sup>b</sup>	1UO <sub>2</sub> :3.94Cl	"
UO <sub>2</sub> Cl <sub>2</sub> .2CsCl	29.75	22.11 " + 22.5 Cs = 56.04 <sup>c</sup>	1UO <sub>2</sub> :2.07Cs	"
UO <sub>2</sub> Cl <sub>2</sub> .2RbCl.2H <sub>2</sub> O	24.8	27.18 " + 16.6 Rb + 13.8Cl <sup>d</sup>	1UO <sub>2</sub> :1.96Rb:3.90Cl	"
	80.3	30.66 " + 19.1 Rb + 15.8Cl <sup>e</sup>	1UO <sub>2</sub> :1.98Rb:3.95Cl	"
UO <sub>2</sub> Cl <sub>2</sub> .2KCl.2H <sub>2</sub> O	0.8	38.57 " + 13.59Cl + 3.86K	1UO <sub>2</sub> :2.69Cl:0.69K	The double salt is decomposed by water at temperatures below 60°.
	14.9	33.71 " + 13.51Cl + K	1UO <sub>2</sub> :3.06Cl:1.06K	
	17.5	37.36 " + 14.50Cl + 5.27K	1UO <sub>2</sub> :2.96Cl:0.96K	
	25	35.01 " + 15.26Cl + K	1UO <sub>2</sub> :3.33Cl:1.33K	
	41.5	35.27 " + 15.92Cl + 7.39K	1UO <sub>2</sub> :3.44Cl:1.44K	
	50	34.18 " + 16.56Cl + K	1UO <sub>2</sub> :3.71Cl:1.71K	
	60	34.19 " + 17.25Cl + 9.14K	1UO <sub>2</sub> :3.85Cl:1.85K	
	71.5	33.55 " + 17.44Cl + 9.28K	1UO <sub>2</sub> :3.96Cl:1.96K	
	78.5	35.26 " + 18.24Cl + 9.95K	1UO <sub>2</sub> :3.95Cl:1.95K	Double Salt "

<sup>a</sup>UO<sub>2</sub>Cl<sub>2</sub>.2N(CH<sub>3</sub>)<sub>4</sub>Cl

<sup>b</sup>UO<sub>2</sub>Cl<sub>2</sub>.N(C<sub>2</sub>H<sub>5</sub>)<sub>4</sub>Cl

<sup>c</sup>UO<sub>2</sub>Cl<sub>2</sub>.2CsCl

<sup>d</sup> = 57.9 gms. UO<sub>2</sub>Cl<sub>2</sub>.2RbCl<sub>2</sub>

<sup>e</sup> = 65.8 gms. UO<sub>2</sub>Cl<sub>2</sub>.2RbCl<sub>2</sub>

URANYL PENTA ANTIPYRINE PERCHLORATE  $[\text{UO}_2(\text{COC}_{10}\text{H}_{12}\text{N}_2)_5](\text{ClO}_4)_2$ 

Cl

100 cc sat. solution of uranyl penta antipyrine perchlorate in water contain 0.46 gm.  $[\text{UO}_2(\text{COC}_{10}\text{H}_{12}\text{N}_2)_5](\text{ClO}_4)_2$  at 20°. (Wilke-Dörfurt and Schliephake, 1929.)

## URANYL CHROMATE

CrO

THE SYSTEM URANYL CHROMATE - WATER  
(Loprest, Marshall and Secoy, 1955)

The  $\underline{X}$  hydrate contains about one mole of water.

t°	Wt. % $\text{UO}_2\text{CrO}_4$	t°	Wt. % $\text{UO}_2\text{CrO}_4$
Ice + soln. + vapor		$\text{UO}_2\text{CrO}_4 \cdot 5\frac{1}{2}\text{H}_2\text{O}$ + soln. + vapor	
-0.00	0.00	25.05 <sup>b</sup>	23.24
- .02	0.099	30.00	32.87
- .03	0.242	35.00	42.69
- .03	0.496	37.50	47.36
- .06	1.044	40.03	51.62
- .09	1.967	41.96	53.70
- .12	2.452	45.06	56.75
		47.64	58.80
Ice + $\text{UO}_2\text{CrO}_4 \cdot 5\frac{1}{2}\text{H}_2\text{O}$ + soln. + vapor		50.10	60.05
		55.14	64.76
		60.18	66.84
-0.15 <sup>a</sup>	3.07	$\text{UO}_2\text{CrO}_4 \cdot 5\frac{1}{2}\text{H}_2\text{O}$ + $\text{UO}_2\text{CrO}_4 \cdot \underline{X}\text{H}_2\text{O}$ + soln. + vapor	
$\text{UO}_2\text{CrO}_4 \cdot 5\frac{1}{2}\text{H}_2\text{O}$ + soln + vapor		66.3	70.04
0.0	3.11	$\text{UO}_2\text{CrO}_4 \cdot \underline{X}\text{H}_2\text{O}$ + soln. + vapor	
4.98	4.61	70.30	70.50
9.88	6.66	80.45	69.97
10.06	6.78	90.61	70.70
15.01	10.24	100.88	70.24
20.33	15.85	140	70.95
20.65	16.27		
24.7	23.41		

<sup>a</sup>Extrapolated value.

<sup>b</sup>Density = 1.246.

## U URANIUM

THE SYSTEM URANYL CHROMATE - CHROMIC OXIDE - WATER AT 75°  
(Loprest, Marshall and Secoy, 1955)

The average solid contained 1.15 moles H<sub>2</sub>O per mole UO<sub>2</sub>CrO<sub>4</sub>.

	Total mixture, wt. %		Liquid phase, wt. %		Wt. % UO <sub>2</sub> CrO <sub>4</sub> at 0% CrO <sub>3</sub>
	UO <sub>2</sub> CrO <sub>4</sub>	CrO <sub>3</sub>	UO <sub>2</sub> CrO <sub>4</sub>	CrO <sub>3</sub>	
	UO <sub>2</sub> CrO <sub>4</sub>	CrO <sub>3</sub>	UO <sub>2</sub> CrO <sub>4</sub>	CrO <sub>3</sub>	
CrO	68.84	3.06	62.18	3.83	95
	67.93	3.44	60.98	4.48	91
	64.71	5.02	59.37	5.86	97
	64.09	5.37	50.65	6.13	96
	66.74	5.85	8.74	8.74	91
	62.88	7.87	57.69	9.00	99
	69.42	7.94	56.01	11.96	96
	62.34	11.84	57.62	13.60	94
	71.01	10.38	58.19	15.95	95
					(Ave. 94.9)

## URANYL SODIUM CHROMATE 2(UO<sub>3</sub>)CrO<sub>4</sub>·Na<sub>2</sub>CrO<sub>4</sub>·10H<sub>2</sub>O

100 gms. sat. aqueous solution contain 52.52 gms. 2(UO<sub>2</sub>)CrO<sub>4</sub>Na<sub>2</sub>CrO<sub>4</sub> at 20°. (Rimbach, 1904.)

## F URANYL FLUORIDE UO<sub>2</sub>F<sub>2</sub>

The system UO<sub>2</sub>F<sub>2</sub> - H<sub>2</sub>O is shown graphically by Marshall, Gill and Secoy 1954. A saturated solution at the eutectic ~-14° contains about 64% UO<sub>2</sub>F<sub>2</sub> with UO<sub>2</sub>F<sub>2</sub>·2H<sub>2</sub>O the saturating phase. The solubility increases to about 73% at 100°. β and γ forms of the dihydrate are formed at higher temperatures.

### FREEZING POINTS OF UO<sub>2</sub>F<sub>2</sub> IN WATER (Johnson and Kraus, 1952)

Molality of UO <sub>2</sub> F <sub>2</sub>	F.P. depression	Molality of UO <sub>2</sub> F <sub>2</sub>	F.P. depression	Molality of UO <sub>2</sub> F <sub>2</sub>	F.P. depression
0.1005	0.176	2.077	3.189	4.027	7.143
0.3005	0.486	2.554	4.033	4.558	8.406
0.6943	1.058	3.427	5.812	5.249	10.183
1.341	2.003				

Data for the extraction of UO<sub>2</sub><sup>++</sup> from aqueous HF solutions at 20° by ethyl ether are given by Bock and Herrmann, 1956.

## URANYL DOUBLE FLUORIDES WITH ORGANIC BASES

F

SOLUBILITY OF EACH SEPARATELY IN WATER AT 20°  
(Olsson, 1930)

Organic Base		Gms. Compound per 100 cc sat. sol.
Pyridine	$C_5H_5NHUO_2F_3 \cdot H_2O$	1.289
Pyridine	$C_5H_5NH(UO_2)_2F_3 \cdot 3H_2O$	1.952
Quinoline	$C_9H_7NHUO_2F_3 \cdot H_2O$	0.126
Quinoline	$C_9H_7NH(UO_3)_2F_3 \cdot 2H_2O$	0.979
Tetra Methyl Ammonium	$(CH_3)_4N(UO_2)_2F_3 \cdot 2H_2O$	0.143
Tetra Ethyl Ammonium	$(C_2H_5)_4NUO_2F_3$	0.716
Tetra Ethyl Ammonium	$(C_2H_5)_4N(UO_2)_2F_3 \cdot 2H_2O$	0.771
Tri methyl -p- Toly Ammonium	$C_6H_4CH_3(CH_3)_3NUO_2 \cdot 2H_2O$	1.645
Tri methyl -p- Toly Ammonium	$C_6H_4CH_3(CH_3)_3N(UO_2)_2F_3 \cdot H_2O$	3.091
Tri methyl pyridine	$C_5H_2(CH_3)_3NH(UO_2)_3F_7 \cdot 6H_2O$	0.708
Di ethyl aniline	$C_6H_5N(C_2H_5)_2H(UO_2)_2F_3 \cdot 2H_2O$	1.759
Di ethyl aniline	$C_6H_5N(C_2H_5)_2H(UO_2)_2F_3 \cdot H_2O$	3.896
Tri ethyl sulfine	$(C_2H_5)_3S(UO_2)_2F_3 \cdot 2H_2O$	0.897

URANIUM TRIFLUORIDE  $UF_3$ 

Melting points for the systems  $UF_3 + BaF_2$ ,  $UF_3 + SrF_2$  and  
 $UF_3 - BaCl_2$  are given by D'Eye and Martin, 1956, 1957

URANIUM TETRAFLUORIDE  $UF_4$ 

For the system  $UF_4 - LiF$  see Barton, et al., 1958.

URANIUM HEXAFLUORIDE  $UF_6$ 

Data are given for the systems:

$UF_6 + HF$	(Bullard, Ostroski and Stringham, 1957)
$UF_6 + Br_2$	(Fischer and Vogel, 1954a)
$UF_6 + BrF_3$	(Fischer and Vogel, 1954)
$UF_6 + BrF_5$	(Fischer and Vogel, 1954)
$UF_6 + ClF_6$	(Wendolkowski and Barber, 1958)



# U URANIUM

## 10 URANYL IODATE $\text{UO}_2(\text{IO}_3)_2$

SOLUBILITY OF THE DIFFERENT CRYSTALLINE FORMS IN WATER AT 18°  
(Artmann, 1912-13)

		Gms. $\text{UO}_2(\text{IO}_3)_2$ per 100 Gms. $\text{H}_2\text{O}$
$\text{UO}_2(\text{IO}_3)_2 \cdot \text{H}_2\text{O}$	Type I warty, later prismatic needles	0.1049
$\text{UO}_2(\text{IO}_3)_2 \cdot \text{H}_2\text{O}$	Type II pyramids, sphenoids	0.1214
$\text{UO}_2(\text{IO}_3)_2 \cdot 2\text{H}_2\text{O}$		0.2044

## NO URANYL NITRATE $\text{UO}_2(\text{NO}_3)_2$

### THE SYSTEM URANYL NITRATE - WATER

(Below 70°--Wasilieff, 1910; Guempel, 1929. Above 70°--Marshall, Gill and Secoy, 1951; Benrath, 1942.)

From the eutectic to +10° the data of Wasilieff and of Guempel agree well (G. up to 0.5% higher). From about 15° to 35° Guempel's data are about 1% lower. The solubility curve for the hexahydrate is S-shaped with an inflection point at about +5°. Guempel's data are given in column I. Figures in parentheses are interpolated from Wasilieff. Above 60° Marshall's and Benrath's data are in agreement, but Marshall's lie on a smoother curve. (In this temperature range Guempel's and Wasilieff's results are up to 2% too high.) Column II is taken from Marshall.

t°	Wt. % $\text{UO}_2(\text{NO}_3)_2$ in Sat. Sol.	Solid Phase	t°	Wt. % $\text{UO}_2(\text{NO}_3)_2$ in Sat. Sol.	Solid Phase
- 0.3	7.87	Ice	70	77.25	$\text{UO}_2(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$
- 2.9	17.33	"	77.2	78.49	"
- 5.4	24.85	"	85	79.92	"
- 7.2	29.60	"	90.5	80.98	"
-18.0	43.04	"	92	81.37	"
-18.1	43.10	" + $\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$	100	82.57	"
-11.5	46.25	$\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$	110	84.14	"
- 5.5	48.47 (47.9)	"	113	84.67	" + $\text{UO}_2(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O}$
0	49.7 <sup>a</sup> (49.4)	"	120	85.25	$\text{UO}_2(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O}$
5	51.0 <sup>a</sup> (50.5)	"	130	86.13	"
7.6	61.57 (51.4)	"	133	86.54	"
15	52.80 (53.8)	"	137	87.07	"
20	54.40 (55.6)	"	141.2	87.02	"
25	55.90 (57.1)	"	147	87.75	"
30	57.9 <sup>a</sup> (58.8)	"	154.5	88.23	"
35	59.9 <sup>a</sup> (60.6)	"	159	88.74	"
36.1	60.28	"	160	88.94	"
40	62.3 <sup>a</sup> (62.7)	"	165.5	89.92	"
45	65.0 (65.0)	"	172	90.78	"
54.5	70.25	"	180	91.01	"
57.4	72.76	"	184	91.63	"
58.6	75.65	" + $\text{UO}_2(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$			
62	76.83	$\text{UO}_2(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$			<sup>a</sup> interpolated

THE SYSTEM URANYL NITRATE NITRIC ACID WATER AT 25°  
(Colani, 1926)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
Free HNO <sub>3</sub>	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>		Free HNO <sub>3</sub>	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>	
0.0	56.08	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O	46.12	27.18	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·3H <sub>2</sub> O
12.35	40.36	"	50.43	25.79	"
25.14	30.29	"	53.20	26.77	"
28.67	29.65	"	53.71	27.49	"
29.84	31.27	"	55.24	27.24	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·2H <sub>2</sub> O
30.43	36.72	"	60.38	23.65	"
30.15	37.99	"	66.71	22.29	"
32.31	36.28	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·3H <sub>2</sub> O	68.83	22.49	"

SOLUBILITY OF URANYL NITRATE HEXAHYDRATE IN AQUEOUS NITRIC ACID AT 20°  
(Nichols; Howes, et al., 1919)

Per cent concentration of aq. HNO <sub>3</sub>	10.0	20.0	30.0	40.0	70.0
Gms. UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O per 100 gms. solvent	160.0	115.0	80.0	65.0	65.0

## URANYL DOUBLE NITRATES

NO

(Ammonium, Cesium, Potassium and Rubidium Salts)

(Rimbach, 1904)

Formula of Salt	t°	Gms. per 100 Gms. Sat. Solution		Atomic Relation in Solution
		UO <sub>2</sub>	Total Salt	
UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·NH <sub>4</sub> NO <sub>3</sub>	0.5	29.71 + 2.92	NH <sub>4</sub> = -	1UO <sub>2</sub> : 1.47 NH <sub>4</sub> : 3.47 NO <sub>3</sub>
"	24.9	36.46 + 3.54	" = 68.95	" : 1.46 " : 3.46 "
"	59	44.37 + 2.90	" = -	" : 0.98 " : 2.98 "
"	80.7	44.95 + 2.98	" = 78.95	" : 1 " : 3 "
UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·CsNO <sub>3</sub>	16	31.39 + 6.59	Cs = 55.4	" : 0.44 Cs
UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·KNO <sub>3</sub>	0.5	31.98 + 1.72	K = -	" : 2.37 NO <sub>3</sub> : 0.37 K
"	13	33.40 + 2.72	" = -	" : 2.57 " : 0.57 "
"	25	37.07 + 4.01	"a = 64.82	" : 1.60 " : 0.76 "
"	45	42.18 + 5.16	" = -	" : 2.84 " : 0.84 "
"	59	41.65 + 6.03	" = -	" : 3 " : 1 "
"	80.6	43.71 + 6.38	" = 80.1	" : 3.01 " : 1.01 "
UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·RbNO <sub>3</sub>	25	35.41 + 4.65	Rb <sup>b</sup> = 59.60	" : 1.40 " : 0.45 Rb
"	80	34.66 + 11.01	" = 69.49	" : 3 " : 1.01 "

a + 23.5 NO<sub>3</sub>b + 19.74 NO<sub>3</sub>

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## SOLUBILITY OF URANYL POTASSIUM NITRATES IN AQUEOUS NITRIC ACID AT 20° (Nichols, Howes et al., 1919)

Results for $\text{UO}_2(\text{NO}_3)_2 \cdot \text{KNO}_3$			Results for $\text{UO}_2(\text{NO}_3)_2 \cdot 2\text{KNO}_3$		
% $\text{HNO}_3$ in solvent	Gms. $\text{UO}_2(\text{NO}_3)_2 \cdot \text{KNO}_3$ per 100 gms. solvent	Solid Phase	% $\text{HNO}_3$ in solvent	Gms. $\text{UO}_2(\text{NO}_3)_2 \cdot 2\text{KNO}_3$ per 100 gms. solvent	Solid Phase
0.0	85.5	$\text{KNO}_3$	0.0	62.9	$\text{KNO}_3$
10.0	82.0	"	10.0	52.2	"
20.0	99.8	"	20.0	45.7	"
30.0	89.0	$\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$	30.0	51.8	"
30.0	89.5	$\text{UO}_2(\text{NO}_3)_2 \cdot \text{KNO}_3$	40.0	67.2	"
40.0	81.0	"	50.0	52.3	$\text{UO}_2(\text{NO}_3)_2 \cdot 2\text{KNO}_3$
50.0	54.0	"	50.0	57.2	$\text{UO}_2(\text{NO}_3)_2 \cdot \text{KNO}_3$
60.0	33.9	"			

Data for the systems  $\text{UO}_2(\text{NO}_3)_2 - \text{Ba}(\text{NO}_3)_2 - \text{H}_2\text{O}$ ,  $\text{UO}_2(\text{NO}_3)_2 - \text{Ca}(\text{NO}_3)_2 - \text{H}_2\text{O}$  and  $\text{UO}_2(\text{NO}_3)_2 - \text{Sr}(\text{NO}_3)_2 - \text{H}_2\text{O}$  at 0°, 25° and 50° are given by Yakimov, Nosova and Grishin, 1958.

## THE SYSTEM URANYL NITRATE - ETHYL ETHER - WATER

Additional data for this system are given Warner, 1952 and McKay and Mathieson, 1951.

### Results at 0° (Misciatelli, 193C)

Gms. per 100 gms. lower layer			Gms. per 100 gms. upper layer			* Solid Phase
$(\text{C}_2\text{H}_5)_2\text{O}$	$\text{H}_2\text{O}$	$\text{UO}_2(\text{NO}_3)_2$	$(\text{C}_2\text{H}_5)_2\text{O}$	$\text{H}_2\text{O}$	$\text{UO}_2(\text{NO}_3)_2$	
0	52.0	48.0	-	-	-	$\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$
4.15	47.47	48.38	45.15	10.29	44.56	"
5.00	46.30	48.70	41.17	13.56	45.27	"
5.50	65.50	38.00	67.50	6.50	26.00	None
6.48	65.00	28.52	87.85	3.02	9.13	"
9.48	66.56	25.09	86.46	6.95	6.58	"
7.05	73.50	19.38	97.49	0.96	1.55	"
9.79	77.74	12.47	98.53	1.60	0.31	"
11.6	88.40	-	99.0	1.0	-	"
-	-	-	68.0	7.0	24.5	"
-	-	-	78.0	-	22.0	"

## Results at 20° (Guempel, 1929; Misciattelli, 1930)

Gms. per 100 gms. lower layer			Gms. per 100 gms. upper layer			Solid Phase	
(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	H <sub>2</sub> O	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>	(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	H <sub>2</sub> O	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>		
-	45.6	54.4	-	-	- (G,M)	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O	
3.30	42.47	54.23	38.12	12.80	49.08 (G)	"	
3.87	43.52	52.61	42.88	8.10	49.02 (M)	"	
4.00	60.0	36.0	67.10	7.0	25.90 (M)	None	
3.30	42.47	54.23	49.08	12.80	38.12 (G)	"	
4.5	72.0	23.5	96.0	1.50	2.5 (M)	"	
5.3	56.44	38.26	62.50	8.25	29.25 (G)	"	
6.1	75.33	18.57	96.0	3.11	0.89 (G)	"	
6.50	93.5	-	99.0	1.0	- (M)	"	NO
-	-	-	86.4	1.10	12.50 (M)	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>	
-	-	-	91.22	-	8.78 (M)	"	

## Results at 25° (Katzin and Sullivan, 1951)

## Two-Liquid Phase Region

Aqueous Layer		Organic Layer		Organic Layer		Solid Phase
% H <sub>2</sub> O	% UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>	% H <sub>2</sub> O	% UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>	% H <sub>2</sub> O	% UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>	
9.40	-	1.25	-	8.36	56.95	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O + UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·3H <sub>2</sub> O·(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O
83.49	8.80	1.25	0.00	7.56	54.28	
80.86	10.27	1.10	0.00	7.21	54.71	
66.44	29.05	2.04	5.80	7.56	55.49	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·3H <sub>2</sub> O·(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O + UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·2H <sub>2</sub> O·2(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O
59.71	36.23	4.23	19.35	6.30	53.01	
56.14	38.44	5.49	24.32	6.16	53.69	
51.75	44.24	7.55	34.52	5.39	53.16	UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> ·2H <sub>2</sub> O·2(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O
53.25	44.89	7.79	39.42	4.72	53.39	
44.23	47.28	8.95	49.97			
42.20	55.48 <sup>a</sup>	9.32	49.60 <sup>a</sup>			
41.93	55.57 <sup>a</sup>	9.36	49.70 <sup>a</sup>			

<sup>a</sup>Saturated with UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>ODISTRIBUTION OF URANYL NITRATE BETWEEN ETHER AND NITRIC ACID  
SOLUTIONS AT 20°  
(Norstrom and Sillen, 1948)

At least two determinations of the concentrations of uranium were made at each acid strength. Only one of these is listed below, and the values for "Q", the ratio of the amounts of U<sub>3</sub>O<sub>8</sub> in equal volumes of each phase, indicate the variation found at each concentration.

Additional data which are in good agreement with those of Norstrom and Sillen are given by Juttner, 1901; Bogden, 1905; 1906; Pavlov, 1924; and Archibald, 1932.

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## DISTRIBUTION OF URANYL NITRATE BETWEEN ETHER AND NITRIC ACID SOLUTIONS AT 20°--Cont.

- Results in Nitric Acid Solutions -

NO	Moles H <sup>+</sup> per liter			Mg. U <sub>3</sub> O <sub>8</sub> per 10 ml.			Q <sub>U<sub>3</sub>O<sub>8</sub></sub>
	Aqueous Phase	Ether Phase	Q <sub>H</sub>	Aqueous Phase	Ether Phase		
	5.57	3.94	0.71	14.8	32.5	2.03 - 2.20	
	4.72	3.31	.70	14.2	33.0	2.33 - 2.37	
	4.4	3.0	.68	17.5	36.8	2.02 - 2.13	
	4.32	2.99	.69	14.7	34.0	2.00 - 2.42	
	3.94	2.65	.67	17.2	34.9	2.02 - 2.04	
	3.74	2.44	.65	16.7	37.1	2.15 - 2.22	
	3.35	1.99	.59	15.8	33.7	2.13 - 2.54	
	2.74	1.25	.46	26.2	26.5	0.97 - 1.02	
	2.60	1.09	.42	30.6	22.9	0.75 - 0.79	
	2.52	0.97	.39	34.7	16.5	0.48 - 0.64	
	2.5	.96	.38	35.7	17.3	0.47 - 0.56	
	2.00	.53	.26	41.6	8.6	0.201 - 0.206	
	1.60	.29	1.18	46.0	3.9	0.080 - 0.086	
1.5	.26	.17	46.0	3.6	0.063 - 0.078		
0.75	.06	.08	48.7	0.5	0.010 - 0.013		

- Results in Nitric Acid Solutions Saturated with Ammonium Nitrate<sup>a</sup> -

3.42	3.64	1.06	11.2	25.8	2.30	- 2.60
2.73	3.07	1.12	11.6	30.7	2.65	- 2.73
2.43	2.87	1.18	12.6	30.5	2.39	- 2.52
2.31	2.67	1.15	10.2	32.1	2.87	- 3.22
1.72	2.19	1.27	10.7	33.7	3.13	- 3.27
1.13	1.45	1.29	9.1	33.7	3.70	
1.12	1.46	1.30	9.5	34.2	3.44	- 3.61
1.08	1.25	1.15	11.6	33.9	2.92	- 2.95
0.98	1.20	1.23	12.0	35.3	2.94	- 3.08
.96	1.18	1.23	10.8	32.2	2.85	- 3.09
.61	0.77	1.26	11.8	31.3	2.55	- 2.65
.60	.74	1.24	11.5	29.9	2.60	- 2.63
.27	.33	1.23	12.6	28.2	2.17	- 2.24
.26	.31	1.20	12.3	27.0	2.00	- 2.20
.11	.13	1.18	12.8	26.4	2.06	- 2.19
.10	.12	1.16	12.7	24.7	1.88	- 2.02

<sup>a</sup>Additional data for extractions from HNO<sub>3</sub> + NH<sub>4</sub>NO<sub>3</sub> solutions are given by Nikolaev and Kurnakova (1958), Cepelak (1958), Cepelak, Maly and Machacek (1957).

Data for UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub> extraction from solutions containing Li, Na, K, NH<sub>4</sub>, Mg, Ca, Sr, Ba, Zn, Cd, Al and Fe nitrates at 0.15° and 25° are reported by Vdovenko and Kovaleva, 1957 See also Bock and Bock, 1950.

THE SYSTEM  $\text{UO}_2(\text{NO}_3)_2$  DIETHYL CELLOSOLVE - WATER AT 25°  
(Katzin and Sullivan, 1951)

## Two Liquid Region

Aqueous Phase		Organic Phase		Organic Phase		Solid Phase
H <sub>2</sub> O	$\text{UO}_2(\text{NO}_3)_2$	H <sub>2</sub> O	$\text{UO}_2(\text{NO}_3)_2$	H <sub>2</sub> O	$\text{UO}_2(\text{NO}_3)_2$	
74.51	-	3.28	-	11.91	54.18	$\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$
61.06	16.55	4.56	8.16	10.77	55.31	"
55.52	20.47	6.88	17.22	10.31	54.25	" + $\text{UO}_2(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O} \cdot \text{Cellosolve}$
56.19	25.93	9.10	24.15	6.57	45.63	$\text{UO}_2(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O} \cdot \text{Cellosolve}$
55.83	29.13	10.45	29.69	6.32	45.08	"
47.47	42.27	11.52	43.73	6.33	45.60	$\text{UO}_2(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O} \cdot 2\text{Cellosolve}$
39.63	54.73 <sup>a</sup>	12.55	53.49 <sup>a</sup>	6.48	46.01	"
39.83	55.48 <sup>a</sup>	12.22	54.05 <sup>a</sup>	5.86	48.21	$\text{UO}_2(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O} \cdot 2\text{Cellosolve}$ NO

<sup>a</sup>Saturated with  $\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$

THE SYSTEM  $\text{UO}_2(\text{NO}_3)_2$  - HEXYL ETHER - WATER AT 25°  
(Katzin and Sullivan, 1951)

## Two Liquid Region

Aqueous Phase		Organic Phase		Organic Phase		Solid Phase
H <sub>2</sub> O	$\text{UO}_2(\text{NO}_3)_2$	H <sub>2</sub> O	$\text{UO}_2(\text{NO}_3)_2$	H <sub>2</sub> O	$\text{UO}_2(\text{NO}_3)_2$	
0.99	-	1.0	-	1.27	13.54	$\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$
60.44	38.30 <sup>a</sup>	1.0	0.0 <sup>a</sup>	1.92	18.09	" + $\text{UO}_2(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$
				2.11	18.55	
				1.93	17.82	
				2.66	22.19	$\text{UO}_2(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O} +$
				2.06	23.08	$\text{UO}_2(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O} \cdot \text{Hexyl Ether}$

<sup>a</sup>Saturated with  $\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$

THE SYSTEM  $\text{UO}_2(\text{NO}_3)_2$  - ACETONE - WATER AT 25°  
(Katzin and Sullivan, 1951)

Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
H <sub>2</sub> O	$\text{UO}_2(\text{NO}_3)_2$			H <sub>2</sub> O	$\text{UO}_2(\text{NO}_3)_2$		
45.5	54.5		$\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$	11.73	70.34		$\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O} + \text{UO}_2(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$
37.54	46.77		"	11.71	70.45		"
27.14	59.99		"	11.33	70.30		"
25.12	60.75		"	10.40	70.88		$\text{UO}_2(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O} + \text{UO}_2(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$
21.21	61.37		"	10.61	70.42		"
22.39	61.37		"	9.76	70.82		$\text{UO}_2(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O} + 1:2:1$
17.41	62.71		"	9.88	70.88		"
15.55	63.29		"	7.54	71.66		$1:2:1 + \text{UO}_2(\text{NO}_3)_2 \cdot 2 \text{ acetone}$
15.37	64.46		"	8.48	69.51		"
				9.21	68.86		"
				9.57	69.20		"

1:2:1 =  $\text{UO}_2(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O} \cdot 2(\text{CH}_3)_2\text{CO}$



DISTRIBUTION OF URANYL NITRATE BETWEEN VARIOUS ORGANIC  
AND AQUEOUS SOLUTIONS

- |                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                             |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (1) Warner, 1952<br>(2) Warner, 1953<br>(3) McKay and Mathieson, 1951<br>(4) Kooi, 1956<br>(5) Alcock, Best, Hesford and McKay, 1958<br>(6) Rydberg and Bernstrom, 1957<br>(7) Jenkins and McKay, 1954<br>(8) Gardner, McKay and Warren, 1952<br>(9) Walton, Barker and Byfleet, 1955<br>(10) Katzin and Sullivan, 1951 | (11) deKeyser, Cypres and Herrmann, 1950<br>(12) Beranova, Maly and Vesely, 1958<br>(13) Healy and McKay, 1956<br>(14) Karpacheva, Khorkhorina and Agashkina, 1957<br>(15) Selmi, 1955<br>(16) Dizdar, Gal and Rajnvaajn, 1957<br>(17) Vdovenko, Lipovskii and Kuzina, 1957 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

NO

Organic Phase	Aqueous Phase	t°	Reference
methylisobutylketone	H <sub>2</sub> O, aq. HNO <sub>3</sub> , aq. Ca(NO <sub>3</sub> ) <sub>2</sub>	2,20,25,40	1,2,4,6,7,10,11
nitromethane	H <sub>2</sub> O	20	2
nitromethane	aq. HNO <sub>3</sub>	20	2
diisopropyl ether	H <sub>2</sub> O	20,18	1,3
dibutyl ether	H <sub>2</sub> O, aq. nitrates	20,18	1,3,7,14,17
dihexyl ether	H <sub>2</sub> O	18	3,10
dibutyl cellosolve	H <sub>2</sub> O	18	3
dibutyl carbitol	H <sub>2</sub> O, aq. HNO <sub>3</sub> , Ca(NO <sub>3</sub> ) <sub>2</sub> , Al(NO <sub>3</sub> ) <sub>3</sub> , Cu(NO <sub>3</sub> ) <sub>2</sub>	18	3,4,7,8
penta-ether	H <sub>2</sub> O	18	3,8
isoamyl acetate	H <sub>2</sub> O	18	3
methyl isobutyl ketone	H <sub>2</sub> O, aq. NH <sub>4</sub> NO <sub>3</sub>	18	3,15
ethyl n-butyl ether	H <sub>2</sub> O	20	1
ethyl n-propyl ether	H <sub>2</sub> O	20	1
2,2 dichloroethyl ether	H <sub>2</sub> O	20	1
methyl ethyl ketone	H <sub>2</sub> O, aq. NH <sub>4</sub> NO <sub>3</sub>	20	1,11
methyl n-amyl ketone	H <sub>2</sub> O	20	1
diisobutyl ketone	H <sub>2</sub> O	20	1
n-butanol	H <sub>2</sub> O	20	1,11
iso-butanol	H <sub>2</sub> O	25	10,11
methylethyl ketone + benzene	H <sub>2</sub> O	20	1
tributyl phosphate	aq. HNO <sub>3</sub>	-	5,12,13

(Cont.)



# U URANIUM

## DISTRIBUTION OF URANYL NITRATE BETWEEN VARIOUS ORGANIC AND AQUEOUS SOLUTIONS--Cont.

	Organic Phase	Aqueous Phase	t°	Reference
	benzene + thiophenoyl trifluoroacetone	aq. HNO <sub>3</sub>	-	9
	diethyl cellosolve	H <sub>2</sub> O	25	10
	butyl acetate	H <sub>2</sub> O, aq. nitrates	20	11, 14
	amyl acetate	H <sub>2</sub> O	20	11
	isopropyl acetate	H <sub>2</sub> O	20	11
NO	isoamyl alcohol	H <sub>2</sub> O	20	11
	methyl isobutyl carbinol	H <sub>2</sub> O	20	11
	ethyl acetate	H <sub>2</sub> O	20	11
	30% tributyl phosphate in methyl isobutyl ketone	aq. HNO <sub>3</sub>	-	16

## SOLUBILITY OF URANYL NITRATE IN ETHER (Bachelet and Cheylan, 1947)

Although the solubility curve drawn by them shows no breaks, the authors report the formation of two etherates upon evaporation:  $\text{UO}_2(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O} \cdot 2(\text{C}_2\text{H}_5)_2\text{O}$ , M.P. 45° and  $\text{UO}_2(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O} \cdot 4(\text{C}_2\text{H}_5)_2\text{O}$ , M.P. 2.2°. The following data were read from the authors' rather rough curve.

Temperature°:	-80	-40	-20	0	20	40
Gms. $\text{UO}_2(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O}$ per 100 gms. ether:	10	22	50	88	127	175

## SOLUBILITY OF URANYL NITRATE ETHERATES IN ETHER (Vdovenko, Koval'skaya and Kovaleva, 1957)

$\text{UO}_2(\text{NO}_3)_2 \cdot 2(\text{C}_2\text{H}_5)_2\text{O}$ (soly. 5.3 g U per 100 g sat. solu in ether at 15°)						
$\text{UO}_2(\text{NO}_3)_2 \cdot 2(\text{C}_2\text{H}_5)_2\text{O} \cdot 2\text{H}_2\text{O}$ (soly. 31.8 g U	"	"	"	"	"	"
$\text{UO}_2(\text{NO}_3)_2 \cdot (\text{C}_2\text{H}_5)_2\text{O} \cdot 3\text{H}_2\text{O}$ (soly. 29.9 g U	"	"	"	"	"	"

## SOLUBILITY OF URANYL NITRATE IN ORGANIC SOLVENTS AT 20° (Yaffe, 1949)

Each solvent was shaken with  $\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  from one to four days. The salt was then extracted from the solution with water and determined colorimetrically. A large number of other solvents were used in which the solubility was "less than 0.1 gms. per 100 ml."

## SOLUBILITY OF URANYL NITRATE IN ORGANIC SOLVENTS AT 20--Cont.

Solvent:	Gms. $UO_2(NO_3)_2 \cdot 6H_2O$ per 100 ml.	Solvent:	Gms. $UO_2(NO_3)_2 \cdot 6H_2O$ per 100 ml.	Solvent:
	Solvent		Solvent	
Diethyl Cellosolve	102	Dibutoxytetraethylene Glycol	90	NO
Dimethyl Cellosolve	92	Isobutylcarbinol	57	
Diethyl Ether	74	Diethylcarbinol	57	
Ethylhexyl Cellosolve	68	n-Amyl Alcohol	55	
Dibutyl Cellosolve	49	2-Ethyl Butyl Alcohol	49	
Dibutyl Carbitol	44	Methyl Amyl Alcohol	43	
Pelargonic Ether	17	n-Heptyl Alcohol	43	
n-Butyl Ether	16	Capryl Alcohol	37	
Xanthyl Ether	14	Geraniol	36	
Amyl Ether	11	$\beta, \gamma$ -Dibromopropanol	32	
Hexyl Ether	9	Undecanol	27	
Isopropyl Ether	9	Tetradecanol	13	
Dichloroisopropyl Ether	5	Cyclohexanone	105	
$\beta$ -Ethoxyl Ethyl Acetate	125	Methyl Ethyl Ketone <sup>a</sup>	100	
Ethyl Acetylglycollate	110	Diethyl Ketone	76	
Ethyl Acetate	82	Methyl Isobutyl Ketone	75	
Butyl Cellosolve Acetate	77	Methyl n-Amyl Ketone	68	
Butyl Acetate	68	Diisopropyl Ketone	41	
Isopropyl Acetate	64	Acetaldehyde	42	
sec-Butyl Acetate	61	Citronellal	34	
Amyl Formate	56	Anisaldehyde	27	
n-Butyl Propionate	55	n-Butyraldehyde	22	
Isoamyl Acetate	55	Nitromethane	64	
Isobutyl Acetate	50	Triglycol Dichloride	57	
Ethyl Sebacate	48	1-Nitropropane	8	
Amyl Acetate	46	2-Nitropropane	4	
Butyl Adipate	40	Nitrobenzene	1.5	
n-Butyl Sebacate	37	Tetrabutyl Urea	6.0	
n-Amyl Propionate	37	Amyl Succinate	25	
$\beta$ -Phenyl Ethyl Acetate	35	Amyl Butyrate	25	
Methyl Phenyl Acetate	33	Isoamyl Formate	24	
Isobutyl Propionate	31	Amyl Valerionate	21	
Vinyl Acetate	31	Geraniol Acetate	16	
Isoamyl Propionate	27	n-Butyl Oxalate	9	
		Isoamyl n-Caproate	7	

<sup>a</sup>plus 15% Xylene

## SOLUBILITY OF URANYL NITRATE HEXAHYDRATE IN ORGANIC SOLVENTS

Solvent:	Gms. $UO_2(NO_3)_2$ per 100 gms.	Solvent:	Gms. $UO_2(NO_3)_2$ per 100 gms.
	Sat. Sol.		Sat. Sol.

## Results of Warner, 1952 at 20°

Water	54.08	Methyl isobutyl ketone	43.07
Methyl ethyl ketone	54.67	Methyl isobutyl carbinol	34.00
diethyl ether	49.16	Diisopropyl ether	15.05
n-Butanol	45.35		

(Cont.)

# U URANIUM

## SOLUBILITY OF URANYL NITRATE HEXAHYDRATE IN ORGANIC SOLVENTS--Cont.

Solvent:	Gms. $\text{UO}_2(\text{NO}_3)_2$ per 100 gms.	Solvent:	Gms. $\text{UO}_2(\text{NO}_3)_2$ per 100 gms.
	Sat. Sol.		Sat. Sol.

### Results of Warner, 1953 at 20°

NO	Water	54.0	Methyl propyl ketone	48.4
	methanol	67.5	methyl butyl ketone	42.5
	Ethanol	61.5	methyl isobutyl ketone	42.8
	Propanol	52.9	methyl t-butyl ketone	41.5
	iso propanol	54.9	methyl amyl ketone	38.2
	Butanol	46.2	methyl phenyl ketone	31.2
	n-amyl alcohol	38.7	nitromethane	14.0
	n-hexyl alcohol	34.1	nitroethane	5.1
	n-heptyl alcohol	31.0	1-nitropropane	1.1
	n-octyl alcohol	28.0	ethyl ether	49.1
	2-octanol	27.1	furan	0.3
	2 ethyl-1-hexanol	23.5	tetrahydrofuran	46.4
	cyclohexanol	40.3	dioxane	29.1
	acetone	61.7	$(\text{C}_6\text{H}_5\text{CH}_2)_2\text{O}$	1.7
	methyl ethyl ketone	54.7		

### Results of deKeyser, Cypres and Herrmann, 1950 at 20°

Water	54.08	butanol	45.35
Ethyl ether	49.16	iso-butyl alcohol	44.07
Ethyl acetate	46.29	sec. butyl alcohol	47.12
Butyl acetate	44.40	iso amyl alcohol	39.45
Amyl acetate	34.54	methyl isobutyl carbinol	34.00
methyl ethyl ketone	54.67	Iso propyl ether	15.05
methyl isobutyl ketone	43.07		

### Results of Templeton and Hall, 1950 at 25°

iso amyl alcohol	44.1	Ethyl butyrate	40.6
methyl n-hexyl ketone	38.6		

### Other Data

tri n-butyl phosphate	43.5 (25-27°)	(Wendlandt and Bryant, 1956)
acetone	1.5 (12°)	(deConinck, 1900)
85% alcohol	3.2 (12°)	(deConinck, 1900)

URANIUM (IV) OXIDE  $\text{UO}_2$ 

0

SOLUBILITIES AT 25°  
(Gayer and Leider, 1957)

<u>In Aqueous <math>\text{HClO}_4</math></u>		<u>In Aqueous NaOH</u>	
Solvent: Moles $\text{HClO}_4$ per 1000 gms. $\text{H}_2\text{O}$	Sat. Sol. Moles $\text{UO}_2$ per per 1000 gms. $\text{H}_2\text{O}$	Sat. Sol. moles per 1000 gms. $\text{H}_2\text{O}$ NaOH	$\text{UO}_2$
0.039	0.022	0	$3.0 \times 10^{-6}$
0.096	0.057	0.080	$6.3 \times 10^{-6}$
0.14	0.067	0.144	$2.7 \times 10^{-5}$
1.9	0.095	0.215	$4.1 \times 10^{-5}$
2.9	0.15	0.266	$4.5 \times 10^{-5}$
3.9	2.1	0.484	$7.0 \times 10^{-5}$
		0.632	$5.9 \times 10^{-5}$

At 500°, 2000 bars 0.00005 wt %  $\text{UO}_2$  dissolve in steam. (Ellis and Fyfe, 1957)

URANIUM (VI) OXIDE  $\text{UO}_3$ 

0

SOLUBILITY IN AQUEOUS  $\text{HClO}_4$  AND NaOH SOLUTIONS AT 25°  
(Geyer and Leider, 1955)

The solid phase is  $\text{UO}_3 \cdot \text{H}_2\text{O}$ . All concentrations are in moles per 1000 gms.  $\text{H}_2\text{O}$ .

<u>Aqueous <math>\text{HClO}_4</math> Solutions</u>				<u>Aqueous NaOH solutions</u>			
$\text{HClO}_4$	$\text{UO}_3$	$\text{HClO}_4$	$\text{UO}_3$	NaOH	$\text{UO}_2$ ( $\times 10^5$ )	NaOH	$\text{UO}_2$ ( $\times 10^5$ )
0.0	$3.95 \times 10^{-5}$	0.202	0.185	0.0	3.95	0.0777	10.0
0.0202	0.0184	0.406	0.290	0.0045	4.75	0.1114	4.20
0.0406	0.0420	0.608	0.360	0.0076	6.22	0.5545	19.7
0.101	0.0946	0.812	0.488	0.0090	3.95	0.6093	9.5
0.142	0.113	1.01	0.652	0.0199	7.90	0.6106	13.1
				0.0203	4.45	0.6816	13.5
				0.0390	7.09	0.7668	14.7
				0.0453	6.30		

Data for the system  $\text{UO}_3 - \text{H}_2\text{SO}_4 - \text{H}_2\text{O}$  at 150 - 290° are given by Marshall, 1955.

# U URANIUM

## PO URANYL PHOSPHATES

### SOLUBILITY IN PHOSPHORIC ACID SOLUTIONS (Schreyer and Baes, Jr., 1954, 1955)

Three phases were found  $(\text{UO}_2)_3(\text{PO}_4)_2 \cdot 6\text{H}_2\text{O}$  in solutions containing less than 0.014 M total  $\text{PO}_4^{3-}$ ,  $\text{UO}_2\text{HPO}_4 \cdot 4\text{H}_2\text{O}$  when  $\text{PO}_4^{3-}$  is between 0.014 and 6.1 M, and  $\text{UO}_2(\text{H}_2\text{PO}_4)_2 \cdot 3\text{H}_2\text{O}$  when  $\text{PO}_4^{3-}$  is greater than 6.1 M. The results are given graphically. In the latter paper results in aq  $\text{HClO}_4$  solutions are also given.

## PO URANYL DOUBLE PHOSPHATES

Salt	Ksp	
$\text{UO}_2\text{HPO}_4$	$2.14 \times 10^{-11}$	
$\text{UO}_2\text{KPO}_4$	$7.76 \times 10^{-24}$	
$\text{UO}_2\text{NH}_4\text{PO}_4$	$4.36 \times 10^{-27}$	(Chukhlantsev and Stepanov, 1956)

## PO URANIUM PHOSPHATES

### THE SYSTEM $\text{UO}_2 - \text{P}_2\text{O}_5 - \text{H}_2\text{O}$ AT 25° (Schreyer, 1954, 1955)

Moles per liter		dens.	Solid Phase	Moles per liter		dens.	Solid Phase
$\text{UO}_2$	$\text{PO}_4$			$\text{UO}_2$	$\text{PO}_4$		
0.0002	1.495	1.0757	$\text{U}(\text{HPO}_4)_2 \cdot 6\text{H}_2\text{O}$	0.3541	8.556	1.5062	$\text{U}(\text{HPO}_4)_2 \cdot 6\text{H}_2\text{O}$
0.000525	1.863	1.0951		0.5078	9.133	1.5623	
0.000624	1.937	1.0975		0.5203	9.382	1.5850	
0.00110	2.358	-		0.9256	10.91	1.7597	
0.00389	3.240	-		1.2340	11.48	1.8882	
0.00427	3.150	-		1.2535	11.32	1.8877	
0.00686	3.630	-		0.62 <sup>a</sup>	9.8 <sup>a</sup>	1.63 <sup>a</sup>	
0.00690	3.794	1.1913		0.7800	11.76	1.7848	
0.01652	4.243	-		0.7868	11.79	1.7613	
0.0317	5.190	1.2694		0.8156	12.16	1.8082	
0.0436	5.94	-	$\text{U}(\text{HPO}_4)_2 \cdot 8\text{H}_2\text{O}$	0.8597	12.42	1.8226	$\text{U}(\text{HPO}_4)_2 \cdot 8\text{H}_2\text{O}$
0.0999	6.306	1.3384		0.8552	12.42	1.8128	
0.1907	7.356	1.4187		1.0417	14.9	1.9455	
0.1734	7.463	1.4170		1.1366	14.30	1.9566	
0.1933	7.567	1.4215		1.3199	14.97	2.0219	
0.3739	8.972	1.5118		1.2743	15.24	2.0382	

<sup>a</sup>Transition point

A study of the system  $\text{U}(\text{HPO}_4)_2 - \text{Cl}_2\text{O}_7 - \text{H}_2\text{O}$  at  $25^\circ$  by Schreyer and Philips (1956) showed the solid phases to be  $\text{U}(\text{HPO}_4)_2$ ,  $\text{U}(\text{HPO}_4)_2 \cdot 2\text{H}_2\text{O}$ ,  $\text{U}(\text{H}_2\text{PO}_4)_2(\text{ClO}_4)_2 \cdot 6\text{H}_2\text{O}$  and  $\text{U}(\text{H}_2\text{PO}_4)_2(\text{ClO}_4)_2 \cdot 4\text{H}_2\text{O}$ . 1 - 12 M  $\text{HClO}_4$  solutions were employed. The data are given in graph form.

URANYL SULFATE  $\text{UO}_2\text{SO}_4$ 

SO

SOLUBILITY OF URANYL SULFATE IN WATER  
(Secoy, 1948)

Moles UO <sub>2</sub> SO <sub>4</sub> per 1000 gms. H <sub>2</sub> O			Moles UO <sub>2</sub> SO <sub>4</sub> per 1000 gms. H <sub>2</sub> O		
t°		Solid Phase	t°		Solid Phase
- 0.0705	0.03 <sup>d</sup>	Ice	106.2	5.26	UO <sub>2</sub> SO <sub>4</sub> ·3H <sub>2</sub> O
- .1100	.05 <sup>d</sup>	"	116.8	5.59	"
- .200	.10 <sup>d</sup>	"	118.4	5.73	"
- .516	.30 <sup>d</sup>	"	119.9	5.66	"
- .948	.60 <sup>d</sup>	"	125.2	5.90	"
-17.7	2.87	"	134.9	6.25	"
-22.9	3.33	"	139.0	6.51	"
-38.5	3.82	Ice+UO <sub>2</sub> SO <sub>4</sub> ·3H <sub>2</sub> O	140.7	6.55	"
-27.0	3.84	UO <sub>2</sub> SO <sub>4</sub> ·3H <sub>2</sub> O	145.1	6.72	"
30.0	4.135	"	149.6	6.89	"
35.0	4.171	"	153.6	7.14	"
40.0	4.225	"	168.6	7.75	"
46.8	4.31	"	181	8.66	UO <sub>2</sub> SO <sub>4</sub> ·3H <sub>2</sub> O+UO <sub>2</sub> SO <sub>4</sub> ·H <sub>2</sub> O
57.3	4.50	"	152	8.97	UO <sub>2</sub> SO <sub>4</sub> ·H <sub>2</sub> O
71.7	4.73	"	287	7.75	"
80.8	4.70	"	49.2m	4.70	UO <sub>2</sub> SO <sub>4</sub> ·2H <sub>2</sub> O
90.1	5.02	"	53.2m	4.73	"
93.5	5.06	"	75.5m	5.06	"

d = Dittrick, 1899

m = metastable

Results at High Temperatures  
(Secoy, 1950)

Two liquid phases are formed.

t°	Wt. % $\text{UO}_2\text{SO}_4$	Phase	t°	Wt. % $\text{UO}_2\text{SO}_4$	Phase
335.1	0.77	$\text{UO}_2\text{SO}_4$ -rich liquid	312.5	58.64	water-rich liquid
319.4	3.15		316.2	60.60	
310.1	5.86		320.5	62.32	
299.9	12.30		339.6	67.43	
295.8	20.40		363.0	71.00	
295.5	31.65	water-rich liquid	365	72.60	solid monohydrate
297.5	40.72		347	72.85	
302.3	48.06		311	73.49	
308.2	55.45				

The critical temperature of the aqueous phase is  $374^\circ$ .

# U URANIUM

## SOLUBILITY OF URANYL SULFATE IN SEVERAL SOLVENTS (de Coninck, 1901, 1903)

	Solvent	t°	Gms. $\text{UO}_2\text{SO}_4 \cdot 3\text{H}_2\text{O}$ per 100 Gms. Solvent
	Water	13.2	18.9
	Water	15.5	20.5
	16.2% Alcohol	10	12.3
	85% Alcohol	16	2.6
	Conc. HCl	13	30
	Conc. HBr (d=1.21)	12	16.8
	Conc. $\text{HNO}_3$	12	9.1
	Conc. $\text{H}_2\text{SO}_4$ (d=1.138)	13	24.3
SO	1 Vol. HCl + 1 Vol. $\text{HNO}_3$	16	18
	Selenic Acid (d=1.4)	15	27

## SOLUBILITY OF URANYL SULFATE IN AQUEOUS SOLUTIONS OF SULFURIC ACID AT 25° (Colani, 1928)

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
$\text{UO}_2\text{SO}_4$	$\text{H}_2\text{SO}_4$ (free)	Solid Phase	$\text{UO}_2\text{SO}_4$	$\text{H}_2\text{SO}_4$ (free)	Solid Phase
61.18	0.0	$\text{UO}_2\text{SO}_4 \cdot 3\text{H}_2\text{O}$	6.62	59.83	1:1:5
58.96	1.64	"	4.69	63.82	"
47.96	10.56	"	3.81	67.40	"
30.03	25.42	"	4.70	70.70	"
28.65	26.99	" + $\text{UO}_2\text{SO}_4 \cdot 2\text{H}_2\text{O}$	7.09	72.49	" + 1:1:2
27.25	28.00	$\text{UO}_2\text{SO}_4 \cdot 2\text{H}_2\text{O}$	6.74	75.33	1:1:2
21.79	30.53	"	10.72	74.81	"
17.03	40.19	"	16.90	71.14	"
15.77	43.45	"	19.10	69.18	"
15.88	45.22	"	19.65	68.93	" $\frac{1}{2}$ 1:1: $\frac{1}{2}$
17.74	47.75	" + 1:1:5	17.76	71.52	1:1: $\frac{1}{2}$
16.00	49.86	1:1:5	11.37	78.78	" $\frac{1}{2}$
12.13	53.32	"	7.81	82.86	"
			3.77	89.62	"

$$1:1:5 = \text{UO}_2\text{SO}_4 \cdot \text{H}_2\text{SO}_4 \cdot 5\text{H}_2\text{O} \quad 1:1:2 = \text{UO}_2\text{SO}_4 \cdot \text{H}_2\text{SO}_4 \cdot 2\text{H}_2\text{O}$$

$$1:1:\frac{1}{2} = \text{UO}_2\text{SO}_4 \cdot \text{H}_2\text{SO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$$

## URANYL POTASSIUM SULFATE $\text{UO}_2\text{SO}_4 \cdot \text{K}_2\text{SO}_4 \cdot 2\text{H}_2\text{O}$

100 gms. sat. aq. solution contain 10.41 gms.  $\text{UO}_2\text{SO}_4 \cdot \text{K}_2\text{SO}_4$  at 25° and 23.13 gms. at 70.5°. (Rimbach, 1904.)

SOLUBILITY OF  $\text{UO}_2\text{SO}_4 \cdot 2\text{K}_2\text{SO}_4 \cdot 2\text{H}_2\text{O} + \text{UO}_2\text{SO}_4 \cdot \text{K}_2\text{SO}_4 \cdot 2\text{H}_2\text{O}$  IN WATER

t°	Gms. per 100 Gms. Solution			Atomic Relation in Sol.			Mol. % in Solid Phase	
	$\text{UO}_2$	K	$\text{SO}_4$	$\text{UO}_2$	K	$\text{SO}_4$	Mono Salt	Di Salt
14	0.85	4.19	5.71	1	35.75	18.88	29	71
50	6.70	8.15	12.37	1	5.20	8.40	76	24
80	14.29	8.54	15.53	1	4.13	3.06	12	88

URANIUM SULFATE (ous)  $\text{U}(\text{SO}_4)_2$ 

50

SOLUBILITY IN WATER  
(Giolitti and Bucci, 1905)

t°	Gms. $\text{U}(\text{SO}_4)_2$ per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. $\text{U}(\text{SO}_4)_2$ per 100 Gms. Sat. Sol.	Solid Phase
18	10.17	$\text{U}(\text{SO}_4)_2 \cdot 8\text{H}_2\text{O}$	93	63.2	$\text{U}(\text{SO}_4)_2 \cdot 8\text{H}_2\text{O}$
25.6	13.32	"	24	9.8	$\text{U}(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O}$
37	19.98	"	37	8.3	"
48.2	28.72	"	48.2	8.1(7.8)	"
62	36.8	"	63	7.3	"

The determinations were made with difficulty on account of the considerable tendency towards formation of basic sulfate and simultaneous clouding of the solution.

SOLUBILITY OF URANIUM SULFATE IN 0.1 NORMAL SULFURIC ACID SOLUTIONS  
(Meyer and Nachod, 1924)

Tenth normal sulfuric acid was used as solvent instead of water to prevent hydrolysis to  $\text{UOSO}_4 \cdot 2\text{H}_2\text{O}$ . The saturated solutions were prepared by constant agitation for 12 hours of 3-5 gms. of each hydrate with 10-12 cc. of 0.1 N acid.

t°	Gms. $\text{U}(\text{SO}_4)_2$ per 100 gms. Sat. Sol.	Solid Phase	t°	Gms. $\text{U}(\text{SO}_4)_2$ per 100 gms. Sat. Sol.	Solid Phase
15.5	6.61	$\text{U}(\text{SO}_4)_2 \cdot 8\text{H}_2\text{O}$	92.0	6.61	Polymeric 4 Hydrate
20.0	8.78	"	22.7	13.68	$\text{U}(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O}$
22.4	9.68	"	25.0	12.62	"
25.0	11.22	"	30.4	10.92	"
30.4	13.88	"	40.0	8.98	"
40.0	18.50	"	50.0	8.32	"
60.0	29.93	"	80.0	6.93	"



## U URANIUM

### APPROXIMATE SOLUBILITY OF URANIUM SULFATE IN AQUEOUS SOLUTIONS (deConinck, 1903)

Solvent	t°	Gms. U(SO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O per 100 Gms. Solvent
Water	11	23.2
Dilute HCl (1:4)	9	17.2
Dilute HNO <sub>3</sub> (1:4)	10.5	18.2
Dilute Selenic Acid (1:4)	11.4	21.7
Dilute H <sub>2</sub> SO <sub>4</sub> (1:4)	10	15.6
Dilute Alcohol (1:4)	11.3	12.3

## SeO URANYL SELENITE UO<sub>2</sub>SeO<sub>3</sub>

The K<sub>sp</sub> is  $3.8 \times 10^{-11}$  (Krylov and Chukhlantsev, 1957).

## V VANADIUM

The percentage solubility of vanadium in mercury at 20°, determined by filtering an amalgam of the metal through a sintered glass filter, was found by Irvin and Russell, 1932, to be less than  $5 \times 10^{-5}$ .

## F VANADIUM FLUORIDES

### THE SYSTEM V<sub>2</sub>O<sub>5</sub> - HF - H<sub>2</sub>O (Nikolaev and Buslaev, 1955)

Results at 16°			Results at 25°		
Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
HF	V <sub>2</sub> O <sub>5</sub>		HF	V <sub>2</sub> O <sub>5</sub>	
44.2	45.1	3VO <sub>2</sub> F·HF·H <sub>2</sub> O	6.7	10.5	V <sub>2</sub> O <sub>5</sub>
46.6	45.4		10.8	15.9	
40.0	44.6		15.2	22.3	
53.0	45.0		21.5	30.4	
54.5	43.5	2VO <sub>2</sub> F·3HF·H <sub>2</sub> O	29.0	32.7	3VO <sub>2</sub> F·HF·H <sub>2</sub> O
56.8	40.4		35.0	35.1	
61.2	35.6		38.2	40.0	
63.0	33.4		41.3	46.4	
65.1	31.4	VOF <sub>3</sub>			
68.0	29.8				
71.0	26.8				
75.5	23.4				
77.8	22.8				
78.5	22.7				

Data for the extraction of V(III) and V(V) from aq HF solutions by ethyl ether at 20° is given by Bock and Herrmann, 1956

VANADIUM DIOXIDE  $\text{VO}_2$ 

0

Melting points in the systems  $\text{VO}_2$  - CaO and  $\text{VO}_2$  -  $\text{SiO}_2$  were determined by Morozov, 1939.

VANADIUM TRIOXIDE  $\text{V}_2\text{O}_3$ 

Melting points in the systems  $\text{V}_2\text{O}_3$  - CaO and  $\text{V}_2\text{O}_3$  -  $\text{SiO}_2$  were determined by Morozov, 1939.

VANADIUM PENTOXIDE  $\text{V}_2\text{O}_5$ 

100 gms. sat. solution of vanadium pentoxide in water at 25° contain 0.07 gm.  $\text{V}_2\text{O}_5$  at 25° and 0.07 gm. at 100°. (Meyer and Aulich, 1930.)

SOLUBILITY OF VANADIUM PENTOXIDE IN ACID SOLUTIONS  
(Britton and Welford, 1940)

Additional data in aq. HCl and  $\text{H}_2\text{SO}_4$  solutions is given by Fischer, 1916. For results in conc.  $\text{H}_2\text{SO}_4$ , see under vanadium sulfate.

Normality of Solvent		At 18°		At 100°	
		Gms. V <sub>2</sub> O <sub>5</sub> per liter	Moles V <sub>2</sub> O <sub>5</sub> per liter	Gms. V <sub>2</sub> O <sub>5</sub> per liter	Moles V <sub>2</sub> O <sub>5</sub> per liter
HCl	2.00N	36.40	0.200	32.60	0.179
	0.500	12.05	.0662	10.65	.0585
	0.200	5.40	.0297	4.30	.0237
HNO <sub>3</sub>	0.900N	22.80	0.125	14.95	0.0822
	0.400	11.60	.0638	7.05	.0387
	0.100	2.85	.0157	1.90	.0104
HClO <sub>4</sub>	0.375N	10.10	0.0555	-	-
	0.094	2.85	.0157	-	-
H <sub>2</sub> SO <sub>4</sub>	1.800N	32.55	0.179	20.60	0.113
	0.750	12.25	.0838	8.70	.0479
	0.180	4.15	.0228	2.10	.115
NaHSO <sub>4</sub>	0.450N	8.15	0.0448	2.30	0.0127
	0.225	4.30	.0237	1.15	.0063
	0.090	1.95	.0107	0.55	.0030
CCl <sub>3</sub> COOH	0.888N	12.50	0.0687	-	-
	0.222	5.80	.0318	-	-
	0.089	2.60	.0143	-	-
CH <sub>3</sub> COOH	2.00N	0.40	0.0022	-	-
	.500	0.55	.0030	-	-
	.200	0.80	.044	-	-

## V VANADIUM

Melting points in the systems  $V_2O_5 + CaO$  and  $V_2O_5 + SiO_2$  were determined by Morozov, 1939.

### PO VANADYL PHOSPHATE $(VO)_3(PO_4)_2$

The Ksp of  $(VO)_3(PO_4)_2$  at  $25^\circ$  is  $8 \times 10^{-25}$ . (Zolotavin and Kuznetsova, 1956.)

### SO VANADIUM IV SULFATES $(VO_2)_x(SO)_y$

THE SYSTEM VANADIUM DIOXIDE - SULFUR TRIOXIDE - WATER AT  $30^\circ$   
(Rohrer, Lanford, and Kiehl, 1942)

Gms. per 100 gms. Sat. Sol.		Density	Solid Phase	Gms. per 100 gms. Sat. Sol.		Density	Solid Phase
$VO_2$	$SO_3$			$VO_2$	$SO_3$		
0.0068	0.0	0.996	A	6.04	37.50	1.448	C
3.45	3.33	1.048	A	2.27	46.96	1.506	C
7.21	6.83	1.096	A	2.11	48.17	1.517	C
11.51	10.93	1.231	A	2.05	50.96	1.662	C
13.41	12.78	1.278	A	2.19	52.45	1.578	C
16.19	15.40	1.361	A	2.80	51.91	1.583	Dm
20.21	19.02	1.468	A	2.51	52.27	1.589	Dm
24.10	22.22	1.595	Am	0.96	55.24	1.593	Dm
25.41	23.38	1.639	Am	.37	58.06	1.622	D
25.80	23.83	1.663	Am	.275	58.89	1.582	D
21.14	20.09	1.508	B	.245	59.58	1.717	D
17.24	22.35	1.473	B	.072	65.52	1.754	D
17.28	22.50	1.461	B	.080	69.09	1.783	D
12.40	26.77	1.427	B	.080	71.16	1.787	D
11.24	27.40	1.422	B	.088	72.97	1.795	D
8.11	32.35	1.416	B	.097	73.67	1.801	E
6.70	35.44	1.436	B	.086	74.46	1.844	E
6.52	36.11	1.441	B	.081	74.56	1.811	E
17.35	28.09	1.535	Cm	.062	79.17	1.827	E
17.36	28.09	-	Cm	.041	80.18	1.827	E
14.77	29.71	1.506	Cm	.035	80.58	1.835	E
13.52	30.72	1.496	Cm	.036	81.02	1.825	E
11.73	31.64	-	Cm				

m = metastable

A =  $VO_2 \cdot H_2O$

B =  $VO_2 \cdot SO_3 \cdot 5H_2O$

C =  $VO_2 \cdot SO_3 \cdot 3H_2O$

D =  $2VO_2 \cdot 3SO_3 \cdot 4H_2O$

E =  $VO_2 \cdot SO_3$

VANADIUM (V) SULFATES  $(V_2O_5)_x(SO_3)_y$ 

50

THE SYSTEM  $V_2O_5 - SO_3 - H_2O$   
(Marakov and Repa, 1938; Lanford and Kiehl, 1940)

At 25° and 75°, Marakov and Repa found four stable solid phases, none of which contained  $SO_3$ . At 30° however, Lanford and Kiehl found that three of the solids were hydrated compounds of  $SO_3 + V_2O_5$ . The later authors do not mention the data of Marakov and Repa, although the general shape of the solubility curves are the same in each case, it is hard to tell which data and solid phases represent the true equilibrium. Marakov's data may also be found in the article by Marakov and Repa (1940) on the system  $Na_2O - SO_3 - V_2O_5 - H_2O$ .

## Results of Marakov and Repa, 1938

At 25°		At 75°		Solid Phase at each temperature
Sat. Sol. Wt. %		Sat. Sol. Wt. %		
$V_2O_5$	$H_2SO_4$	$V_2O_5$	$H_2SO_4$	
0.04	0.0	0.95	0.0	$V_2O_5 \cdot 3H_2O$
0.79	2.61	1.48	17.43	"
2.02	17.98	2.00	24.18	"
4.26	26.34	2.01	24.43	"
4.53	26.96	5.06	33.00	"
5.10	27.94	-	-	"
5.90	28.15	6.10	34.30	$V_2O_5 \cdot 3H_2O + V_2O_5 \cdot 2H_2O$
5.64	31.28	5.48	38.02	$V_2O_5 \cdot 2H_2O$
3.82	37.98	5.27	41.01	"
3.40	39.50	5.13	46.50	"
4.73	41.52	8.29	49.53	$V_2O_5 \cdot 2H_2O + V_2O_5 \cdot H_2O$
1.85	47.81	8.09	52.31	$V_2O_5 \cdot H_2O$
6.90	52.50	9.08	57.33	"
6.83	52.40	-	-	"
10.37	52.93	-	-	"
12.48	53.17	11.96	57.56	$V_2O_5 \cdot H_2O + V_2O_5$
10.79	59.09	10.80	60.20	$V_2O_5$
10.24	58.70	7.51	64.98	"
1.01	90.60	7.52	70.50	"
		0.13	93.44	"

(cont'd.)

# V VANADIUM

Results at 30° (Lanford and Kiehl, 1940)

	Sat. Sol. Mole %		Density	Solid Phase	Sat. Sol. Mole %		Density	Solid Phase
	V <sub>2</sub> O <sub>5</sub>	SO <sub>3</sub>			V <sub>2</sub> O <sub>5</sub>	SO <sub>3</sub>		
SO	0.011	0.000	0.996	-	2.030	22.33	1.734	B + C
	.094	.684	1.030	-	1.920	22.26	1.717	C
	.172	1.428	1.066	A	1.690	22.34	1.694	C
	.212	1.742	1.070	A	1.580	22.47	1.695	C
	.270	2.150	1.091	A	1.020	23.20	-	C
	.459	4.232	1.178	A	0.710	24.34	-	C
	.587	5.341	1.219	A	.306	26.72	-	C
	.650	8.04	1.319	A	.311	28.15	-	C
	1.001	9.81	1.370	A	1.280	28.00m	-	D
	1.388	11.26	1.440	A + B	0.601	28.23m	1.739	D
	1.060	11.11	1.418	B	.560	28.28m	1.731	D
	0.870	11.32	-	B	.360	28.61m	1.708	D
	.646	12.24	-	B	.056	30.22	1.727	D
	.600	13.53	-	B	.019	32.78	1.745	D
	.578	13.75	1.443	B	.018	36.91	1.790	D
	.620	14.58	1.466	B	.015	39.43	1.799	D
	.898	16.46	1.519	B	.014	48.93	1.817	D
	1.690	20.73	1.661	B	.300	28.68	1.714	D + E

A = V<sub>2</sub>O<sub>5</sub>      B = V<sub>2</sub>O<sub>5</sub>·2SO<sub>3</sub>·8H<sub>2</sub>O      C = V<sub>2</sub>O<sub>5</sub>·2SO<sub>3</sub>·4H<sub>2</sub>O

D = V<sub>2</sub>O<sub>5</sub>·4SO<sub>3</sub>·4H<sub>2</sub>O      E = V<sub>2</sub>O<sub>5</sub>·2SO<sub>3</sub>·3H<sub>2</sub>O

m = metastable

## SOLUBILITY OF VANADIUM PENTOXIDE IN SULFURIC ACID SOLUTIONS (Meyer and Aulich, 1930)

Solvent (H <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O)		Gms. V <sub>2</sub> O <sub>5</sub> per 100 Gms. Sat. Sol.	
Density	Wt. % H <sub>2</sub> SO <sub>4</sub>	25°	100°
1.000	0.0	0.07	0.07
1.055	8.07	1.87	1.69
1.106	15.2	2.62	2.02
1.233	31.5	2.00	2.55
1.378	47.8	2.04	1.87
1.549	64.2	2.62	3.69
1.651	73.0	3.99	6.68
1.776	84.1	10.81	4.27
1.810	88.04	15.03	2.71
1.828	91.7	2.73	1.32
1.840	98.5	1.49	0.7

TUNGSTIC OXIDE  $WO_3$ 

0

 $WO_3$  IN AQUEOUS HCl

Moles per Liter		Moles per Liter		Moles per Liter		Moles per Liter	
HCl	$WO_3$	HCl	$WO_3$	HCl	$WO_3$	HCl	$WO_3$
0.015	0.00110	0.50	0.000537	2.78	0.00108	6.85	0.00276
0.075	0.000920	1.00	0.000711	4.17	0.00153	7.20	0.00384
0.11	0.000859	1.41	0.00090	5.50	0.00184		

THE SYSTEM  $WO_3$  - HF -  $H_2O$  AT 25°  
(Nikolaev, 1954)

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
HF	$WO_3$		HF	$WO_3$	
1.75	0.77	-	50.0	17.2	$WO_3$
12.63	6.85	-	62.5	15.6	"
16.5	7.00	-	72.3	12.85	"
17.0	7.85	-	76.0	11.32	"
25.5	8.75	$WO_3 \cdot H_2O$	78.0	10.1	$WF_6$
29.6	10.1	"	80.3	7.65	"
31.5	12.5	$WO_3$	85.0	5.5	"
35.0	11.5	"	92.6	2.1	"
44.0	13.5	"	98.3	0.20	"

SOLUBILITY OF  $WO_3$  IN HYDROCHLORIC ACID SOLUTIONS  
(Wakkad and Rizk, 1957)

Moles per Liter		Moles per Liter	
HCl	$WO_3$	HCl	$WO_3$
7.20	0.00384	1.00	0.000711
6.85	0.00274	0.50	0.000537
5.50	0.00184	0.110	0.000859
4.17	0.00153	0.075	0.000920
2.78	0.00108	0.015	0.00110

THE SOLUBILITY OF  $WO_3$  IN AQUEOUS KF SOLUTIONS  
(Schmitz Dumont and Oppenhoff, 1954)

Moles KF per liter	0.07	0.21	0.45
Moles $WO_3$ per liter	0.003	0.010	0.023

63.8 wt. %  $WO_3$  dissolves in  $NaWO_3$  at 750°. (Rabes and Schenck, 1949.)

Xe XENON

Xe XENON

#### SOLUBILITY OF XENON IN WATER

Morrison and Johnstone, 1954 determined the solubility in a special apparatus that assured equilibrium between liquid and vapor. The results are lower (especially at higher temperatures) than previously published values. They are internally consistent and are considered reliable:

( $\beta$  = cc Xe, measured at 0°, 760 ml, per cc H<sub>2</sub>O)

t°	$\beta$	t°	$\beta$	t°	$\beta$
12.7	0.1355	30.2	0.0845	47.9	0.0594
15.1	0.1236	40.0	0.0693	59.0	0.0508
15.5	0.1211	40.5	0.0678	71.7	0.0438
19.6	0.1109				

(Earlier Values of von Antropoff, 1909-10)

The results are in terms of the coef. of absorption  $\beta$ , as defined by Bunsen and modified by Kuenen in respect to the substitution of mass for volume of water.

t°	0°	10°	20°	30°	40°	50°
Abs. Coef. $\beta$	0.2180	0.1500	0.1109	0.0900	0.0812	0.0878

Other (high) values are reported by Valentiner, 1927, 1930.

#### SOLUBILITY OF XENON IN AQUEOUS SALT SOLUTIONS (Eucken and Hertzberg, 1950)

At 0°		At 20°	
Moles NaCl per 1000 Gms. H <sub>2</sub> O	$\beta$	Moles NaCl per 1000 Gms. H <sub>2</sub> O	$\beta$
0	0.222	0	0.1107
0.76	0.1595	0.285	0.0990
1.17	0.1323	1.32	0.0661
2.68	0.0719	1.80	0.0564

In aqueous NaCl solutions, Morrison and Johnstone, 1955 report a salting-out coefficient of 0.149 at 25°, and 0.113 in aqueous KI.

$$k = \frac{\log S_0/S}{C}, \quad \text{where } S_0 \text{ is soly. in water, } C \text{ is in moles/1000 gms. H}_2\text{O}.$$

SOLUBILITY OF XENON IN WATER AND IN ANILINE  
(Antropoff, 1919)

The determinations were made with the highest accuracy possible. An apparatus was used in which the solvent and its vapor touched no cock. The results are expressed in terms of the Bunsen absorption coefficient  $\beta$ , as modified by Kuenen. They show the volume of xenon in cubic centimeters (reduced to 0° and 760 mm.) dissolved by one gram of solvent. However, the values in water are high.

Coef. of absorption $\beta$ in			Coef. of absorption $\beta$ in		
t°	Water	Aniline	t°	Water	Aniline
0	0.242	-	30	0.098	0.455
10	0.174	0.669	40	0.082	0.431
20	0.123	0.501	50	0.073	0.411

SOLUBILITY OF XENON IN CYCLOHEXANES  
(Clever, Saylor and Gross, 1958)

Solvent	116°	130°	143.1°
methylcyclohexane	4.80	4.30	3.73
perfluoro methylcyclohexane	2.33	2.06	1.87

SOLUBILITY OF XENON IN SEVERAL HYDROCARBONS  
(Clever, 1958)

(One atmosphere total pressure)

t°	Ostwald Coeff. $\ell$	Mole fraction	t°	Ostwald Coeff. $\ell$	Mole fraction
<u>In benzene</u>			<u>In isooctane</u>		
16	3.59	0.0132	16	4.68	0.0313
25	3.08	0.0111	25.5	4.08	0.0264
34.45	2.98	0.0106	34.4	3.70	0.0241
43.1	2.90	0.0101	43	3.36	0.0214
<u>In cyclohexane</u>			<u>In n-dodecane</u>		
16	5.26	0.0233	16	3.78	0.0348
26	4.42	0.0192	25	3.35	0.0304
34.45	4.25	0.0181	34.4	3.08	0.0274
43.1	4.00	0.0168	43	2.84	0.0247
<u>In n-hexane</u>					
16	5.60	0.0298			
25.3	4.84	0.0254			
34.4	4.45	0.0229			
43.1	3.95	0.0201			

In nitromethane  $\ell = 1.14$  at 24.85° (Friedman, 1954)



## Xe XENON

Data for the solubility of xenon in CCl<sub>4</sub> are reported by Kay and Penneman, 1955.

In olive oil,  $\beta = 1.9$  at 22° and 1.7 at 37°. (Loomis, 1946)

### SOLUBILITY OF XENON IN LIQUID OXYGEN (v. Stackelberg, 1934)

In determination of the saturation point was made by means of vapor pressure measurements.

t°	Mol. Xe per 1.0 mol. Xe + O
70	0.141
80	0.217
90	0.304

Data for the solubility of Xe in liquid N<sub>2</sub>, He and H<sub>2</sub> are given by Ewald, 1955.

Data for systems of Xe with Diborane, Trimethylboron, SO<sub>2</sub>, H<sub>2</sub>S, methylether, methyl alcohol and BF<sub>3</sub> are given by Wiber, and Karbe, 1948.

## Y YTTRIUM BROMIDE YBr<sub>3</sub>

### SOLUBILITY OF YTTRIUM BROMIDE IN WATER (Crew, Stewart and Hopkins, 1925)

The solutions were saturated by frequent agitation during 5 hours and equilibrium was approached from above and from below.

t°	Gms. YBr <sub>3</sub> per 100 gms. H <sub>2</sub> O	t°	Gms. YBr <sub>3</sub> per 100 gms. H <sub>2</sub> O
0	64.0	75	111.3
30	83.3	95	129.6
50	96.1		

## CH YTTRIUM ACETATE Y(CH<sub>3</sub>COO)<sub>3</sub>·4H<sub>2</sub>O

100 gms. sat. solution of yttrium acetate in water prepared by constant rotation for 24 hours contained 8.28 gms. Y(CH<sub>3</sub>COOH)<sub>3</sub> at 25°. (Meyer and Müller, 1920.)

6.26 gms. Y(CH<sub>3</sub>COO)<sub>3</sub> are dissolved in 100 ml of sat. solu. in ethylenediamine at 30°. (Moeller and Zimmerman, 1953)

YTTRIUM GLYCOLATE  $Y(C_2H_3O_3)_3 \cdot 2H_2O$ 

CH

One liter of water dissolves 2.447 gms. of the salt at 20°. (Jantsch and Grünkraut, 1912-1913.)

YTTRIUM LACTATE  $Y(C_3H_5O_3)_3 \cdot 2H_2O$ 

1000 cc. sat. solution of yttrium lactate in water prepared by constant rotation in a thermostat contain 1.096 gm.  $Y(C_3H_5O_3)_3 \cdot 2H_2O$  at 20°. (Jantsch, 1926.)

YTTRIUM MALONATE  $Y_2(C_3H_2O_4)_3 \cdot 8H_2O$ 

SOLUBILITY IN AQUEOUS MALONIC ACID AND AMMONIUM MALONATE SOLUTIONS  
(Holmberg, 1907)

Solvent	t°	Gms. $Y_2(C_3H_2O_4)_3$ per 100 Gms. Solvent
1 Gm. Am. Malonate per 10 cc. Solution	20	0.3
2 Gms. Malonic Acid per 10 cc. Solution	20	2.3

YTTRIUM TARTRATE  $Y_2(C_4H_4O_6)_3 \cdot 5H_2O$ 

SOLUBILITY IN AQUEOUS TARTARIC ACID AND AMMONIUM TARTRATE SOLUTIONS AT 20°  
(Holmberg, 1907)

Aq. Solvent:	Gms. $Y_2(C_4H_4O_6)_3$ per 100 Gms. Sat. Sol.	Aq. Solvent:	Gms. $Y_2(C_4H_4O_6)_3$ per 100 Gms. Sat. Sol.
1 gm. Am. Tartrate per 10 cc. solution	0.6	2 gms. Tartaric Acid per 10 cc. solution	0.02
2 gms. Am. Tartrate per 10 cc. solution	1.1	4 gms. Tartaric Acid per 10 cc. solution	0.02

## YTTRIUM SODIUM ETHYLENE DIAMINE TETRAACETATE

At 25° 0.334 moles anhydrous salt  $NaY[C_2H_4N_2(COO)_4]$  are dissolved in 1000 gms. of sat. solu. in water.

# Y YTTRIUM ACE

## CH YTTRIUM ACETYLACETONATE $Y[CH(COCH_3)_2]_3$

### SOLUBILITY IN ORGANIC SOLVENTS (Erametsa and Hamala, 1958)

Solvent	t°	Gms.	Solvent	t°	Gms.
		$\frac{1}{2}O_3$ per 1000 ml			$\frac{1}{2}O_3$ per 1000 ml
Carbon tetrachloride	20	1.7	Acetylacetone	20	4.25
Chloroform	20	5.7	"	30	6.2
Acetone	20	10.5	"	40	9.3
Butanol	20	4.8	"	50	12.2
Ethanol	20	4.0	"	60	15.2
			"	75	19.8

## YTTRIUM SULFONATES

### SOLUBILITY OF YTTRIUM SULFONATES IN WATER

Sulfonate and Formula	t°	Gms. Anhy. Sulfonate per 100	Authority
		Gms. H <sub>2</sub> O	
Yttrium Benzene Sulfonate Y(C <sub>6</sub> H <sub>5</sub> SO <sub>3</sub> ) <sub>3</sub> ·9H <sub>2</sub> O	15	60.4	Hoimberg, 1907
Yttrium Benzene m Nitrobenzene Sulfonate Y(C <sub>6</sub> H <sub>4</sub> ·NO <sub>3</sub> ·SO <sub>3</sub> ) <sub>3</sub> ·7H <sub>2</sub> O	15	48.3	"
Yttrium Bromonitrobenzene Sulfonate Y(C <sub>6</sub> H <sub>3</sub> Br·NO <sub>2</sub> ·SO <sub>3</sub> ·1.4·2) <sub>3</sub> ·10H <sub>2</sub> O	25	3.88	Katz and James, 1913

## CM YTTRIUM COBALTICYANIDE $Y_2(CoC_6N_6)_2 \cdot 8H_2O$

1000 gms. aq. 10% HCl ( $d_{15} = 1.05$ ) dissolve 2.78 gms. of the salt at 25°. (James and Willand, 1916.)

## YTTRIUM FERROCYANIDES

Salt.	Soly. in water at 25° moles per liter
$Y_6K_4 [Fe(CN)_6]_7 \cdot 30H_2O$	$6.2 \times 10^{-6}$
$YRb [Fe(CN)_6] \cdot 2H_2O$	$1.8 \times 10^{-4}$
$YCs [Fe(CN)_6] \cdot 2H_2O$	$5.2 \times 10^{-5}$

YTTRIUM OXALATE  $Y_2(C_2O_4)_3 \cdot 9H_2O$ 

CO

One liter  $H_2O$  dissolves 0.001 gm.  $Y_2(C_2O_4)_3$  at  $25^\circ$ , determined by the electrolytic method. (Rimbach and Schubert, 1909.)

100 gms. aqueous ammonium oxalate solution (3.26%  $(NH_4)_2C_2O_4 \cdot H_2O$ ) dissolve 0.01714 gm.  $Y_2(C_2O_4)_3 \cdot 9H_2O$  at room temp. (Cleve, 1902.)

100 gms. aq. 2.16  $N H_2SO_4$  dissolve 0.6884 gm.  $Y_2(C_2O_4)_3$  at  $25^\circ$ . (Wirth, 1932.)

100 gms. aq. 4.32  $N H_2SO_4$  dissolve 1.4 gms.  $Y_2(C_2O_4)_3$  at  $25^\circ$ . (Wirth, 1932.)

100 cc. aq. 20% methylamine oxalate dissolve 0.877 gm. yttrium oxalate at ord. temp.

100 cc. aq. 20% ethylamine oxalate dissolve 1.653 gms. yttrium oxalate at ord. temp.

100 cc. aq. 20% triethylamine oxalate dissolve 1.006 gms. yttrium oxalate at ord. temp. (Grant and James, 1917.)

YTTRIUM POTASSIUM OXALATE  $Y_2(C_2O_4)_3 \cdot 4K_2C_2O_4 \cdot 12H_2O$ SOLUBILITY IN WATER AT  $25^\circ$ 

(Pratt and James, 1911)

The determinations were made with great care. The mixtures were constantly rotated for 8 weeks.

$d_{25}$ of Sat. Sol.	Gms. per 100 Gms. $H_2O$		Solid Phase	
	$Y_2(C_2O_4)_3$	$K_2C_2O_4$		
1.008	Trace	1.31	Solid	Solution
1.035	0.02	5.30	"	"
1.059	0.06	8.88	"	"
1.096	0.27	14.50	"	"
1.132	0.72	20.27	"	"
1.166	1.37	26.02	$Y_2(C_2O_4)_3 \cdot 4K_2C_2O_4 \cdot 12H_2O$	"
1.174	1.50	27.44	"	"
1.199	1.49	32.83	"	"
1.222	1.48	37.68	"	"
1.231	1.42	39.12	$K_2C_2O_4$	"
1.228	1.09	38.77	"	"
1.218	0	37.87	"	"

# Y YTTRIUM

## SOLUBILITY OF YTTRIUM OXALATE IN AQUEOUS SOLUTIONS OF NITRIC ACID ALONE AND CONTAINING OXALAIC ACID AT 90° (Neckers and Kremers, 1928)

Conc. of Aq. HNO <sub>3</sub> in normality	Gms. Y <sub>2</sub> O <sub>3</sub> per 100 cc sat. sol.	Solid Phase
2.5	1.3180	Y <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> ·9H <sub>2</sub> O
5.0	3.0135	"
2.5 + 5% (COOH) <sub>2</sub>	0.4315	"
5.0 + "	1.4515	"

## C1 YTTRIUM CHLORIDE YCl<sub>3</sub>

### SOLUBILITY OF YTTRIUM CHLORIDE IN WATER (Crew, Steinert and Hopkins, 1925; Williams, Fogg and James, 1925)

t°	Gms. YCl <sub>3</sub> per 100 gms. sat. sol.		Solid Phase	t°	Gms. YCl <sub>3</sub> per 100 gms. sat. sol.		Solid Phase
	C. S. and H.	W. F. and J.			C. S. and H.	W. F. and J.	
0	42.36	43.60	YCl <sub>3</sub> ·6H <sub>2</sub> O	40	43.30	44.70	YCl <sub>3</sub> ·6H <sub>2</sub> O
10	42.65	43.85	"	50	43.45	45.07	"
20	42.87	44.08	"	60	43.60	-	"
25	42.95	44.20	"	70	43.75	-	"
30	43.07	44.33	"	80	43.86	-	"

### SOLUBILITY OF YTTRIUM CHLORIDE IN AQUEOUS HYDROCHLORIC ACID OF DENSITY 1.1051 (Williams, Fogg and James, 1925)

Constant agitation in a thermostat for 9 hours and approaching equilibrium from above and below was employed.

t°	Gms. YCl <sub>3</sub> per 100 gms. sat. sol.	Solid Phase	t°	Gms. YCl <sub>3</sub> per 100 gms. sat. sol.	Solid Phase
10	24.35	YCl <sub>3</sub> ·6H <sub>2</sub> O	40	26.52	YCl <sub>3</sub> ·6H <sub>2</sub> O
20	24.63	"	50	27.55	"
30	25.48	"			

100 cc. of water, saturated with HCl at 0° (1 atm.) contain 0.024 gms. Y<sub>2</sub>O<sub>3</sub>. Fischer, W., and Z.-Pf., 1949

100 cc. of a mixture of equal volumes of ether and water, saturated with HCl at 0° (1 atm) contain 0.0015 gms. Y<sub>2</sub>O<sub>3</sub>. (Fischer, W., and Z.-Pf., 1949.)

100 gms. alcohol dissolve 61.1 gms. YCl<sub>3</sub> at 15°. (Matignon, 1906.)

100 gms. alcohol dissolve 60.5 gms. YCl<sub>3</sub> at 20°. (Matignon, 1909.)

100 gms. pyridine dissolve 6.5 gms. YCl<sub>3</sub> at 15°. (Matignon, 1906.)

YTTRIUM HEXAANTIPYRINE PERCHLORATE  $Y(COC_{10}H_{12}N_2)_6(ClO_4)_3$  ClO

100 cc sat. solution of the salt in water contain 0.55 gm.  
 $Y(COC_{10}H_{12}N_2)_6(ClO_4)_3$  at 20°. (Wilke-Dörfurt and Schliephake, 1928.)

YTTRIUM HEXAANTIPYRINE IODIDE  $Y(COC_{10}H_{12}N_2)_6I_3$  I

100 cc sat. solution of the salt in water contain 4.44 gm.  
 $Y(COC_{10}H_{12}N_2)_6O_3$  at 20°. (Wilke-Dörfurt and Schliephake, 1928.)

YTTRIUM IODATE  $Y(IO_3)_3 \cdot 3H_2O$  10

100 gms.  $H_2O$  dissolve 0.53 gm. yttrium iodate. (Berlin.)

YTTRIUM NITRATE  $Y(NO_3)_3$  NO

SOLUBILITY OF YTTRIUM NITRATE IN WATER  
 (Crew, Steinert and Hopkins, 1925)

Saturation was obtained by frequent agitation during 5 hours and approaching equilibrium from above and from below.

t°	Gms. $Y(NO_3)_3$ per 100 gms. $H_2O$	t°	Gms. $Y(NO_3)_3$ per 100 gms. $H_2O$
0.0	93.1	60.2	200.0
22.5	134.5	66.5	211.0
35.0	155.0		

Data for the distribution of  $Y(NO_3)_3$  between tributyl phosphate and water is given by Healy and McKay, 1956.

100 cc of a sat. solution of yttrium nitrate in ethyl ether prepared by frequent agitation and allowing to stand over night at about 20°, contain 0.792 gm.  $Y_2O_3$ . A saturated ethereal solution prepared as above but using yttrium nitrate dehydrated at 150°, contains 0.803 gm.  $Y_2O_3$  per 100 cc. - (Wells, 1930.)

When a mixture of rare earth nitrates containing 10%  $Y(NO_3)_3$  is shaken with n-hexyl ketone and water at room temperature the distribution ratio was found to be less than 0.0012, with 33.0% of the anhydrous nitrates in the aqueous phase (Rothschild, Templeton, and Hall, 1948.)

The solubility of a mixture of rare earth nitrates containing 23%  $Y(NO_3)_3$  was found to be 12.0 gms. of anhydrous nitrates per 100 gms. of saturated solution in isoamyl alcohol and 3.22 gms. per 100 gms. saturated solution in methyl n-hexyl ketone at room temperature. (Rothschild, Templeton, and Hall, 1948.)

# Y YTTRIUM

## NO YTTRIUM BASIC NITRATE $3Y_2O_3 \cdot 4N_2O_5 \cdot 2H_2O$

THE SYSTEM YTTRIUM NITRATE - YTTRIUM HYDROXIDE - WATER AT 25°  
(James and Pratt, 1910)

The determinations were made with very great care. The mixtures were rotated  $4\frac{1}{2}$  months.

$d_{25}$ of Sat. Sol.	Gms. per 100 Gms. $H_2O$		Solid Phase
	$Y(NO_3)_3$	$Y_2O_3$ as $Y(OH)_3$	
1.0260	3.13	0.014	$Y(OH)_3$
1.1106	13.87	0.034	"
1.1907	24.94	0.063	"
1.2517	33.02	0.160	" + $3Y_2O_3 \cdot 4N_2O_5 \cdot 2H_2O$
1.3268	44.35	0.114	$3Y_2O_3 \cdot 4N_2O_5 \cdot 2H_2O$
1.4104	58.61	0.095	"
1.4867	73.03	0.078	"
1.5587	89.06	0.074	"
1.6259	103.80	0.075	"
1.6931	122.40	0.080	"
1.7440	137.10	0.083	" + $Y(NO_3)_3$
1.7446	141.6	0	$Y(NO_3)_3$

## O YTTRIUM OXIDE $Y_2O_3$

## OH YTTRIUM HYDROXIDE $Y(OH)_3$

Oka, 1940 found the solubility of  $Y(OH)_3$  to be  $1.8 \times 10^{-6}$  moles per liter by potentiometric titration. Moeller and Kremers (1944) found  $1.2 \times 10^{-6}$  moles/l. and Moeller and Fogel (1950),  $0.9 \times 10^{-6}$  moles/liter (25°).

One liter sat. solution of yttrium oxide in water contain 0.000008 gm. mol.  $Y_2O_3$  at 29° as determined by electrometric titration. (Busch, 1927.)

The Ksp of  $Y(OH)_3$  is  $1 \times 10^{-24}$  (Korenman, 1955)

Data for the precipitation of  $Y_2O_3$  and other rare earth oxides from ammonium acetate solutions ARE given by Perey, 1949.

## PO YTTRIUM HYPOPHOSPHATE $Y_4(P_2O_6)_3$

SOLUBILITY IN AQUEOUS HYDROCHLORIC ACID AT 25°  
(Moeller and Quinty, 1952)

Normality of HCl	Moles $\frac{1}{4} (P_2O_6)_3$ per liter
0.20	0.000302
0.30	0.000552
1.00	0.002690

YTTRIUM DIMETHYL PHOSPHATE  $Y_2[(CH_3)_2PO_4]_6$ 

PO

## SOLUBILITY IN WATER

Marsh, 1939. Results in parentheses by Morgan and James, 1914.

t°	Gms. $Y_2[(CH_3)_2PO_4]_6$ per 100 gms. $H_2O$
0	6.44
25	3.53 (2.8)
50	1.90
95	- (0.55)

YTTRIUM SULFATE  $Y_2(SO_4)_3$ 

SO

## SOLUBILITY IN WATER

Crew, Steinert and Hopkins, 1925; Jackson and Rienacker, 1930; Spedding and Jaffe, 1954; James and Holden, 1913. The solid phase is the octahydrate.

t°	Gms. $Y_2(SO_4)_3$ per 100 gms. $H_2O$	t°	Gms. $Y_2(SO_4)_3$ per 100 gms. $H_2O$
3.6	7.94	40	3.75 (J. and R.)
15.8	7.49	50	5.37
20	7.46 (J. and R.)	75	3.22
25	7.20	95	2.03
	5.38 (J. and H.)		
	7.39 (S. and J.)		

Results at High Temperatures  
(Jones, Lietzke and Marshall, 1957)

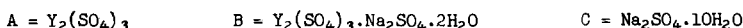
t°	Wt. $Y_2(SO_4)_3$	t°	Wt. $Y_2(SO_4)_3$
108	4.76	163	0.64
150	2.38	176	0.48
155	1.59	186	0.23
160	1.19	195	0.12
161	0.95		



# Y YTTRIUM

## SOLUBILITY OF YTTRIUM SULFATE IN AQUEOUS SOLUTIONS OF SODIUM SULFATE AT 25° (James and Holden, 1923.)

Equilibrium was reached very slowly and it was necessary to rotate the mixtures for 14 months before final equilibrium was reached.



	Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase
	Y <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>		Y <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	
SO	5.61	1.29	A	1.90	14.89	B
	6.38	3.85	A	1.79	16.51	B
	7.40	6.21	A	1.86	18.44	B
	8.43	8.52	A + B	2.99	19.96	B
	5.86	7.57	B	3.04	21.05	B
	4.75	7.72	B	2.27	27.14	B
	3.42	10.14	B	1.52	28.22	B
	2.36	11.36	B	1.61	28.13	B
	2.02	13.42	B	5.38	0	C

Data for the solubility of Y<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> in aqueous UO<sub>2</sub>SO<sub>4</sub> solutions above 150° is given by Jones, Lietzke and Marshall, 1957.

## CH YTTERBIUM BROMONITROBENZENE SULFONATE Yb(C<sub>6</sub>H<sub>3</sub>Br.NO<sub>2</sub>.SO<sub>3</sub>.1.4.3)<sub>3</sub>.12H<sub>2</sub>O

100 gms. sat. solution in water contain 7.294 gms. of the anhydrous salt at 25°. (Katz and James, 1913.)

## CN YTTERBIUM COBALTICYANIDE Yb<sub>2</sub>[Co(CN)<sub>6</sub>]<sub>2</sub>.9H<sub>2</sub>O

1000 gms. aqueous 10% HCl (d<sub>15</sub> = 1.05) dissolve 0.38 gm. of the salt at 25°. (James and Willand, 1916.)

## CO YTTERBIUM OXALATE Yb<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub>.10H<sub>2</sub>O

### SOLUBILITY IN WATER AND IN SEVERAL AQUEOUS SOLUTIONS

Aqueous Solution of:	% Conc. of Aq. Sol.	t°	Gms. Yb <sub>2</sub> (C <sub>2</sub> O <sub>4</sub> ) <sub>3</sub> per 100 cc. Solvent	Authority
Water	-	25	0.000334	Rimbach and Schubert, 1909
(NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub> .H <sub>2</sub> O	3.26	ord.	0.095	Cleve, 1902
M thylamine Oxalate	20	"	5.24 <sup>a</sup>	Grant and James, 1917
Ethylamine Oxalate	20	"	5.86 <sup>a</sup>	Grant and James, 1917
Triethylamine Oxalate	20	"	2.05 <sup>a</sup>	Grant and James, 1917
Sulfuric Acid (1 N)	4.9	"	0.372	Cleve, 1902

<sup>a</sup>The authors do not state whether their figures are for anhydrous or hydrated salt.

Data for the solubility of ytterbium oxalate in oxalic acid - sodium oxalate buffers at 25° have been determined by Crouthamel and Martin, Jr., 1950.

YTTERBIUM CHLORIDE  $\text{YbCl}_3 \cdot 6\text{H}_2\text{O}$ 

Cl

## SOLUBILITY OF YTTERBIUM CHLORIDE IN AQUEOUS HYDROCHLORIC ACID OF DENSITY 1.1051

(Williams, Fogg and James, 1925)

Constant rotation in a thermostat for 9 hours and approaching equilibrium from above and below was employed.

Solid phase  $\text{YbCl}_3 \cdot 6\text{H}_2\text{O}$  throughout.

t°	Gms. $\text{YbCl}_3$ per 100 gms. sat. sol.	t°	Gms. $\text{YbCl}_3$ per 100 gms. sat. sol.
10	32.00	40	33.84
20	32.38	50	34.88
30	33.03		

YTTERBIUM DIMETHYL PHOSPHATE  $\text{Yb}_2[(\text{CH}_3)_2\text{PO}_4]_6$ 

PO

100 gms.  $\text{H}_2\text{O}$  dissolve 1.2 gms.  $\text{Yb}_2[(\text{CH}_3)_2\text{PO}_4]_6$  at 25° and 0.25 gm. at 95°. (Morgan and James, 1914.)

The following results differing from the above are by Marsh, 1939.

t°	Gms. $\text{Yb}_2[(\text{CH}_3)_2\text{PO}_4]_6$
0	2.68
25	1.35
50	0.7%

YTTERBIUM SULFATE  $\text{Yb}_2(\text{SO}_4)_3 \cdot 8\text{H}_2\text{O}$ 

SO

SOLUBILITY IN WATER  
(Cleve, 1902)

t°	Gms. $\text{Yb}_2(\text{SO}_4)_3$ per 100 gms. $\text{H}_2\text{O}$	t°	Gms. $\text{Yb}_2(\text{SO}_4)_3$ per 100 gms. $\text{H}_2\text{O}$	t°	Gms. $\text{Yb}_2(\text{SO}_4)_3$ per 100 gms. $\text{H}_2\text{O}$
0	44.2	35	19.1	70	7.22
15.5	34.6	40	18.7 <sup>a</sup>	80	6.92
20	28.3 <sup>a</sup>	55	11.5	90	5.83
25	29.3 <sup>b</sup>	60	10.4	100	4.67

<sup>a</sup>Jackson and Rienacker, 1930

<sup>b</sup>Spedding and Jaffe, 1954

## Zn ZINC

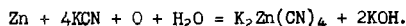
## Zn ZINC

### SOLUBILITY IN WATER AT 25° (Pariaud and Archinard, 1952)

Degassed, triply distilled water at pH 7.0 was used. The metal was electrolytically pure. An average of 6 closely agreeing determinations equilibrated for 17 and 32 days showed 0.710 mg per liter. Dithizone was used for analysis.

### SOLUBILITY OF ZINC IN AQUEOUS POTASSIUM CYANIDE SOLUTIONS (White, 1919)

The weight of zinc dissolved per 24 hours from rectangular (2.5 x 1.5 cm.) pieces of ordinary commercial rolled sheet zinc 0.03 mm. in thickness, when suspended in aqueous potassium cyanide solutions, was determined. Uniform conditions were maintained in each experiment but the temperature was not held constant. The influence of oxygen concentration, cyanide concentration, alkalinity, etc. was studied. The main reaction in presence of oxygen is



Therefore, 6.0 milligrams of oxygen per liter is equivalent to 0.0089 per cent KCN and to 24.5 milligrams of Zn per liter. However, in the absence of oxygen some zinc may dissolve. Numerous tables and curves are given.

### SOLUBILITY OF ZINC IN MILK (Quam, 1929)

Highly polished 4 x 7.5 cm. strips of zinc were each immersed in 50 cc portions of raw milk and rocked 46 times per minute for 30 minutes. The loss in weight of the Zn strips was determined and the results expressed in mgs. Zn dissolved per sq. decimeter of surface exposed.

t°	Mgs. Zn dissolved per sq. cm.	t°	Mgs. Zn dissolved per sq. cm.
30	0.432	75	1.78
40	0.744	85	1.546
50	1.03	95	1.03
60	1.546		

Data for the system  $\text{Zn} + \text{CuCl}_2 = \text{ZnCl}_2 + \text{Cu}$  are reported by Palkin and Chepurko, 1956.

For the system Zn - Ga see Genta, 1955.

## AsO ZINC ARSENITE $\text{Zn}_3(\text{AsO}_3)_2$

The Ksp is  $2.8 \times 10^{-20}$  at 20°, as determined in  $\text{HNO}_3$ ,  $\text{HCl}$ , and  $\text{H}_2\text{SO}_4$  solutions. (Chukhlantsev, 1957.)

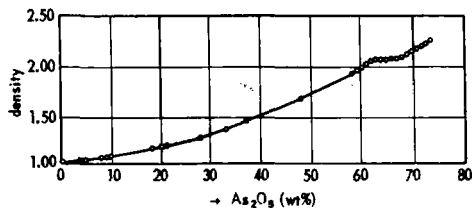
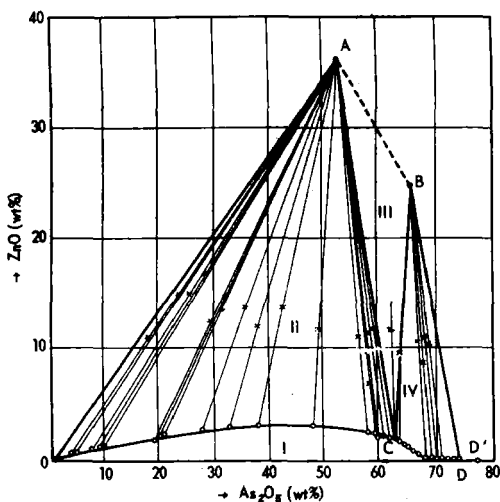
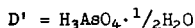
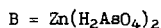
Data for the solubility of zinc arsenites in dil.  $\text{NH}_3$  and acetic acid solutions at  $25^\circ$  and  $70^\circ$  are given by Kuperman, Orlov, Krutitskaya and Trushkina, 1955.

100 gms. 95% formic acid dissolve 0.86 gms.  $\text{Zn}_3(\text{AsO}_3)_2$  at  $21^\circ$ . (Aschan, 1913.)

ZINC ARSENATE  $\text{Zn}_3(\text{AsO}_4)_2$ 

AsO

THE SYSTEM ZINC OXIDE - ARSENIC PENTOXIDE - WATER AT  $30^\circ$   
(Takahashi and Sasaki, 1953)



Point C occurs in a solution containing 61.92%  $\text{As}_2\text{O}_5$ .

## Zn ZINC

Chuklantsev, 1956 reports the solubility product constant  $[Zn]^3 [AsO_4]^2$  to be  $1.3 \times 10^{-38}$  by acid solubility measurements and  $1.08 \times 10^{-37}$  from radiotracer determinations. Other data in dil  $NH_3$  and acetic acid solutions at 25° and 70° are reported by Kuperman, Orlov, Krutitskaya and Trushkina, 1955.

100 gms. 95% formic acid dissolve 0.26 gm.  $Zn_3(AsO_4)_2$  at 21°. (Aschan, 1913.)

## AsO ZINC CACODYLATE $Zn[(CH_3)_2AsOO]_2 \cdot 7H_2O$

### SOLUBILITY OF ZINC CACODYLATE IN WATER (Tiollis and Perdreau, 1939)

t°	Gms. $Zn[(CH_3)_2AsOO]_2$ per 100 gms. sat. sol.	Solid Phase
1	25.9	$Zn[(CH_3)_2AsOO]_2 \cdot 7H_2O$
8	28.0	"
21	33.2	"
23	36.5	"
25	40.0	" + $Zn[(CH_3)_2AsOO]_2 \cdot H_2O$
27.5	38.1	$Zn[(CH_3)_2AsOO]_2 \cdot H_2O$
30	36.5	"
34	35.5	"
42	34.2	"
56	34.0	"
64	34.3	$Zn[(CH_3)_2AsOO]_2$
72	36.0	"
84	39.2	"
98	44.2	"

These authors also give similar results for the solubility of cadmium cacodylate in water.

## BO ZINC BORATES

Melting point diagrams for the systems  $ZnO + B_2O_3$  and  $ZnO + B_2O_3 + SiO_2$  are given by Ingerson, Morey, and Tuttle (1948) and by Torpov and Konovalov (1949).

ZINC BROMIDE  $\text{ZnBr}_2$ 

Br

SOLUBILITY IN WATER  
(Dietz, 1900; see also Etard, 1894)

t°	Gms. $\text{ZnBr}_2$ per 100 Gms. Solution	Mols. $\text{ZnBr}_2$ per 100 Mols. $\text{H}_2\text{O}$	Solid Phase	t°	Gms. $\text{ZnBr}_2$ per 100 Gms. Solution	Mols. $\text{ZnBr}_2$ per 100 Mols. $\text{H}_2\text{O}$	Solid Phase
-15	77.13	27.0	$\text{ZnBr}_2 \cdot 3\text{H}_2\text{O}$	25	82.46	37.6	$\text{ZnBr}_2 \cdot 2\text{H}_2\text{O}$
-10	78.45	29.1	"	30	84.08	42.3	"
-5	80.64	33.3	"	37	86.20	50.0	"
-8	79.06	30.2	$\text{ZnBr}_2 \cdot 2\text{H}_2\text{O}$	35	85.45	46.9	$\text{ZnBr}_3$
0	79.55	31.1	"	40	85.53	47.4	"
+13	80.76	33.5	"	60	86.08	49.5	"
18	81.46	35.1	"	80	86.57	51.5	"
				100	87.05	53.8	"

The transition point of  $\text{ZnBr}_2 \cdot 2\text{H}_2\text{O} \rightarrow \text{ZnBr}_2$  is given as 35° by Ishikawa and Yoshida, 1930.

Data for the solubility of  $\text{ZnBr}_2$  in aqueous  $\text{NH}_3$  solutions at 25° are given by Urazov, Kirakosyan and Mkhitaryan, 1958.

SOLUBILITY OF ZINC BROMIDE IN DIETHYL ETHER  
(Rowley and Anderson, 1941)

t°	Gms. $\text{ZnBr}_2$ per 100 gms. Ether	Solid Phase	t°	Gms. $\text{ZnBr}_2$ per 100 gms. Ether	Solid Phase
-20	47.7	$\text{ZnBr}_2 \cdot 2(\text{C}_2\text{H}_5)_2\text{O}$	5	178.3	$\text{ZnBr}_2 \cdot (\text{C}_2\text{H}_5)_2\text{O}$
-15.8	67.2	"	10	195.7	"
-10	92.3	"	15	222.6	"
-5	107.7	"	20	231.8	$\text{ZnBr}_2$
0	133.3	"	25	236.0	"
			35	243.5	"

SOLUBILITY OF ANHYDROUS ZINC BROMIDE IN PURE ACETONE  
(Bell, Rowlands, Bamford, Thomas and Jones, 1930)

t°	Gms. $\text{ZnBr}_2$ per 100 gms. $(\text{CH}_3)_2\text{CO}$	Solid Phase
20	364.0	$\text{ZnBr}_2 \cdot \frac{1}{2}(\text{CH}_3)_2\text{CO}$
30	363.0	"
31 tr.pt.	-	" + $\text{ZnBr}_2$
40	380.0	$\text{ZnBr}_2$
50	381.0	"

100 cc pyridine dissolve 4.4 gms.  $\text{ZnBr}_2$  at 18°. (Muller, R., 1924.)

## Zn ZINC

### CH ZINC FORMATE $\text{Zn}(\text{HCOO})_2$

#### SOLUBILITY OF ZINC FORMATE IN WATER (Ashton, Houston and Saylor, 1933)

t°	Gms. $\text{Zn}(\text{HCOO})_2$ per 100 gms. $\text{H}_2\text{O}$	Solid Phase	t°	Gms. $\text{Zn}(\text{HCOO})_2$ per 100 gms. $\text{H}_2\text{O}$	Solid Phase
0	3.7	$\text{Zn}(\text{HCOO})_2 \cdot 2\text{H}_2\text{O}$	60	11.8	$\text{Zn}(\text{HCOO})_2 \cdot 2\text{H}_2\text{O}$
10	4.3	"	70	15.5	"
20	5.2	"	80	21.2	"
30	6.1	"	90	28.8	"
40	7.4	"	100	38.0	"
50	9.2	"			

### CH ZINC ACETATE $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2$

100 gms.  $\text{H}_2\text{O}$  dissolve 41.6 gms.  $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot \text{H}_2\text{O}$  at  $15^\circ$ , d of sat. sol. = 1.165. (Greenish and Smith, 1902.)

#### SOLUBILITY IN AQUEOUS ETHYL ALCOHOL AT $25^\circ$ (Seidell, 1910)

Wt. % $\text{C}_2\text{H}_5\text{OH}$ in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2\text{H}_2\text{O}$ per 100 Gms. Sat. Sol.	Wt. % $\text{C}_2\text{H}_5\text{OH}$ in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2\text{H}_2\text{O}$ per 100 Gms. Sat. Sol.
0	1.168	30.80	60	0.920	10.60
10	1.127	27.20	70	0.880	7.80
20	1.090	23.70	80	0.850	5.50
30	1.055	20.40	90	0.830	4.20
40	1.015	17.00	95	0.825	4.00
50	0.970	13.80	100	0.796	1.18 <sup>a</sup>

<sup>a</sup> = gms. anhydrous salt. The solid phase was  $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2\text{H}_2\text{O}$  in all cases except this solution.

100 cc. anhydrous hydrazine dissolve 4 gms. zinc acetate with separation of a white suspension at ordinary temperature. (Welsh and Broderson, 1915.)

100 gms. methyl alcohol dissolve 1.9 gm. anhydrous zinc acetate at  $15^\circ$  and 1.9 gms. at  $66.6^\circ$  (b.pt.). (Henstock, 1934.)

SOLUBILITY OF ZINC ACETATE IN PURE ACETIC ACID  
(Davidson and McAllister, 1930)

t°	Mol. Percentage Zn(CH <sub>3</sub> COO) <sub>2</sub> in sat. sol.		Solid Phase	t°	Mol. Percentage Zn(CH <sub>3</sub> COO) <sub>2</sub> in sat. sol.		Solid Phase
40.5	0.0050		Zn(CH <sub>3</sub> COO) <sub>2</sub>	56	0.0150		Zn(CH <sub>3</sub> COO) <sub>2</sub>
43	0.0054		"	62	0.0231		"
48	0.0085		"	72	0.0382		"
52	0.0109		"				

Results are also given for the ternary system Zn(CH<sub>3</sub>COO)<sub>2</sub> + NaCH<sub>3</sub>COO + CH<sub>3</sub>COOH by Davidson and McAllister, 1930.

Results for the ternary system Zn(CH<sub>3</sub>COO)<sub>2</sub> + NH<sub>4</sub>CH<sub>3</sub>COO + CH<sub>3</sub>COOH are given by Davidson and Griswold, 1935.

Results for the ternary system Zn(CH<sub>3</sub>COO)<sub>2</sub> + ZnCl<sub>2</sub> + CH<sub>3</sub>COOH are given by Davidson and Chappell, 1939.

SOLUBILITY OF ZINC ACETATE IN LITHIUM NITRATE SOLUTIONS IN ACETIC ACID  
(Griswold, Ash, and McReynolds, 1945)

R = Mole % LiNO<sub>3</sub> in Solvent      S = Mole % Zn(CH<sub>3</sub>COO)<sub>2</sub> in Sat. Sol.

The solid phase was unsolvated zinc acetate throughout.

S	t°	S	t°	R	S
R = 1.450		R = 9.60		Temperature = 30°	
0.1020	37.7	0.786	35.6	0.000	0.056
.1295	48.2	1.005	46.0	0.663	.055
.1799	56.9	1.063	49.8	1.021	.073
.2352	66.0	1.262	58.1	1.353	.092
.3102	77.5	1.462	67.8	1.694	.129
.3651	83.0	2.067	80.3	2.49	.159
				3.02	.204
R = 3.90		R = 11.90		3.69	.251
				4.38	.309
.317	41.1	1.210	39.9	5.40	.356
.352	47.7	1.386	47.1	6.40	.433
.448	57.5	1.631	57.7	7.42	.525
.539	65.1	1.937	69.0	8.46	.574
.650	73.8	2.230	74.6	9.48	.612
.741	79.1	2.941	86.0	10.51	.660
R = 8.00					
.799	47.7	1.150	65.0		
.902	53.5	1.339	71.5		
.981	57.6	1.559	77.8		

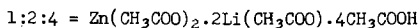


# Zn ZINC

## SOLUBILITY OF ZINC ACETATE IN LITHIUM ACETATE SOLUTIONS IN ACETIC ACID (Griswold and Van Horne, 1945)

R = Mole % Li(CH<sub>3</sub>COO) in Solvent      R = Mole % Zn(CH<sub>3</sub>COO)<sub>2</sub> in Sat. Sol.

S	t°	S	t°	S	t°
R = 2.50 Solid Phase Zn(Ac) <sub>2</sub>		R = 7.97 Solid Phase 1:2:4		R = 10.00 Solid Phase 1:2:4	
0.705	35.0	1.44	14.0	1.43	16.5
0.800	47.0	1.82	18.3	2.03	22.0
1.106	75.3	2.09	20.9	2.16	22.6
1.170	79.5	2.25	21.2	2.33	23.8
		2.35	22.9	2.50	25.3
R = 5.00 Solid Phase Zn(Ac) <sub>2</sub>		R = 10.00 Solid Phase Zn(Ac) <sub>2</sub>		R = 12.50 Solid Phase Zn(Ac) <sub>2</sub>	
1.565	37.9				
1.572	38.0	2.70	41.8	3.45	51.5
1.604	42.0	2.99	52.6	3.96	67.0
1.887	59.5	3.07	56.7	4.28	74.6
1.897	63.5	3.27	61.8	4.61	82.9
2.416	83.8	3.53	69.2	4.77	86.6
2.445	84.7	3.55	69.6	5.08	93.0
R = 7.97 Solid Phase Zn(Ac) <sub>2</sub>		3.81	77.3		
		3.99	81.5		
				R = 12.50 Solid Phase 1:2:4	
2.04	36.7			2.53	28.4
2.13	39.7			2.86	30.5
2.35	47.6			3.69	35.1
3.07	66.6			3.96	36.9
3.31	72.6			4.03	36.7
3.45	75.8			4.28	37.4
4.14	90.1				



Isothermal curves (50°, 70°) are also presented which show the solubility of zinc acetate in acetic acid with added lithium acetate.

# CH ZINC FUMARATE ZnC<sub>4</sub>H<sub>2</sub>O<sub>4</sub>·5H<sub>2</sub>O

100 gms. H<sub>2</sub>O dissolve 1.96 gms. of the compound at 30°. The sat. solution was analyzed by evaporating to dryness and drying the residue at 100°. The result, therefore, probably refers to the anhydrous compound. (Weiss and Downs, 1923.)

ZINC TARTRATE  $C_4H_4O_6 \cdot Zn \cdot 2H_2O$ 

CH

SOLUBILITY IN WATER  
(Cantoni and Zachoder, 1905)

Gms. $C_4H_4O_6 \cdot Zn \cdot 2H_2O$ per t° 100 cc. Solution		Gms. $C_4H_4O_6 \cdot Zn \cdot 2H_2O$ per t° 100 cc. Solution		Gms. $C_4H_4O_6 \cdot Zn \cdot 2H_2O$ per t° 100 cc. Solution	
15	0.019	40	0.060	65	0.100
20	0.022	45	0.073	70	0.088
25	0.036	50	0.087	75	0.078
30	0.041	55	0.116	80	0.059
35	0.055	60	0.104	85	0.041

ZINC XANTHATE  $(C_2H_5OCS)_2Zn$ 

The Ksp is  $5 \times 10^{-9}$ . (Oyama, Shimoizaka, Usui, Ohba, and Yamasaki, 1957.)

ZINC XANTHOGENATE  $(C_2H_5OCS_2C_2H_5)_2Zn$ 

0.0009 gms. zinc xanthogenate dissolve in 100 ml of water. (Sheka and Kriss, 1957.)

ZINC VALERATE  $Zn(C_4H_9COO)_2 \cdot 2H_2O$ SOLUBILITY OF ZINC VALERATE IN AQUEOUS ALCOHOL SOLUTIONS AT 25°  
(Seidell, 1910)

Wt. % $C_2H_5OH$ in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. $Zn(C_4H_9COO)_2 \cdot 2H_2O$ per 100 Gms. Sat. Sol.	Wt. % $C_2H_5OH$ in Solvent	d <sub>25</sub> of Sat. Sol.	Gms. $Zn(C_4H_9COO)_2 \cdot 2H_2O$ per 100 Gms. Sat. Sol.
0	1.004	1.44	85	0.836	2.15
20	0.972	0.75	90	0.827	3.20
40	0.936	0.76	92.3	0.828	5.50
60	0.984	1.15	95	0.832	8.80
80	0.848	1.70	100	0.844	15.60

ZINC GLUCONATE  $Zn(C_6H_{11}O_7)_2 \cdot 3H_2O$ 

100 cc sat. solution of zinc gluconate in water contain 12.7 gms.  $Zn(C_6H_{11}O_7)_2$  at 25°. (May, Weissberg and Herrick, 1929.)

# Zn ZINC

## CH ZINC BENZOATE $\text{Zn}(\text{C}_7\text{H}_5\text{O}_2)_2$

	SOLUBILITY IN WATER (Pajetta, 1906)						
	15.9°	17°	27.8°	31.5°	37.5°	49.8°	39°
Gms. $\text{Zn}(\text{C}_7\text{H}_5\text{O}_2)_2$ per 100 gms. aq. solution	2.55	2.49	2.41	2.05	1.87	1.62	1.45

### SOLUBILITY OF ZINC BENZOATE IN SEVERAL SOLVENTS (Henstock, 1934)

Solvent	t°	Gms. $\text{Zn}(\text{C}_6\text{H}_5\text{COO})_2$ per 100 gms. solvent
Methyl Alcohol	15	9.90
Methyl Alcohol	65.9 (b.pt.)	6.62
Acetone	15	1.00
Benzene	15	4.20

## ZINC BENZOATE, CHLORO, NITRO, OXY, BENZOATES

### SOLUBILITY OF EACH SEPARATELY IN WATER AT 20° (Ephraim and Pfister, 1925)

	Gms. anhydrous compound per 100 cc. sat. sol.
Zinc Benzoate $\text{Zn}(\text{C}_6\text{H}_5\text{COO})_2 \cdot \text{H}_2\text{O}$	2.048
Zinc 4-Chloro Benzoate $\text{Zn}(\text{C}_6\text{H}_4\text{ClCOO})_2 \cdot 2\text{H}_2\text{O}$	0.649
Zinc 4-Methoxy Benzoate $\text{Zn}(\text{C}_6\text{H}_4\text{OCH}_3\text{COO})_2 \cdot \text{H}_2\text{O}$	1.174
Zinc 4-Nitro Benzoate $\text{Zn}(\text{C}_6\text{H}_4\text{NO}_2\text{COO})_2 \cdot 2\text{H}_2\text{O}$	0.556
Zinc 4-Oxy Benzoate $\text{Zn}(\text{C}_6\text{H}_4\text{OHCOO})_2 \cdot 8\text{H}_2\text{O}$	1.687

## ZINC NITROSO $\beta$ PHENYL HYDROXYLAMINE $\text{Zn}[\text{C}_6\text{H}_5 \cdot \text{N}(\text{NO}) \cdot \text{O}]_2$

One liter sat. solution in water contains 0.00049 gm. at = 0.032 gm Zn at 18°. (Pinkus and Martin, 1927.)

## ZINC TETRACHLOROPHTHALATE $\text{Zn}[\text{C}_6\text{Cl}_4(\text{COO})_2]$

100 gms. of a saturated solution in water at 25° contain 3.0 gms. of the Salt. 100 gms. of a saturated solution in water at 75° contain 2.0 gms. of the Salt. (Lawlor, 1947)

ZINC CINNAMATE  $\text{Zn}(\text{C}_9\text{H}_7\text{O}_2)_2 \cdot 2\text{H}_2\text{O}$ 

CH

100 cc. sat. solution of zinc cinnamate in water contain 0.15 gm.  $\text{Zn}(\text{C}_9\text{H}_7\text{O}_2)_2$  at 20°. (Ephraim, and Pfister, 1925.)

100 cc. sat. solution in water contain 0.144 gm. zinc cinnamate at 26.5°. (De Jong, 1909.)

## ZINC 8-HYDROXYQUINOLATES

The Ksp of zinc oxine is  $3.73 \times 10^{-21}$  (Tinovskaya, 1950);  $3.2 \times 10^{-26}$  (Borrel and Paris, 1952). See also Weber, 1953.

The Ksp of zinc 2-methyl 8-hydroxyquinolate is  $10^{-26}$  (Borrel and Paris, 1952) See also Weber, 1953

Data for the Ksp of zinc 8-hydroxy quinoline - 5 - sulfonate at 25° are given by Nasanen and Uusitalo, 1954. Ksp data for the 5,7 dibromo 8-hydroxyquinoline derivative is given by Weber, 1953. For the 5-chloro -7-iodo 8 hydroxy quinolate see Recktenwald, 1955

ZINC DIPHENYL  $\text{Zn}(\text{C}_6\text{H}_5)_2$ SOLUBILITIES AT 20°  
(Strohmeier, 1955)

Heptane	4.2	gms. per liter
Benzene	79	gms. per liter
Dioxane	159	gms. per liter

ZINC ANTIPYRINE SALTS  $\text{Zn}(\text{C}_{11}\text{H}_{12}\text{N}_2\text{O})_2 \cdot \lambda_2$ 

## Results of Kumov, 1951

	Gms. Salt at 15° per 100 ml solvent		
	water	ethanol	ethyl ether
zinc antipyrine bromide	2.10	0.48	0
zinc antipyrine thiocyanate	0.40 (0.33%) <sup>a</sup>	0.32	0.14
zinc antipyrine chloride	1.70	0.44	0.23
zinc antipyrine iodide	0.65	0.63	0.036

<sup>a</sup>Burkat, 1956. Burkat also found the double salt:  $[(\text{C}_{11}\text{H}_{12}\text{N}_2\text{O})_2\text{H}_2\text{Zn}(\text{SCN})_4] \cdot 2\text{C}_{11}\text{H}_{12}\text{N}_2\text{O}$  with a solubility in water of 0.07% at 15°.

## Zn ZINC

### ZINC CAMPHO CARBONATE $\text{Zn}(\text{C}_{11}\text{H}_{15}\text{O}_3)_2$

SOLUBILITY OF ZINC CAMPHO CARBONATE IN SEVERAL SOLVENTS AT 10°  
(Picon, 1931)

Solvent	Gms. $\text{Zn}(\text{C}_{11}\text{H}_{15}\text{O}_3)_2$ per liter sat. sol.
Water	4.0
Petroleum	373.3
Acetone	281.0
Olive oil	125.0 (15°)

When the compound is dissolved in boiling benzene and is then separated from this solvent and thus completely dehydrated, it becomes soluble to the extent of 500 gms. per liter in methyl alcohol, ethyl alcohol, benzene, chloroform, carbon tetrachloride, carbon disulfide and petroleum ether.

### CH ZINC BENZENE SULFONATE $\text{Zn}(\text{C}_6\text{H}_5\text{SO}_3)_2$

SOLUBILITY IN WATER  
(Ephraim and Seger, 1952)

t°	Gms. $\text{Zn}(\text{C}_6\text{H}_5\text{SO}_3)_2$ per 100 cc. sat. sol.	Solid Phase
10.0	14.769	$\text{Zn}(\text{C}_6\text{H}_5\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$
34.0	19.107	"
49.5	24.705	"
64.5	32.018	"
80.5	40.085	"
82.0	41.014	"

### ZINC NAPHTHALENE SULFONATES

SOLUBILITIES IN WATER

	t°	Gms. $\text{Zn}(\text{C}_{10}\text{H}_7\text{SO}_3)_2$ per 100 cc. sat. sol.	Solid Phase	
Zinc Naphthalene-2-Sulfonate	20	0.487	$\text{Zn}(\text{C}_{10}\text{H}_7\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	(2)
" " "	25	0.45	"	(4)
" " "	32	0.579	"	(2)
" " "	45	0.853	"	(2)
" " "	54.5	1.218	"	(2)
" " "	65	1.690	"	(2)
" " "	76.5	2.512	"	(2)
" " "	82	3.130	"	(2)
" Naphthalene-1-	17	0.659	$\text{Zn}(\text{C}_{10}\text{H}_7\text{SO}_3)_2 \cdot 6\text{H}_2\text{O}$	(2)
" " -6- oxy -2-	20	0.874	$\text{Zn}(\text{C}_{10}\text{H}_7\text{SO}_3)_2 \cdot 8\text{H}_2\text{O}$	(1)
" " -5-chlor 1-	20	1.205	$\text{Zn}(\text{C}_{10}\text{H}_6\text{ClSO}_3)_2 \cdot 4\text{H}_2\text{O}$	(1)
" -2,6,8-Naphthylamine disulfonate	15	34.5 <sup>a</sup>	$\text{ZnC}_{10}\text{H}_5\text{NH}_2(\text{SO}_3)_2$	(3)
" -2,5,7-	15	39.4 <sup>a</sup>	"	(3)

(1) Ephraim and Pfister, 1925a. (2) Ephraim and Seger, 1925. (3) Braunschweig, 1922, 1926.

(4) Witt, 1915

<sup>a</sup>These results are in terms of grams per 100 grams of the saturated solution instead of gms. per 100 cc. sat. solution.

## ZINC PHENANTHRENE SULFONATES

CH

## SOLUBILITY IN WATER

Name and Formula	t°	Gms. Anhy. Salt per 100 Gms. H <sub>2</sub> O	Authority
Zinc 2-Phenanthrene (C <sub>14</sub> H <sub>9</sub> .SO <sub>3</sub> ) <sub>2</sub> Zn.6H <sub>2</sub> O	20	0.083	Sandquist, 1912
Zinc 3-Phenanthrene (C <sub>14</sub> H <sub>9</sub> .SO <sub>3</sub> ) <sub>2</sub> Zn.4H <sub>2</sub> O	20	0.19	Sandquist, 1912
Zinc 10-Phenanthrene (C <sub>14</sub> H <sub>9</sub> .SO <sub>3</sub> ) <sub>2</sub> Zn.6H <sub>2</sub> O	20	0.15	Sandquist, 1912

 ZINC ANTHRACENE SULFONATES Zn(C<sub>14</sub>H<sub>9</sub>SO<sub>3</sub>)<sub>2</sub>  
 ZnC<sub>14</sub>H<sub>9</sub>S<sub>2</sub>O<sub>6</sub>

CH

 SOLUBILITY IN WATER  
 (Federov and Lodygin, 1942)

Salt	Gms. Salt per 100 gms. Sat. Sol.	
	20°	100°
α-Zn(C <sub>14</sub> H <sub>9</sub> SO <sub>3</sub> ) <sub>2</sub> .6H <sub>2</sub> O	0.048 (0.05 <sup>a</sup> )	0.443
β-Zn(C <sub>14</sub> H <sub>9</sub> SO <sub>3</sub> ) <sub>2</sub> .6H <sub>2</sub> O	.0074 <sup>a</sup>	.131
1,8-ZnC <sub>14</sub> H <sub>8</sub> S <sub>2</sub> O <sub>6</sub> .4H <sub>2</sub> O	.155	.708
1,5-ZnC <sub>14</sub> H <sub>8</sub> S <sub>2</sub> O <sub>6</sub> .3H <sub>2</sub> O	2.389	5.819
2,6-ZnC <sub>14</sub> H <sub>8</sub> S <sub>2</sub> O <sub>6</sub> .6H <sub>2</sub> O	0.054	0.275
2,7-ZnC <sub>14</sub> H <sub>8</sub> S <sub>2</sub> O <sub>6</sub> .4H <sub>2</sub> O	.573	1.806

<sup>a</sup>Ephriam and Pfister, 1925ZINC ANTHRAQUINONE DISULFINATE Zn[C<sub>14</sub>H<sub>6</sub>O<sub>2</sub>(SO<sub>2</sub>)<sub>2</sub>]

## RESULTS OF KOZLOV AND SMOLIN, 1949

	t°	Gms. H <sub>2</sub> O to dissolve 1 gm. of salt
Zinc 1,5-C <sub>14</sub> H <sub>6</sub> O <sub>2</sub> (SO <sub>2</sub> ) <sub>2</sub> .5H <sub>2</sub> O	20	98
" " " "	100	30
Zinc 1,8-C <sub>14</sub> H <sub>6</sub> O <sub>2</sub> (SO <sub>2</sub> ) <sub>2</sub> .4H <sub>2</sub> O	20	200
" " " "	100	95

## Zn ZINC

### CH ZINC PHENOL SULFONATE

SOLUBILITY OF ZINC PHENOLSULFONATE,  $p$   $(C_6H_4 \cdot OH \cdot SO_3)_2 Zn \cdot 8H_2O$ , IN  
AQUEOUS ALCOHOL SOLUTIONS AT 25°  
(Seidell, 1910)

Wt. %			Gms.			Wt. %			Gms.		
$C_2H_5OH$	$d_{25}$		$(C_6H_4 \cdot OH \cdot SO_3)_2 Zn \cdot 8H_2O$			$C_2H_5OH$	$d_{25}$		$(C_6H_4 \cdot OH \cdot SO_3)_2 Zn \cdot 8H_2O$		
in	of		per			in	of		per		
Sol-	Sat.		100 Gms.			Sol-	Sat.		100 Gms.		
vent	Sol.	Sat.	Sol.			vent	Sol.	Sat.	Sol.		
0	1.185		39.8			80	1.057		40.7		
20	1.161		40.7			90	1.047		41.4		
40	1.139		42.1			92.3	1.048		41.9		
47	-		42.2			95	1.052		42.9		
60	1.106		41.6			100	1.075		48.8		

100 gms.  $H_2O$  dissolve 37 gms.  $(C_6H_4 \cdot OH \cdot SO_3)_2 Zn \cdot 8H_2O$  at 15° and  $d_{15}$  of sat. sol. = 1.162. (Greenish and Smith, 1902.)

### ZINC HELIANTHATE $Zn(C_{14}H_{14}N_3SO_3)_2 \cdot 4H_2O$

1000 cc.  $H_2O$  dissolve 0.098 gm. of the hydrated salt at 20-25°. (Stark and Dehn, 1918.)

### ZINC STEARATE

Data for the effect of small amounts of additives on the solution temperature of zinc stearate are reported by Chatterjee and Palit, 1954.

### CM ZINC CYANIDE $Zn(CN)_2$

One liter sat. solution of zinc cyanide in water contain 0.000049 gm. mol.  $Zn(CN)_2$  at 18°, as determined by E.M.F. measurements. (Masaki, 1931.)

100 cc. concentrated  $Zn(C_2H_3O_2)_2$  + Aq. dissolve 0.4 gm.  $Zn(CN)_2$ .

100 cc. concentrated  $ZnSO_4$  + Aq. dissolve 0.2 gm. (Joannis, 1882.)

### ZINC FERROCYANIDE $Zn_2Fe(CN)_6$

A saturated solution in water contains  $1.5 \times 10^{-5}$  gm. ions of zinc. (Tananaev, Glushkova and Seifer, 1956.)

The solubility of potassium zinc ferricyanide,  $K_2Zn_3[Fe(CN)_6]_2$  in water at 25° is  $1.2 \times 10^{-14}$  moles per liter. (Grieb and Cone, 1950.)

ZINC FERRICYANIDE  $\text{Zn}_3[\text{Fe}(\text{CN})_6]_2$ 

CN

The solubility in water is  $1.65 \times 10^{-4}$  moles per liter. (Grieb and Cone, 1950.)

ZINC THIOCYANATE  $\text{Zn}(\text{SCN})_2$ 

SCN

One liter sat. solution of zinc thiocyanate in water contains 0.144 gm. mol.  $\text{Zn}(\text{SCN})_2$  at  $18^\circ$ , as determined by E.M.F. measurements. (Masaki, 1931.)

100 gms. liquid sulfur dioxide dissolve 0.73 gm.  $\text{Zn}(\text{SCN})_2$  at  $0^\circ$ . (Jander and Ruppolt, 1937.)

100 gms.  $\text{H}_2\text{O}$  dissolve 0.24 gm. zinc mercuric thiocyanate,  $\text{ZnHg}(\text{CNS})_4$  at  $15^\circ$ . (Robertson, P. W., 1907.)

ZINC CARBONATE  $\text{ZnCO}_3$ 

CO

100 gms. of a sat. solution of  $\text{ZnCO}_3$  in water at  $18^\circ$  and in contact with  $\text{CO}_2$  at a pressure of 1 atmosphere contain 0.07 gm.  $\text{ZnCO}_3$ . At a pressure of 56 atmospheres of  $\text{CO}_2$  0.084 gm.  $\text{ZnCO}_3$  are dissolved. (Hachnel, 1924.)

Ageno and Valla (1911) report that the solubility of  $\text{ZnCO}_3$  in water at  $25^\circ$  is  $1.64 \cdot 10^{-4}$  mols. = 0.206 gm. per liter.

One liter of aq. 5.85% NaCl solution dissolves 0.0586 gm.  $\text{ZnCO}_3$  at  $14^\circ$ . One liter of aq. 7.45% NaCl solution dissolves 0.0477 gm.  $\text{ZnCO}_3$  at  $14^\circ$ . (Cantoni and Passamanik, 1905.)

"If zinc carbonate were not hydrolytically dissociated, its solubility in pure water at  $25^\circ$ , would be  $4.58 \times 10^{-6}$  gms. mols. per liter." (Smith, 1918.)

ZINC BICARBONATE  $\text{Zn}(\text{HCO}_3)_2$ 

SOLUBILITY OF ZINC BICARBONATE IN WATER CONTAINING CARBON DIOXIDE  
(Smith, H. J., 1918)

For description of the experimental method see iron bicarbonate, Vol I, p. 1010.

The calculated pressures are lower than the actual pressures since Henry's Law does not hold at very high pressures.



# Zn ZINC

## SOLUBILITY OF ZINC BICARBONATE IN WATER CONTAINING CARBON DIOXIDE--Cont.

	Atmospheres Pressure of CO <sub>2</sub> , Calc. by Henry's Law	Results at 25°		Results at 30°	
		Gm. Mols. Free H <sub>2</sub> CO <sub>3</sub> per Liter	Gm. Mols. Zn(HCO <sub>3</sub> ) <sub>2</sub> per Liter	Gm. Mols. Free H <sub>2</sub> CO <sub>3</sub> per Liter	Gm. Mols. Zn(HCO <sub>3</sub> ) <sub>2</sub> per Liter
CO	4.12	0.1390	0.00194	0.1838	0.00215
	5.33	0.1797	0.00211	0.3838	0.00277
	7.64	0.2579	0.00242	0.4038	0.00286
	10.61	0.3580	0.00270	0.4601	0.00308
	12.16	0.4103	0.00278	0.6064	0.00324
	13.29	0.4480	0.00291	0.6257	0.00337
	19.73	0.6657	0.00317	0.7470	0.00352
	20.65	0.6969	0.00319	0.8351	0.00376
	22.56	0.7610	0.00343	1.0840	0.00339
	40.61	1.3701	0.00445	1.1275	0.00429

## ZINC OXALATE ZnC<sub>2</sub>O<sub>4</sub>·2H<sub>2</sub>O

### SOLUBILITY IN WATER

9.76°	0.0057 gms. per liter	(Kohlrausch, 1908)
17.92	0.0064 " " "	(Kohlrausch, 1908)
18	0.0209 " " "	(Scholder, Gadenne and Niemann, 1927)
0	0.018 " " "	(Osawa, 1950)
25	0.0256 " " "	(Vosburgh and Beckman, 1940)
		(Clayton and Vosburgh, 1937)
26.15	0.00715 " " "	(Kohlrausch, 1908)

### SOLUBILITY OF ZINC OXALATE IN AQUEOUS SOLUTIONS OF SULFURIC ACID AT 18° (Britton and Jarrett, 1932)

Gm. Mols. per liter		Gm. Mols. per liter	
H <sub>2</sub> SO <sub>4</sub>	ZnC <sub>2</sub> O <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	ZnC <sub>2</sub> O <sub>4</sub>
0.05	0.000445	1.00	0.003901
0.125	0.000737	1.50	0.005550
0.25	0.001395	1.875	0.006695
0.50	0.002178		

### SOLUBILITY OF ZINC OXALATE IN ZINC SULFATE SOLUTIONS AT 25° (Vosburgh and Beckman, 1940)

	Moles x 10 <sup>3</sup> per liter of Saturated Solution				
	0.0	5	10	20	40
ZnSO <sub>4</sub>					
ZnC <sub>2</sub> O <sub>4</sub>	0.168	0.167	0.202	0.269	0.386

SOLUBILITY OF ZINC OXALATE IN AQUEOUS AMMONIUM OXALATE SOLUTIONS AT 25°  
(Kunschert, 1904)

Mol. Normal $(\text{NH}_4)_2\text{C}_2\text{O}_4$	0.05	0.10	0.15	0.20	0.25
Mol. Zn per Liter	0.0022	0.0055	0.01055	0.0174	0.0257

Complex ammonia zinc oxalates are formed. When more than 0.15 free oxalate is present the complex has the formula,  $(\text{NH}_4)_4\text{Zn}(\text{C}_2\text{O}_4)_3$ . In the more dilute solutions it has the composition,  $(\text{NH}_4)_2\text{Zn}(\text{C}_2\text{O}_4)_2$ .

SOLUBILITY OF ZINC OXALATE AT 25° IN AQUEOUS SOLUTIONS OF:  
(Clayton and Vosburgh, 1937)

Cadmium Sulfate		Potassium Oxalate	
Mols. per 1000 gms. $\text{H}_2\text{O}$		Mols. per 1000 gms. $\text{H}_2\text{O}$	
$\text{CdSO}_4$	$\text{ZnC}_2\text{O}_2$	Total Oxalate	$\text{ZnC}_2\text{O}_4$
0.0	0.000168	0.0100	0.000460
0.005	0.000145	0.02745	0.001030
0.010	0.000202	0.04841	0.001803
0.020	0.000226	0.1116	0.006480
0.040	0.000386		
0.080	0.000645		

Data for the solubility of zinc oxalate in solutions containing sodium acetate and potassium nitrate at 35° are given by Bardhan and Aditya, 1955.

ZINC CHLORIDE  $\text{ZnCl}_2$ 

Cl

SOLUBILITY IN WATER  
(Mylius and Dietz, 1905; see also Dietz, 1900; Etard, 1894)

$t^\circ$	Gms. $\text{ZnCl}_2$ per 100 Gms.		Solid Phase	$t^\circ$	Gms. $\text{ZnCl}_2$ per 100 Gms.		Solid Phase
	Water	Solution			Water	Solution	
-5	14	12.3	Ice	0	208	76.5	$\text{ZnCl}_2 \cdot 3\text{H}_2\text{O}$
-10	25	20.0	"	+5	230	69.7	"
-40	83	45.3	"	6.5	252.4	71.6	"
-62	104	51.0	Ice +	5	282	73.8	" <sub>1</sub>
			$\text{ZnCl}_2 \cdot 4\text{H}_2\text{O}$	0	309	75.5	$3\text{H}_2\text{O} + 1\frac{1}{2}\text{H}_2\text{O}$
-50	114	53.0	$\text{ZnCl}_2 \cdot 4\text{H}_2\text{O}$				$\text{ZnCl}_2 \cdot 2$
-40	127	55.9	"	0	235	70.1	$\text{ZnCl}_2 \cdot 2\frac{1}{2}\text{H}_2\text{O}$
-30	160	61.5	$4\text{H}_2\text{O} + 3\text{H}_2\text{O}$				$2\frac{1}{2}\text{H}_2\text{O} + 3\text{H}_2\text{O}$
-10	189	65.4	$\text{ZnCl}_2 \cdot 3\text{H}_2\text{O}$	6.5	252	71.6	

(Cont.)

## Zn ZINC

## SOLUBILITY IN WATER--Cont.

t°	Gms. ZnCl <sub>2</sub> per 100 Gms.		Solid Phase	t°	Gms. ZnCl <sub>2</sub> per 100 Gms.		Solid Phase
	Water	Solution			Water	Solution	
10	272	73.1	ZnCl <sub>2</sub> ·2 $\frac{1}{2}$ H <sub>2</sub> O	26.3	433	81.2	1 $\frac{1}{2}$ H <sub>2</sub> O+ZnCl <sub>2</sub>
12.5	303	75.2	"	0	342	77.4	ZnCl <sub>2</sub> ·H <sub>2</sub> O
11.5	335	77.0	2 $\frac{1}{2}$ H <sub>2</sub> O + 1 $\frac{1}{2}$ H <sub>2</sub> O	10	364	78.4	"
			"	20	396	79.8	"
9	360	78.3	2 $\frac{1}{2}$ H <sub>2</sub> O + H <sub>2</sub> O	28	436	81.3	" + ZnCl <sub>2</sub>
6	385	79.4	ZnCl <sub>2</sub> ·2 $\frac{1}{2}$ H <sub>2</sub> O	31	477	82.7	ZnCl <sub>2</sub> ·H <sub>2</sub> O
Cl	6	74.9	ZnCl <sub>2</sub> ·1 $\frac{1}{2}$ H <sub>2</sub> O	25	432	81.2	ZnCl <sub>2</sub>
	10	76.8	"	40	452	81.9	"
	20	78.6	"	60	488	83.0	"
			"	80	543	84.4	"
			1 $\frac{1}{2}$ H <sub>2</sub> O +	100	615	86.0	"
	26	423	ZnCl <sub>2</sub> ·H <sub>2</sub> O	262	∞	100.0	"

SOLUBILITY OF ZINC CHLORIDE IN HYDROCHLORIC ACID SOLUTIONS AT 25°  
(Kuznetsov and Kozhukovskii, 1936)

Gms. per 1000 gms. H <sub>2</sub> O		Solid Phase	Gms. per 1000 gms. H <sub>2</sub> O		Solid Phase
ZnCl <sub>2</sub>	HCl		ZnCl <sub>2</sub>	HCl	
4291	0.0	ZnCl <sub>2</sub>	3758	356.5	2ZnCl <sub>2</sub> ·HCl·2H <sub>2</sub> O
4063	104.3	"	3285	428.9	"
4153	156.7	"	2593	578.2	"
4214	217.3	"	2488	647.8	"
3891	300.0	2ZnCl <sub>2</sub> ·HCl·2H <sub>2</sub> O	2504	712.7	"

SOLUBILITY OF OXYCHLORIDES OF ZINC IN AQUEOUS SOLUTIONS OF ZINC CHLORIDE  
AT ROOM TEMPERATURE  
(Driot, 1910)

Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase	Gms. per 100 Gms. H <sub>2</sub> O		Solid Phase
ZnCl <sub>2</sub>	ZnO		ZnCl <sub>2</sub>	ZnO	
8.22	0.0137	ZnCl <sub>2</sub> ·4ZnO·6H <sub>2</sub> O	62.85	0.884	ZnCl <sub>2</sub> ·4ZnO·6H <sub>2</sub> O
23.24	0.138	"	96	1.792	"
45.95	0.497	"	124.7	3.213	"
51.5	0.604	"	144.8	2.64	"
56.9	0.723	"	203	1.59	ZnCl <sub>2</sub> ·ZnO·1 $\frac{1}{2}$ H <sub>2</sub> O

Results are also given for mixture of the oxychloride and oxide in aqueous zinc chloride solutions at various temperatures.

Data for equilibrium in the system zinc chloride, zinc oxide and water at 25° and at 50° are given by Holland, 1930. The results are presented according to Janecke's method and can only be converted to the weight basis by tedious calculations. The author failed to find the compound  $\text{ZnCl}_2 \cdot \text{ZnO} \cdot 1\frac{1}{2}\text{H}_2\text{O}$  reported by Driest. He obtained evidence for the existence of two new oxychlorides of zinc, namely,  $\text{ZnCl}_2 \cdot \text{ZnO} \cdot 2\text{H}_2\text{O}$  and  $\text{ZnCl}_2 \cdot \text{ZnO} \cdot \text{H}_2\text{O}$ . Of those formerly described only  $\text{ZnCl}_2 \cdot 5\text{ZnO} \cdot 8\text{H}_2\text{O}$  exists in stable equilibrium in the range of concentration of the present experiments.

Additional data on this system are given by Feitknecht, 1930. The results which are given only in the form of a diagram are in satisfactory agreement with those of Driest. In addition to the solubility of ZnO in aqueous solutions of  $\text{ZnCl}_2$  the author also gives curves showing the solubility of ZnO in aqueous solutions of  $\text{ZnBr}_2$  and of  $\text{ZnI}_2$ .

Cl

Aksel'rud and Spivakovskii (1958) found the salt  $\text{Zn}(\text{OH})_{1.5}\text{Cl}_{0.5} [\text{ZnCl}_2 \cdot 3\text{Zn}(\text{OH})_2]$  to be stable in alkaline solutions containing up to 3.3M  $\text{ZnCl}_2$  and up to 4M NaCl. The activity product is  $4 \times 10^{-14}$ . Upon standing 78 hours this salt is converted to the hydroxide (activity product  $4 \times 10^{-18}$ ).

Data for the solubility of  $\text{ZnCl}_2$  in aq.  $\text{NH}_3$  solutions at 25° are given by Urazov, Kirakosyan and Mkhitarian, 1958.

THE SYSTEM ZINC CHLORIDE - BERYLLIUM CHLORIDE - WATER AT 25°  
(Blidin, 1957)

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
BeCl <sub>2</sub>	ZnCl <sub>2</sub>		BeCl <sub>2</sub>	ZnCl <sub>2</sub>	
41.40	0.0	BeCl <sub>4</sub> ·4H <sub>2</sub> O	24.18	40.22	BeCl <sub>4</sub> ·4H <sub>2</sub> O + ZnCl <sub>2</sub>
38.14	6.20	"	20.60	44.08	ZnCl <sub>2</sub>
35.11	13.70	"	14.90	51.36	"
30.70	20.33	"	10.26	59.54	"
29.42	25.17	"	4.40	71.76	"
26.14	33.10	"	0.0	81.20	"

Data for the system ZnCl<sub>2</sub> - KCl - H<sub>2</sub>O at 25° are given by Lipscomb and Hulett, 1915-16.

Data for the extraction of  $\text{ZnCl}_2$  from aqueous  $\text{ZnSO}_4$  solutions by furfural at 25, 50 and 75° are given by Garwin and Winterbottom, 1957.

When 1 gm. of zinc as chloride is dissolved in 100 cc. of aq. 10% HCl and shaken with 100 cc. of ether, 0.03 per cent of the metal enters the ethereal layer. (Mylius, 1911.)

## Zn ZINC

### SOLUBILITY OF ZINC CHLORIDE IN PYRIDINE (Mason and Mathews, 1925)

t°	Gms. ZnCl <sub>2</sub> per 100 Gms. Sat. Sol.	Solid Phase	t°	Gms. ZnCl <sub>2</sub> per 100 Gms. Sat. Sol.	Solid Phase
0	1.60	ZnCl <sub>2</sub> ·2C <sub>5</sub> H <sub>5</sub> N	45	4.66	ZnCl <sub>2</sub> ·2C <sub>5</sub> H <sub>5</sub> N
5	1.80	"	55	5.85	"
10	2.02	"	65	7.33	"
15	2.28	"	75	9.06	"
20	2.55	"	85	11.11	"
24.12	2.80	"	95	13.60	"
35	3.67	"	105	16.26	"

## Cl

100 gms abs. acetone dissolve 43.5 gms. ZnCl<sub>2</sub> at 18°, d<sub>18</sub> of sat. sol. = 1.14. (Nauman, 1904.)

100 gms. glycerol dissolve 50 gms. ZnCl<sub>2</sub> at 15.5°. (Ossendowski, 1907.)

100 grams of a saturated solution of zinc chloride in furfural contain 20.6 gms. ZnCl<sub>2</sub> at 25°. (Trimble, 1941)

### THE SYSTEM ZnCl<sub>2</sub> - ACETIC ACID (Davidson and Chappell, 1939)

t°	Mol. percent ZnCl <sub>2</sub> in Mixture	Solid Phase	t°	Mol. Percent ZnCl <sub>2</sub> in Mixture	Solid Phase
16.6	0.0	CH <sub>3</sub> COOH	10.35	10.99	CH <sub>3</sub> COOH
15.75	1.77	"	8.55	12.88	"
14.95	3.46	"	7.30	14.14	"
12.85	7.31	"	4.80	16.16	"
11.45	9.67	"	2.0	18.45	"
			4.0	22.07	"

The authors also give results for the system zinc chloride + zinc acetate + acetic acid.

100 gms. sat. solution of zinc chloride in selenium oxychloride (SeOCl<sub>2</sub>) contain 1.10 gms. ZnCl<sub>2</sub> at 25°. (Wise, 1923.)

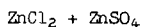
100 cc. anhydrous hydrazine dissolve 8 gms. ZnCl<sub>2</sub> at room temp. (Welsh and Broderson, 1915.)

100 gms. liquid sulfur dioxide dissolve 0.16 gm. ZnCl<sub>2</sub> at 0°. (Jander and Ruppolt, 1937.)

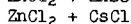
## ZINC THIOUREA CHLORIDE ZnCl<sub>2</sub>·2(NH<sub>2</sub>)<sub>2</sub>CS

One liter of its saturated solution in water contains 174.8 gms. of the compound at about 20°. (Walter and Reimer, 1934.)

Melting points are given for



(Evseeva and Bergman, 1951)



(Markov, Panchenko and Kostenko, 1956)

# ZINC CHLORITE $\text{Zn}(\text{ClO}_2)_2$

## SOLUBILITY OF ZINC CHLORITE IN WATER

(Levi and Curti, 1956)

(Solid Phase  $\text{Zn}(\text{ClO}_2)_2 \cdot 2\text{H}_2\text{O}$ )

t°	Gms. $\text{Zn}(\text{ClO}_2)_2$ per 100 cc. sat. sol.	t°	Gms. $\text{Zn}(\text{ClO}_2)_2$ per 100 cc. sat. sol.
1	5.14	40	7.99
10	5.81	50	8.78
20	6.48	60	9.57
30	7.28	70	10.39

Cl

# ZINC CHLORATE $\text{Zn}(\text{ClO}_3)_2$

## SOLUBILITY IN WATER

(Meusser, 1902; at 18°, Mylius and Funk, 1897)

A =  $\text{Zn}(\text{ClO}_2)_2 \cdot 6\text{H}_2\text{O}$

B =  $\text{Zn}(\text{ClO}_3)_2 \cdot 4\text{H}_2\text{O}$

t°	Gms. $\text{Zn}(\text{ClO}_3)_2$ per 100 Gms. Solution	Mols. $\text{Zn}(\text{ClO}_3)_2$ per 100 Mols. $\text{H}_2\text{O}$	Solid Phase	t°	Gms. $\text{Zn}(\text{ClO}_3)_2$ per 100 Gms. Solution	Mols. $\text{Zn}(\text{ClO}_3)_2$ per 100 Mols. $\text{H}_2\text{O}$	Solid Phase
-18	55.62	9.70	A	30	67.66	16.20	B
0	59.19	11.08	A	40	69.06	17.29	B
8	60.20	11.72	A	55	75.44	24	B
15	67.32	15.96	A	Ice curve			
18	66.52	15.39	B	-13	30.27	3.36	Ice
				-9	26.54	2.80	Ice

Sp. Gr. of solution saturated at  
18° = 1.916.

# ZINC PERCHLORATE $\text{Zn}(\text{ClO}_4)_2$

## SOLUBILITY IN WATER

(Lilich and Dzhurinskii, 1956)

t°	Moles $\text{Zn}(\text{ClO}_4)_2$ per 1000 gms. $\text{H}_2\text{O}$	Solid Phase	t°	Moles $\text{Zn}(\text{ClO}_4)_2$ per 1000 gms. $\text{H}_2\text{O}$	Solid Phase
0	3.97	$\text{Zn}(\text{ClO}_4)_2 \cdot 7\text{H}_2\text{O}$	30	4.37	$\text{Zn}(\text{ClO}_4)_2 \cdot 6\text{H}_2\text{O}$
5	4.01	"	35	4.46	"
10	4.07	"	40	4.52	"
15	4.11	"	45	4.62	"
20	4.17	"	50	4.74	"
25	4.2	$\text{Zn}(\text{ClO}_4)_2 \cdot 6\text{H}_2\text{O}$			

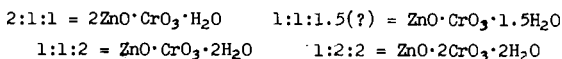
## Zn ZINC

100 gms. furfural dissolve 85 gms.  $\text{Zn}(\text{ClO}_4)_2 \cdot (?6\text{H}_2\text{O})$  at about  $20^\circ$ .  
 100 gms. cellosolve (mono ethyl ether of ethylene glycol) dissolve 130 gms.  $\text{Zn}(\text{ClO}_4)_2 \cdot (?6\text{H}_2\text{O})$  at about  $20^\circ$ . (Chaney and Mann, 1931.)

## CrO ZINC CHROMATES

100 cc sat. solution of this salt in water contain 10.2 gms.  
 $\text{Zn}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6 (\text{ClO}_4)_2$  at  $20^\circ$ . (Wilke-Dörfurt and Schliephake, 1929.)  
 (See p. 0000 for other zinc antipyrine salts.)

THE SYSTEM  $\text{ZnO} - \text{CrO}_3 - \text{H}_2\text{O}$  AT  $25^\circ$   
 (Woodward, Allen and Anderson, 1956)



(Selected Data)

Sat. Sol. Wt. %			Solid Phase	Sat. Sol. Wt. %			Solid Phase
ZnO	CrO <sub>3</sub>	dens.		ZnO	CrO <sub>3</sub>	dens.	
< 0.01	0.004	-	ZnO + S.S.	16.4	39.0	1.688	1:1:2
0.21	0.34	1.000	Solid Solu.	18.3	43.8	1.793	"
0.95	1.89	1.016	"	19.4	47.0	1.865	"
1.36	3.40	1.032	"	20.5	48.7	-	"
2.4	5.4	1.061	" + 2:1:1	21.3	51.5	-	" + 1:2:2
3.73	10.0	1.132	2:1:1	20.4	52.9	2.07	1:2:2
6.00	15.5	1.216	"	18.6	55.0	2.07	"
9.45	22.0	1.323	"	17.9	57.6	-	"
11.5	27.7	1.429	"	16.3	60.7	-	" + CrO <sub>3</sub>
12.6	30.0	-	" + 1:1:1.5(?)	13.4	60.5	-	CrO <sub>3</sub>
15.7	35.1	1.588	1:1:1.5(?)	10.3	61.0	-	"
14.8	35.8	-	"	6.9	61.4	-	"
14.6	35.7	1.602	"	3.6	62.3	-	"
15.4	36.7	-	" + 1:1:2	0.0	63.4	-	"

(Earlier data of Groger, 1911)

An excess of ZnO was, in each case, shaken for 3 days at  $25^\circ$ , with gradually increasing concentrations of chromic acid.

Gms. per Liter			Solid Phase	Gms. per Liter			Solid Phase
Sat.	Sol.			Sat.	Sol.		
ZnO	CrO <sub>3</sub>			ZnO	CrO <sub>3</sub>		
0.409	0.604		$4\text{ZnO} \cdot \text{CrO}_3 \cdot 3\text{H}_2\text{O}$	66.1	151		$4\text{ZnO} \cdot \text{CrO}_3 \cdot 3\text{H}_2\text{O}$
2.24	4.19		"	83.7	192		" + $3\text{ZnO} \cdot 2\text{CrO}_3 \cdot \text{H}_2\text{O}$
5.86	11.5		" + $3\text{ZnO} \cdot \text{CrO}_3 \cdot 2\text{H}_2\text{O}$	123	285		$3\text{ZnO} \cdot 2\text{CrO}_3 \cdot \text{H}_2\text{O}$
10.7	22.2		$3\text{ZnO} \cdot \text{CrO}_3 \cdot 2\text{H}_2\text{O}$	193	450		"
26.7	57.5		"	196	461		" + $\text{ZnO} \cdot \text{CrO}_3 \cdot \text{H}_2\text{O}$
30.4	66.7		" + $4\text{ZnO} \cdot \text{CrO}_3 \cdot 3\text{H}_2\text{O}$	202	475		$\text{ZnO} \cdot \text{CrO}_3 \cdot \text{H}_2\text{O}$
32.2	70.6		$4\text{ZnO} \cdot \text{CrO}_3 \cdot 3\text{H}_2\text{O}$	389	940		"

ZINC FLUORIDE  $\text{ZnF}_2$ 

F

## SOLUBILITY OF ZINC FLUORIDE IN WATER

t°	Gms. $\text{ZnF}_2$ per 100 cc sat. sol.	Solid Phase	
18	1.6	$\text{ZnF}_2 \cdot 4\text{H}_2\text{O}$	(Dietz, 1900)
20	1.62	"	(Kurtenacker, Finger and Hey, 1933)
25	1.516	"	(Carter, 1928)

SOLUBILITY OF ZINC FLUORIDE IN AQUEOUS SOLUTIONS OF  
HYDROFLUORIC ACID AT 20°  
(Kurtenacker, Finger and Hey, 1933)

Gms. per 100 gms. sat. sol.		Solid Phase
HF	$\text{ZnF}_2$	
2.47	2.54	$\text{ZnF}_2 \cdot 4\text{H}_2\text{O}$
3.69	4.98	"
17.38	9.53	"
25.43	11.40	"
29.16	11.84	"

SOLUBILITY OF ZINC FLUORIDE AT 20° IN AQUEOUS SOLUTIONS OF:  
(Kurtenacker, Finger and Hey, 1933)

Ammonium FluoridePotassium Fluoride

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{NH}_4\text{F}$	$\text{ZnF}_2$		KF	$\text{ZnF}_2$	
4.0	0.46	$\text{ZnF}_2 \cdot 4\text{H}_2\text{O}$	1.5	0.25	Mixed crystals
8.6	0.31	"	10.0	0.025	"
13.0	0.16	$\text{ZnF}_2 \cdot 2\text{NH}_4\text{F} \cdot 2\text{H}_2\text{O}$	19.0	-	"
20.4	0.0	"	26.5	-	"
28.0	0.03	"	34.0	-	"
39.8	0.027	"	41.8	-	"

The mixed crystals contained per 1 mol.  $\text{ZnF}_2$  from 1.2 to 1.4 mol. KF.

Data for the extraction of zinc from aqueous HF solutions (1-20N) at 20° by ethyl ether are given by Bock and Herrmann, 1956.

ZINC HEXA ANTIPYRINE FLUOBORATE  $[\text{Zn}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6](\text{BF}_4)_2$ 

100 cc sat. sol. of this salt in water contain 16.4 gms.  $[\text{Zn}(\text{COC}_{10}\text{H}_{12}\text{N}_2)_6](\text{BF}_4)_2$  at 20°. (Wilke-Dorfurt and Mureck, 1929.)



# Zn ZINC

## F ZINC FLUOSILICATE $\text{ZnSiF}_6$

### SOLUBILITY IN WATER

#### Results of Jatlov and Pinaevskaja, 1938

#### Results of Simpson and Glocker, 1953

t°	Gms. $\text{ZnSiF}_6$ per 100 gms. sat. sol.	Solid Phase	t°	Gms. $\text{ZnSiF}_6$ per	
				100 gms. Sat. Sol.	liter Sat. Sol.
- 0.8	5.0	Ice	0	33.45	-
- 1.4	10.0	"	1.7	33.8	481
- 3.2	15.0	"	10.0	34.8	506
- 4.8	20.0	"	18.3	36.0	523
- 7.4	25.0	"	20.	36.2	-
-11.8	30.	"	26.7	37.0	536
-14.6	32.	" + $\text{ZnSiF}_6 \cdot 6\text{H}_2\text{O}$	35.0	37.9	559
0	33.73	$\text{ZnSiF}_6 \cdot 6\text{H}_2\text{O}$	40.	38.4	-
20	35.16	"	43.3	38.8	578
	32.86 (1)	"	51.7	39.55	596
40	37.04	"	60.0	40.3	614
60	38.49	"	68.3	41.1	633
80	40.95	"			
100	42.18	"			

(1) Worthington and Haring, 1931;  
d. = 1.4336

### SOLUBILITY OF ZINC FLUOSILICATE IN FLUOSILICIC ACID AT 20° (Jatlov and Pinaevskaya, 1938)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{H}_2\text{SiF}_6$	$\text{ZnSiF}_6$		$\text{H}_2\text{SiF}_6$	$\text{ZnSiF}_6$	
0.0	35.16	$\text{ZnSiF}_6 \cdot 6\text{H}_2\text{O}$	14.15	20.13	$\text{ZnSiF}_6 \cdot 6\text{H}_2\text{O}$
1.0	34.90	"	26.13	8.47	"
1.81	33.65	"	37.40	3.69	"
6.20	27.64	"	48.95	0.78	"

ZINC IODIDE  $\text{ZnI}_2$ 

I

SOLUBILITY IN WATER  
(Dietz, 1900; see also Etard, 1894)

$t^\circ$	Gms. $\text{ZnI}_2$ per 100 Gms. Solution	Mols. $\text{ZnI}_2$ per 100 Mols. $\text{H}_2\text{O}$	$t^\circ$	Gms. $\text{ZnI}_2$ per 100 Gms. Solution	Mols. $\text{ZnI}_2$ per 100 Mols. $\text{H}_2\text{O}$
Solid Phase $\text{ZnI}_2 \cdot 2\text{H}_2\text{O}$ :			Solid Phase $\text{ZnI}_2$ :		
-10	80.50	23.3	0	81.11	24.2
-5	80.77	23.7	18	81.20	24.4
0	81.16	24.3	40	81.66	25.1
+10	82.06	25.8	60	82.37	26.4
22	83.12	27.8	80	83.05	27.5
27	89.52	50.3	100	83.62	28.7

Sp. Gr. of sat. solution of the anhydrous salt at  $18^\circ = 2.725$ .

Data for the solubility of  $\text{ZnI}_2$  in aqueous  $\text{NH}_3$  solutions at  $25^\circ$  are given by Urazov, Kirakosyan and Mkhitaryan, 1958.

THE SYSTEM ZINC IODIDE - ETHYL ETHER - WATER  
(Guempel, 1929)

Zinc iodide greatly increases the mutual solubility of ether and water. The system has an upper critical solution temperature. At concentrations of salt less than 70 percent a homogeneous liquid is not obtained by increase of temperature.

$t^\circ$ of saturation	Wt. % $\text{ZnI}_2$ in solution	Gms. $(\text{C}_2\text{H}_5)_2\text{O}$ per 100 gms. $(\text{C}_2\text{H}_5)_2\text{O} + \text{H}_2\text{O}$	$t^\circ$ of saturation	Wt. % $\text{ZnI}_2$ in solution	Gms. $(\text{C}_2\text{H}_5)_2\text{O}$ per 100 gms. $(\text{C}_2\text{H}_5)_2\text{O} + \text{H}_2\text{O}$
-6.0	69.93	10.40	21.2	79.86	60.45
+22.4	"	15.68	18.2	"	65.05
39.8	"	22.32	13.5	"	69.21
47.9	"	28.03	3.8	"	75.77
54.5	"	32.81	0.0	84.64	44.10
60.6	"	37.50	+3.6	"	51.75
0.0	74.59	11.96	3.4	"	61.75
+24.0	"	28.11	-1.1	"	66.80
45.2	"	49.37	-6.0	"	68.42
51.1	"	54.67	-2.0	"	73.63
56.0	"	56.0	-3.0	"	74.10
62.6	"	64.4	-5.9	85.08	42.00
-2.1	79.86	15.70	-3.4	"	45.53
+11.1	"	27.30	-0.5	"	54.21
12.6	"	30.79	-2.6	"	65.54
16.5	"	37.74	-12.2	"	70.36
22.0	"	52.98	-30.0	"	75.66
21.5	"	58.73			

Data for the extraction of  $\text{ZnI}_2$  by ether from 6.9N HCl is given by Kitahara, 1948.

## Zn ZINC

100 cc pyridine dissolve 12.6 gms.  $\text{ZnI}_2$  at  $18^\circ$ . (Müller, R., 1924.)

100 gms. glycerol dissolve 40 gms.  $\text{ZnI}_2$  at  $15.5^\circ$ . (Ossendowski, 1907.)

100 gms. liquid ammonia dissolve 0.10 gm.  $\text{ZnI}_2$  at  $0^\circ$ . (Hunt and Boncyk, 1933.)

100 gms. liquid sulfur dioxide dissolve 0.11 gm.  $\text{ZnI}_2$  at  $0^\circ$ . (Jander and Ruppolt, 1937.)

## I ZINC TETRAAMMINE IODIDE $\text{Zn}(\text{NH}_3)_4\text{I}_2$

### SOLUBILITY IN NITROBENZENE AND ACETONITRILE (Fialkov and Shevchenko, 1953)

Moles iodine per mole nitrobenzene	Moles iodine per mole of ammine in sat. sol.	Moles iodine per mole acetonitrile	Moles iodine per mole of ammine in sat. sol.
0.0115	2.10	0.0048	2.00
0.0138	2.18	0.0076	2.06
0.0237	2.11	0.0119	2.04

Melting points in the system  $\text{Zn}(\text{NH}_4)_3\text{I}_2 + \text{I}_2$  are given by Fialkov and Shevchenko, 1952.

## IO ZINC IODATE $\text{Zn}(\text{IO}_3)_2$

### SOLUBILITY IN WATER AT $25^\circ$

0.641	gms. $\text{Zn}(\text{IO}_3)_2$ per 100 gms. sat. sol.	(Ricci and Nesse, 1942)
0.603	gms. $\text{Zn}(\text{IO}_3)_2$ per 100 gms. sat. sol.	(Saegusa, 1950)

100 gms.  $\text{H}_2\text{O}$  dissolve 0.87 gm.  $\text{Zn}(\text{IO}_3)_2$  cold and 1.31 gms. hot. (Rammelsberg, 1838.)

### SOLUBILITY OF ZINC IODATE IN POTASSIUM NITRATE SOLUTIONS AT $25^\circ$ (Saegusa, 1950)

Moles per 1000 gms. $\text{H}_2\text{O}$			Moles per 1000 gms. $\text{H}_2\text{O}$		
$\text{KNO}_3$	$\text{Zn}(\text{IO}_3)_2$	dens. $\frac{25}{4}$	$\text{KNO}_3$	$\text{Zn}(\text{IO}_3)_2$	dens. $\frac{25}{4}$
0.0	0.01461	1.0034	0.2396	0.02088	1.0203
0.002530	0.01476	1.0038	0.4841	0.02488	1.0358
0.01004	0.01518	1.0042	0.6466	0.02420	1.0456
0.05058	0.01694	1.0075	0.7729	0.01960	1.0514
0.1014	0.01839	1.0109	0.9872	0.01804	1.0619

SOLUBILITY OF ZINC IODATE IN WATER - DIOXANE MIXTURES AT 25°  
(Ricci and Nesse, 1942)

Wt. % Dioxane in Solvent	$Zn(IO_3)_2$		Wt. % Dioxane In Solvent	$Zn(IO_3)_2$	
	Gms. per 100 gms. Sat. Sol.	Moles per liter Sat. Sol.		Gms. per 100 gms. Sat. Sol.	Moles per liter Sat. Sol.
0	0.6410	0.01548	60	0.0090	0.00022
10	0.3746	0.00910	70	0.0030	0.000075
20	0.2301	0.00562	80	0.0017	0.000042
30	0.1158	0.00285	90	0.0008	0.000019
40	0.0572	0.00142	100	0.0000	0.000000
50	0.0244	0.000605			

ZINC NITRATE  $Zn(NO_3)_2$ 

## SOLUBILITY OF ZINC NITRATE IN WATER

The earlier determinations of Funk, 1900, and of Jones and Getman, 1904, for the ice curve, are in general agreement with the results of Sieverts and Petzold, 1933. Very accurate determinations made by the freezing-point method are given by Ewing, McGovern and Mathews, Jr., 1933.

Data Sieverts and Petzold, 1933

t°	Gms. $Zn(NO_3)_2$ per 100 gms. sat. sol.	Solid Phase
- 5.8	16.4	Ice
-12.0	25.4	"
-19.6	31.7	"
-28.0	37.1	"
-32.0	38.9	" + $Zn(NO_3)_2 \cdot 9H_2O$
-29.0	39.7	$Zn(NO_3)_2 \cdot 9H_2O$
-23.0	40.8	"
-19.5	-	" $\rightarrow Zn(NO_3)_2 \cdot 6H_2O$
-23.0	43.5m	$Zn(NO_3)_2 \cdot 6H_2O$
-19.0	44.5m	"
+ 0.4	48.3	"
30.0	58.1	"
35.0	61.2	"
36.4mp	-	"
35.8	65.0	" + $Zn(NO_3)_2 \cdot 4H_2O$
43.5	69.7	$Zn(NO_3)_2 \cdot 4H_2O$
45.0	70.2	"
45.5mp	-	"
43.5	75.8	"
37.0	80.7	$Zn(NO_3)_2 \cdot 2H_2O$
54mp	83.2	"
51.8	86.2	" + $Zn(NO_3)_2 \cdot H_2O$
59.0	87.2	$Zn(NO_3)_2 \cdot H_2O$
73.1	89.9	"
73.9	91.2	"
73.0	92.6	"

mp = melting point

m = metastable

Data of Ewing, McG. and M.

t°	Gms. $Zn(NO_3)_2$ per 100 gms. sat. sol.	Solid Phase
25.1	56.1	$Zn(NO_3)_2 \cdot 6H_2O$
27.3	56.9	"
30.4	58.3	"
32.4	59.5	"
34.1	60.8	"
36.1mp	63.4	"
35.4	65.2	"
34.6	66.2	" + $Zn(NO_3)_2 \cdot 4H_2O$
33.1	67.4m	"
40.0	67.9	$Zn(NO_3)_2 \cdot 4H_2O$
43.2	70.0	"
44.7mp	72.5	"
42.4	75.8	"
39.7	77.2	"
38.2	77.8	"
37.2	78.0	" + $Zn(NO_3)_2 \cdot 2H_2O$
32.2	79.0m	"
43.6	79.7	$Zn(NO_3)_2 \cdot 2H_2O$
44.9	79.8	"
51.9	81.9	"
55.4mp	84.0	"
55.2	85.2	"
52.1	86.3	" + $Zn(NO_3)_2 \cdot H_2O$
52.8	86.6	$Zn(NO_3)_2 \cdot H_2O$
59.2	87.6	"
65.2	88.6	"
68.6	89.4	"
70.7	90.0	"

# Zn ZINC

## THE SYSTEM ZINC NITRATE - NITRIC ACID - WATER

### Results of Malquori, 1928 at 20°

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
Zn(NO <sub>3</sub> ) <sub>2</sub>	HNO <sub>3</sub>	Solid Phase	Zn(NO <sub>3</sub> ) <sub>2</sub>	HNO <sub>3</sub>	Solid Phase
54.03	0.0	Zn(NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O	36.02	36.11	Zn(NO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
48.13	10.40	"	32.75	38.10	"
42.09	18.11	"	29.28	49.22	"
36.15	25.35	"	29.03	50.82	"
32.71	30.15	"	29.00	57.19	"
36.11	34.45	" + Zn(NO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O	29.57	59.21	"

NO

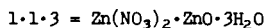
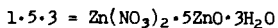
### Results of Ewing, Richards, Taylor Jr., and Winkler, 1933 at 25°

Gms. per 100 gms. sat. sol.			Gms. per 100 gms. sat. sol.		
Zn(NO <sub>3</sub> ) <sub>2</sub>	HNO <sub>3</sub>	Solid Phase	Zn(NO <sub>3</sub> ) <sub>2</sub>	HNO <sub>3</sub>	Solid Phase
56.1	0.0	Zn(NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O	64.2	14.9	Zn(NO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
42.1	3.5	"	62.2	17.9	" + Zn(NO <sub>3</sub> ) <sub>2</sub> ·2H <sub>2</sub> O
49.4	9.5	"	65.9	12.8	Zn(NO <sub>3</sub> ) <sub>2</sub> ·2H <sub>2</sub> O
46.8	15.5	"	57.9	22.6	"
47.6	16.6	"	55.2	26.6	"
49.7	15.5	" + Zn(NO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O	44.6	42.1	"
41.5	24.0	Zn(NO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O	44.9	43.5	"
34.6	36.7	"	46.7	42.2	"
35.0	39.2	"	52.6	36.9	"
37.5	38.0	"	52.1	37.4	Zn(NO <sub>3</sub> ) <sub>2</sub> ·H <sub>2</sub> O
41.4	35.1	"	43.5	47.4	"
45.9	31.6	"	28.1	65.5	"
54.0	24.5	"	15.3	78.9	"
60.5	18.5	"	11.6	85.9	"
62.2	16.8	"	9.9	88.8	"

## EQUILIBRIUM IN THE SYSTEM ZINC OXIDE, NITROGEN PENTOXIDE AND WATER (Denham and Dick, 1931)

### Results at 25°

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	N <sub>2</sub> O <sub>5</sub>	ZnO	
1.015	1.0	0.8	1.5·3
1.094	5.7	4.6	"
1.218	12.7	9.7	"
1.380	20.3	15.5	"
1.585	27.9	21.5	" + 1·1·3
1.657	30.6	22.0	1·1·3
1.695	31.8	23.5	" + Zn(NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O



(Cont.)

## EQUILIBRIUM IN THE SYSTEM ZINC OXIDE, NITROGEN PENTOXIDE AND WATER--Cont.

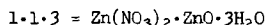
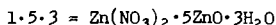
## Results at 25°--Cont.

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	N <sub>2</sub> O <sub>5</sub>	ZnO	
1.675	33.5	22.0	Zn(NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O
1.679	39.6	20.2	"
1.737	42.6	21.4	" + Zn(NO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
1.737	42.6	21.3	Zn(NO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O
1.695	45.6	18.6	"

## Results at 50°

NO

1.022	1.6	1.0	1.5.3
1.116	7.5	5.9	"
1.401	21.6	16.0	"
1.476	24.7	19.0	"
1.503	25.6	19.9	"
1.544	26.7	20.8	" + 1.1.3
1.571	27.4	21.3	1.1.3
1.613	29.5	22.6	"
1.660	31.1	23.8	"
1.750	34.4	26.4	"
1.793	36.0	27.2	"
1.941	40.8	30.9	"



Data for the solubility of Zn(NO<sub>3</sub>)<sub>2</sub> in aqueous NH<sub>3</sub> solutions containing up to 18.77% NH<sub>3</sub> at 25° are given by Urazov, Kirakosyan and Mkhitarian, 1958.

THE SYSTEM Zn(NO<sub>3</sub>)<sub>2</sub> - La(NO<sub>3</sub>)<sub>3</sub> - H<sub>2</sub>O AT 25°  
(Urazov and Shevtsova, 1957)

Sat. Sol. Wt. %		Solid Phase
La(NO <sub>3</sub> ) <sub>3</sub>	Zn(NO <sub>3</sub> ) <sub>2</sub>	
60.27	0.00	La(NO <sub>3</sub> ) <sub>3</sub> ·6H <sub>2</sub> O
56.40	3.12	Solid Solution
54.13	5.87	" "
53.12	6.35	2La(NO <sub>3</sub> ) <sub>3</sub> ·3Zn(NO <sub>3</sub> ) <sub>2</sub> ·24H <sub>2</sub> O
44.30	10.92	"
41.53	13.90	"
36.42	16.62	"
32.97	20.38	"
27.50	24.05	"
20.51	30.22	"
11.42	36.81	"
6.01	43.72	"
3.25	46.48	"
1.64	48.18	"
1.05	51.13	Solid Solution
0.5	53.10	" "
0.00	55.98	Zn(NO <sub>3</sub> ) <sub>2</sub> ·6H <sub>2</sub> O

## Zn ZINC

100 g. of a saturated solution of  $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  in tri-n-butyl phosphate at 25 - 27° contains 20.6 g.  $\text{Zn}(\text{NO}_3)_2$ . Wendlandt and Bryant, 1956.

### SOLUBILITY OF ZINC NITRATE IN LIQUID AMMONIA (Donskaja and Portnev, 1939)

t°	Gms. Zn(NO <sub>3</sub> ) <sub>2</sub> per 100 gms. NH <sub>3</sub>	Solid Phase	t°	Gms. Zn(NO <sub>3</sub> ) <sub>2</sub> per 100 gms. NH <sub>3</sub>	Solid Phase	
NO	-79	1.06	NH <sub>3</sub>	-39	33.62	Zn(NO <sub>3</sub> ) <sub>2</sub> ·8NH <sub>3</sub>
	-79	6.61	"	-31	31.88	"
	-78.5	11.71	"	0	29.01	" + Zn(NO <sub>3</sub> ) <sub>2</sub> ·6NH <sub>3</sub>
	-78	16.34	"	+43	31.88	Zn(NO <sub>3</sub> ) <sub>2</sub> ·6NH <sub>3</sub>
	-77	20.11	" + Zn(NO <sub>3</sub> ) <sub>2</sub> ·10NH <sub>3</sub>	48	53.62	"
	-75	22.17	Zn(NO <sub>3</sub> ) <sub>2</sub> ·10NH <sub>3</sub>	58	35.18	" + Zn(NO <sub>3</sub> ) <sub>2</sub> ·4NH <sub>3</sub>
	-73	24.10	"	60	37.81	Zn(NO <sub>3</sub> ) <sub>2</sub> ·4NH <sub>3</sub>
	-71	26.36	"	63	40.38	"
	-67	29.01	"	68	44.67	"
	-62	31.88	"	75	50.30	"
	-60	33.62	"	79	55.09	"
	-58	35.10	" + Zn(NO <sub>3</sub> ) <sub>2</sub> ·8NH <sub>3</sub>	101	71.38	"
			125	85.40	"	

## O ZINC OXIDE $\text{ZnO}$

Data for the solubility of  $\text{ZnO}$  in fused alkali chlorides and sulfates are given by Voskresenskaya and Kashcheev, 1956.

As part of a study of the system  $\text{ZnO} + \text{Cr}_2\text{O}_3$ , Huttig and Theimer, 1941 determined the solubility of mixtures of  $\text{ZnO}$  and  $\text{Cr}_2\text{O}_3$  in dilute  $\text{HCl}$  and  $\text{H}_2\text{SO}_4$  after heating at various temperatures.

## OH ZINC HYDROXIDE

### SOLUBILITY IN WATER

t°	Solubility				Reference
18	0.00306	gms. $\text{ZnO}$	per liter		(Remy and Kuhlmann, 1924; Remy, 1925)
	0.00292	"	"	"	(Remy and Kuhlmann, 1924; Remy, 1925)
	0.0042	"	"	"	(Dupre)
	0.0042	"	"	"	(Dupre and Bialas, 1903)
	0.0063	"	"	"	(Ragg, 1950)
?	0.0029	"	"	"	(Oka, 1940)
25	0.01	"	"	"	(Bodlander, 1898)
29	0.0155	"	"	"	(Busch, 1927)

Feitknecht and Haberli, 1950 give the  $K_{sp}$  of  $Zn(OH)_2$  as  $4 \times 10^{-16}$  for the amorphous form and  $5 \times 10^{-17}$  for the  $\beta$ -1 form.  $ZnO$  obtained by drying at  $100^\circ$  gave  $8.3 \times 10^{-17}$  and  $ZnO$  obtained by decomposition of  $ZnCO_3$  gave  $2.75 \times 10^{-18}$ .

#### SOLUBILITY OF ZINC HYDROXIDE IN SODIUM HYDROXIDE SOLUTIONS

<u>Results at 20°</u>		<u>Results at "ordinary temp."</u>		
(Arkipov, Pakshver and Podbornova, 1950)		(Rubenbauer, 1902)		
Gms. per liter		Gms. per 20 cc.	Mol.	
NaOH	Zn	Solution	Dilution	
		Na	Zn	of the NaOH
68.4	8.0			
132.0	24.7	0.1012	0.0040	4.50
202	45.5	0.1978	0.0150	2.33
360	80.4	0.4278	0.0442	1.06
		0.6670	0.1771	0.70
		0.9660	0.9630	0.48
		1.4951	0.2481	0.31
		2.9901	0.3700	0.16

#### Results at $25^\circ$

(Fulton and Swinehart, 1954)

Moles per 1000 g. $H_2O$		Moles per 1000 g. $H_2O$		Moles per 1000 g. $H_2O$	
NaOH	Zn	NaOH	Zn	NaOH	Zn
0.0000	$1.0 \times 10^{-5}$	0.0186	$3.66 \times 10^{-6}$	0.190	$1.610 \times 10^{-2}$
.000413	5.83	.0311	7.57	.1554	1.168
.000858	6.07	.0386	10.7	.3416	5.636
.00182	5.49	.0497	15.1	.5430	13.79
.00452	9.05	.0669	24.7	.8641	34.71
.00721	13.7	.102	50.9	1.167	64.43
.00986	19.5				

#### SOLUBILITY OF CRYSTALLINE ZINC HYDROXIDE IN AQUEOUS SOLUTIONS OF AMMONIUM HYDROXIDE AND OF SODIUM HYDROXIDE AT $25^\circ$

(Dietrich and Johnston, 1927)

(Results are also given for  $0^\circ$  and  $35^\circ$ )

Attention is called to the discordant character of previous results due to the uncertain nature of the solid phase present in each case. The authors used crystalline zinc hydroxide prepared by dissolving washed precipitated zinc hydroxide in ammonia and gradually removing the ammonia from the solution by absorption from the vapor phase by concentrated sulfuric acid. The crystals which gradually deposit contain 18.12%  $H_2O$  corresponding to pure  $Zn(OH)_2$ . Equilibrium was reached within 24 hours. The following are the interpolated values from the average experimental results.



# Zn ZINC

## SOLUBILITY OF CRYSTALLINE ZINC HYDROXIDE IN AQUEOUS SOLUTIONS OF AMMONIUM HYDROXIDE AND OF SODIUM HYDROXIDE AT 25°--Cont.

Gm. Mol. NaOH or NH <sub>4</sub> OH per 1000 gms. H <sub>2</sub> O	Gm. Mols. Zn(OH) <sub>2</sub> dissolved per 1000 gms. H <sub>2</sub> O in aq.:		Gm. Mol. NaOH or NH <sub>4</sub> OH per 1000 gms. H <sub>2</sub> O	Gm. Mols. Zn(OH) <sub>2</sub> dissolved per 1000 gms. H <sub>2</sub> O in aq.:	
	NH <sub>4</sub> OH	NaOH		NH <sub>4</sub> OH	NaOH
0.0	0.00002	0.00002	1.5	0.0496	0.1042
0.2	0.00130	0.00206	2.0	0.0790	0.1832
0.3	0.00275	0.00444	2.5	0.1105	0.2845
0.4	0.00468	0.00760	3.0	0.1428	0.4065
0.5	0.00705	0.0115	3.5	0.1757	0.5470
OH 0.75	0.0147	0.02625	4.0	0.2096	0.7032
1.0	0.0246	0.0468	5.0	0.2785	1.0740

## SOLUBILITY OF ZINC HYDROXIDE IN AQUEOUS SODIUM HYDROXIDE AT 30° (Fricke, 1928)

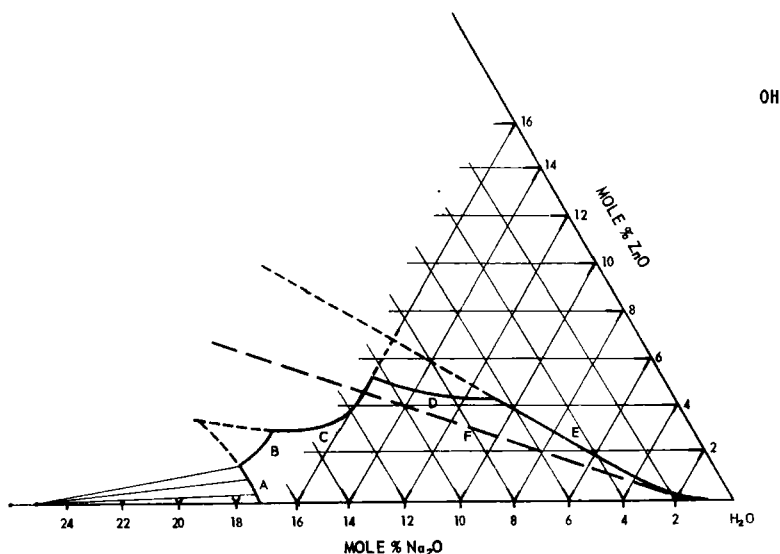
The mixtures were agitated for periods up to 15 days. The solubility increased with time owing to the formation of ZnO.

Gms. per 100 gms. sat. sol.		Gms. per 100 gms. sat. sol.	
NaOH	ZnO	NaOH	ZnO
7.10	1.44	22.0	8.76
13.3	5.15	24.6	12.81
13.7	6.81	28.3	13.8
17.8	9.81	31.75	21.57

Results for the solubility of calcined and hydrated zinc oxide in aqueous solutions of NaOH and of KOH, and for sodium zincate in aqueous solutions of NaOH are given by Muller, Muller and Fouvel, 1927. See also Deshpande and Kabadi, 1951.

THE SYSTEM  $\text{ZnO} - \text{Na}_2\text{O} - \text{H}_2\text{O}$ 

Souchevanov, 1952 constructed the following diagram of the system at  $30^\circ$ . The stable saturating phases are (A)  $\text{NaOH} \cdot \text{H}_2\text{O}$ , (B)  $\text{Na}_2[\text{Zn}(\text{OH})_4]$ , (C)  $\text{Na}[\text{Zn}(\text{OH})_3]$ , (D)  $\text{Na}[\text{Zn}(\text{OH})_3] \cdot 3\text{H}_2\text{O}$ , (E)  $\text{Zn}(\text{OH})_2$ . Metastable solubilities along curve F are in metastable equilibrium with an amorphous hydrate containing 40 mole %  $\text{H}_2\text{O}$ .



Data for the system  $\text{Zn}(\text{OH})_2 - \text{H}_2\text{O}_2 - \text{H}_2\text{O}$  at  $-20$ ,  $-10$ ,  $0$ ,  $20$ ,  $30^\circ$  are reported by Makarov, 1957 and Makarov and Ladeinov, 1957.

## SOLUBILITY OF ZINC HYDROXIDE IN POTASSIUM HYDROXIDE SOLUTIONS

Results of Souchevanov, 1952 at  $18-22^\circ$

Mole % $\text{K}_2\text{O}$	Mole %		Mole % $\text{K}_2\text{O}$	Mole %	
	ZnO	$\text{Zn}(\text{OH})_2$		ZnO	$\text{Zn}(\text{OH})_2$
1.0	0.0	0.0	8.0	1.84	4.44
2.0	0.20	0.34	9.0	2.22	5.42
3.0	0.42	0.83	10.0	2.64	6.60
4.0	0.65	1.44	11.0	3.18	7.80
5.0	0.90	2.12	12.0	3.72	-
6.0	1.18	2.82	13.0	4.30	-
7.0	1.50	3.56			

# Zn ZINC

(Results of Klein, 1912)

The determinations were made by adding aq.  $\text{ZnSO}_4$  solution (containing one gm. mol. per liter) to aq. KOH solutions until a permanent precipitate just appeared. The titrations are also recalculated to mols. per liter and correction made for the dilution of the KOH solution by the aq.  $\text{ZnSO}_4$ .

	Normality of Aq. KOH	cc. $\text{ZnSO}_4$ Sol. per 50 cc. Aq. KOH	Calculated Mols. per Liter of Sat. Sol.		
			Orig. Conc. KOH	Corrected Conc. of KOH	Conc. of Zn
OH	1	5.5	1	0.9	0.10
	1.78	13.1	1.78	1.42	0.209
	2	14.3	2	1.56	0.223
	2.22	17.9	2.22	1.63	0.266
	2.5	18.8	2.5	1.81	0.272
	3	24.6	3	2.02	0.330
	3.6	29.1	3.6	2.28	0.368
	4	34	4	2.38	0.405
	6	56 (?)	6	2.78	0.540

Other data at 15° and 30° are given by Iofa, Mirlina and Moiseeva, 1949. See also Deshpande and Kabadi, 1952.

## SOLUBILITY OF ZINC HYDROXIDE IN AQUEOUS AMMONIA SOLUTIONS

(In addition to the data below, see p. 1674)

Results of Euler (1903)			Results of Bonsdorff (1904) at 25°			
t°	Normality of Aq. Ammonia	Mols. Zn per Liter	Normality of Aq. Ammonia	Gms. ZnO per Liter	Normality of Aq. Ammonia	Gms. ZnO per Liter
15-17	0.485	0.013-0.010*	0.311	0.85	0.321	0.34
15-17	0.97	0.034	0.825	3.84	0.643	0.845
21	0.253	0.0029	1.287	7.28	1.215	2.70
21	0.259	0.0022*			1.928	5.07
21	0.500	0.0097			2.570	7.01
21	0.518	0.0070			3.213	10.16

Euler states that the higher results of Herz are due to incompletely purified zinc hydroxide and uses material precipitated from the nitrate for his experiments. Different preparations of  $\text{Zn}(\text{OH})_2$  containing from 55 to 77 per cent  $\text{H}_2\text{O}$  were used and in the two cases marked \* ZnO was used.

Bonsdorff used for his second series of determinations,  $\text{Zn}(\text{OH})_2$  precipitated from the nitrate and brought in moist condition into the ammonia solutions.

## SOLUBILITY OF ZINC HYDROXIDE IN AQUEOUS AMMONIA SOLUTIONS--Cont.

Results of Herz, 1902 at 17-19°

(in ammonia and amines)

Results of Arkipov,  
Pakshver and  
Podbornova, 1950  
at 20°

	Normality of Dissolved Zn	Gms. ZnO per 20 cc. Solution	Gms. per Liter	
			NH <sub>3</sub>	Zn
0.0942 NH <sub>3</sub>	0.0011	0.00185	46.7	10.6
0.236 NH <sub>3</sub>	0.0110	0.0180	82.3	16.2
0.707 NH <sub>3</sub>	0.059	0.0958	130.5	19.3
0.0944 NH <sub>2</sub> CH <sub>3</sub>	0.0005	0.0008	139.0	19.3
0.472 NH <sub>2</sub> CH <sub>3</sub>	0.0081	0.0132	188.5	18.2
0.944 NH <sub>2</sub> CH <sub>3</sub>	0.03	0.0484	213.0	18.7
0.068 NH <sub>2</sub> C <sub>2</sub> H <sub>5</sub>	0.0003	0.0005		
0.51 NH <sub>2</sub> C <sub>2</sub> H <sub>5</sub>	0.0045	0.0074		
0.68 NH <sub>2</sub> C <sub>2</sub> H <sub>5</sub>	0.0098	0.0161		

OH

Additional data in NH<sub>3</sub> solutions are given by Venkateswarlu, 1953.

SOLUBILITY OF ZINC HYDROXIDE IN ONE PER CENT AQUEOUS SALT  
SOLUTIONS AT 16°-20°  
(Snyder, 1878)

The CO<sub>2</sub> free Zn(OH)<sub>2</sub> dissolved is calculated as milligrams Zn per liter of the given salt solution. Additional determinations are also given.

Aq. Salt Solution	Mgs. Zn per Liter Solution	Aq. Salt Solution	Mgs. Zn per Liter Solution	Aq. Salt Solution	Mgs. Zn per Liter Solution
NaCl	51	K <sub>2</sub> SO <sub>4</sub>	37.5	K <sub>2</sub> CO <sub>3</sub>	0
KCl	43	MgSO <sub>4</sub>	27	NH <sub>4</sub> Cl	95
CaCl <sub>2</sub>	57.5	KNO <sub>3</sub>	17.5	NH <sub>4</sub> NO <sub>3</sub>	77
MgCl <sub>2</sub>	65	Ba(NO <sub>3</sub> ) <sub>2</sub>	25	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	88
BaCl <sub>2</sub>	38				

## Zn ZINC

ZINC PHOSPHATES  $\text{Zn}_3(\text{PO}_4)_2$ ,  $\text{ZnHPO}_4$ ,  $\text{Zn}(\text{H}_2\text{PO}_4)_2$ 

## THE SYSTEM ZINC OXIDE - PHOSPHORUS PENTOXIDE - WATER

The results of Eberly, Gross and Crowell (1920), below, and those of Salmon and Terrey (1950), following, are in good agreement.

Data of Eberly, Gross and Crowell, 1920

The flasks containing the mixtures were kept in thermostats and occasionally shaken during several weeks. The analyses of the saturated solutions and solid phases were repeated at intervals of two weeks until constant results were obtained.

<u>Results at 25°</u>			<u>Results at 37°</u>		
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 Gms. sat. sol.		Solid Phase
$\text{P}_2\text{O}_5$	ZnO		$\text{P}_2\text{O}_5$	ZnO	
5.08	2.38	$\text{Zn}_3(\text{PO}_4)_2 \cdot 4\text{H}_2\text{O}$	4.87	2.08	$\text{Zn}_3(\text{PO}_4)_2 \cdot 4\text{H}_2\text{O}$
9.76	4.65	"	9.46	4.12	"
12.42	6.13	"	13.60	6.27	"
13.52	6.56	"	18.13	8.78	"
14.00	6.74	"	19.48	9.66	"
14.37	6.97	"	20.32	10.16	"
14.83	7.37	"	21.96	10.88	$\text{ZnHPO}_4 \cdot 3\text{H}_2\text{O}$
15.98	7.71	$\text{ZnHPO}_4 \cdot 3\text{H}_2\text{O}$	26.75	13.26	"
17.15	8.26	"	29.65	14.77	"
18.33	8.73	"	33.39	17.06	"
22.75	10.74	"	34.58	17.92	"
26.48	12.47	"	36.13	16.00	$\text{ZnHPO}_4 \cdot \text{H}_2\text{O}$
28.70	13.48	"	37.80	15.78	"
30.09	14.16	"	39.93	16.12	"
32.55	15.40	"	42.42	15.81	"
33.79	15.82	"	42.65	15.82	"
37.15	17.30	"	44.89	17.83	"
39.61	18.04	"	46.11	18.05	$\text{Zn}(\text{H}_2\text{PO}_4)_2 \cdot 2\text{H}_2\text{O}$
42.05	16.14	$\text{Zn}(\text{H}_2\text{PO}_4)_2 \cdot 2\text{H}_2\text{O}$	46.41	14.74	"
44.53	13.20	"	48.99	12.55	"
48.70	9.58	"	51.35	11.26	"
52.25	7.64	"	51.92	11.12	"
55.97	7.23	"	54.32	10.82	"

(con't.)

## THE SYSTEM ZINC OXIDE - PHOSPHORUS PENTOXIDE - WATER--Cont.

Data of Salmon and Terrey, 1950

Sat. Sol. Wt. %			Sat. Sol. Wt. %			Sat. Sol. Wt. %		
P <sub>2</sub> O <sub>5</sub>	ZnO	dens.	P <sub>2</sub> O <sub>5</sub>	ZnO	dens.	P <sub>2</sub> O <sub>5</sub>	ZnO	dens.
At 25°			At 50°			At 75°		
0.435	0.231 <sup>a</sup>	1.003	0.84	0.40 <sup>a</sup>	1.00 <sup>a</sup>	1.56	0.58 <sup>a</sup>	-
0.489	0.267	1.004	1.61	0.68	1.02	7.27	2.68	-
0.714	0.373	1.007	4.93	2.01	1.05	7.32	2.66	-
0.935	0.484	1.01	6.64	2.78	1.07	13.57	5.71	-
1.16	0.586	1.01	7.67	3.22	1.08	18.77	8.72	-
3.13	1.52	1.04	10.58	4.62	1.12	24.42	12.33	-
4.07	1.95	1.04	13.86	6.23	1.14	24.73	12.59	-
4.09	1.95	1.04	17.56	8.27	1.24	25.0	12.80	-
8.72	4.25	1.11	17.91	8.51	1.26	25.7	13.27	-
11.60	5.59	-	18.31	8.68	1.27	26.3	13.78	-
14.92	7.28	1.23	22.04	10.98	1.33	26.7	13.96	-
17.87	8.63 <sup>b</sup>	1.28	22.61	11.40	1.36	27.2	14.25	-
19.39	9.30	1.30	23.56	11.90	1.37	29.8	16.32	-
21.03	10.13	1.33	27.4	14.35	1.46	31.3	17.49 <sup>c</sup>	-
26.4	12.64	-	27.5	14.41	1.46	35.7	18.47	-
35.5	16.6 <sup>c</sup>	-	28.3	14.74	1.45	45.3	25.2	-
37.3	15.95	1.63	29.6	15.60	1.52			
39.8	15.91	-	30.0	15.97	1.52	At 86.3		
40.6	15.75	-	31.3	16.34 <sup>b</sup>	1.54			
44.9	13.06 <sup>d</sup>	1.67	34.4	17.48	1.64	0.77	0.26 <sup>a</sup>	0.99
49.6	9.03	-	35.3	17.49	1.62	1.52	0.50	0.99
53.7	7.66	-	38.7	17.30 <sup>c</sup>	1.65	7.36	2.61	1.05
55.3	7.23	1.67	41.3	17.73	-	13.63	5.67	1.16
57.0	7.51	1.72	41.4	18.10	-	15.43	6.66	1.19
57.3	7.75	-	43.5	17.34	-	18.06	8.29	1.18
59.1	5.25 <sup>e</sup>	-	45.9	15.98	-	20.90	10.05	1.26
60.3	3.72	-	49.3	17.2 <sup>d</sup>	-	22.83	11.38	1.31
62.1	2.45	1.69	50.9	15.36	-	23.51	11.79	1.32
63.5	1.55	1.69	53.4	12.62	-	23.84	11.99	-
			56.7	11.93	-	24.02	12.17	-
						26.4	13.60	-
						29.1	15.65	-
						32.9	18.20 <sup>c</sup>	-
						38.5	20.09	-
						At 100°		
0.467	0.236 <sup>a</sup>	1.00						
0.907	0.442	1.01	3.98	1.54 <sup>a</sup>	1.02			
0.984	0.508	1.01	7.93	3.20	1.08			
4.10	1.85	1.05	10.43	4.42	1.12			
7.69	3.50	1.10	16.21	7.52	1.22			
7.77	3.49	1.09	23.10	11.64	1.36	7.37	2.52 <sup>a</sup>	-
13.66	6.49	1.19	26.6	13.79	1.44	13.94	5.81	-
14.49	6.84	1.20	28.6	15.37	1.49	17.82	8.08	-
17.04	8.26	1.25	32.7	16.81 <sup>b</sup>	1.58	21.29	10.33	-
18.02	8.76	1.27	36.2	18.42	1.65	21.93	10.88	-
18.02	8.70	1.26						
19.56	9.70 <sup>b</sup>	1.30	Solid phase Zn <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> ·4H <sub>2</sub> O					
21.07	10.68	1.34	Solid phase ZnHPO <sub>4</sub> ·3H <sub>2</sub> O					
24.13	12.27	1.39	Solid phase ZnHPO <sub>4</sub> ·H <sub>2</sub> O					
52.7	11.94 <sup>d</sup>	-	Solid phase Zn(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·2H <sub>2</sub> O					
55.1	10.66	-	Solid phase Zn(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> ·2H <sub>3</sub> PO <sub>4</sub>					

## Zn ZINC

Zharovskii (1950) gives the  $K_{sp}$  of  $Zn_3(PO_4)_2$  at 18-20° as  $9.1 \times 10^{-33}$ .

Melting points in the system ZnO -  $P_2O_5$  are given by Katnak and Hummel, 1958.

## PO ZINC AMMONIUM PHOSPHATE $ZnNH_4PO_4$

t°	Gms. per liter H <sub>2</sub> O	Reference
10.5	0.0136	(Artmann, 1915)
17.5	0.0145	(Artmann, 1915)
20	0.015	(Vol'fkovich and Remen, 1955)

## ReO ZINC TETRAMINE PERRHENATE $[Zn(NH_3)_4](ReO_4)_2$

One liter sat. solution of this salt in aqueous ammonia of d = 0.930 (19 percent) contain 1.852 gm. at 20°. (Wilke-Dorfurt and Gunzert, 1933.)

## S ZINC SULFIDE ZnS

The solubility product was calculated from thermochemical data by Kapustinsky, 1940 who found the value  $7.4 \times 10^{-27}$ . The calculated solubility in moles per liter is as follows:

pH =	3	5	7	9	11
S =	$8.3 \times 10^{-6}$	$8.3 \times 10^{-8}$	$1.2 \times 10^{-9}$	$8.6 \times 10^{-11}$	$8.6 \times 10^{-12}$

Critical reviews of the published determinations of the solubilities of the metal sulfides in water are given by Kolthoff, 1931, and Ravitz, 1936. The preferred value for ZnS, calculated by Ravitz with the aid of recent viscosity data is  $1.47 \times 10^{-9}$  gm. mols. per liter.

1000 cc. aq. 2.0 n  $H_2SO_4$  sat. with  $H_2S$  at 1 atmosphere pressure, dissolve 0.6172 gm. ZnS (=  $6.34 \cdot 10^{-3}$  gm. mols. ZnS) at 20°. (Moser and Behr, 1924.)

Goates, Gordon and Faux (1952) calculated the thermodynamic  $K_{sp}$  at 25° to be  $8 \times 10^{-25}$ .

At 200°, 0.00005 gms. ZnS dissolve in 100 gms.  $H_2O$ ; at 300°, 0.0001 gms. dissolve. (Verhoogen, 1937.)

ZINC SULFITE  $\text{ZnSO}_3$ 

50

EQUILIBRIUM IN THE SYSTEM ZINC OXIDE, SULFUR DIOXIDE AND WATER  
(Terres and Buhl, 1934)

The determinations were made by the synthetic method. The results are given in the present paper only in the form of a small diagram from which the following approximate values were read. Additional data are given at 20° by Jager, 1957.

Results at 15°			Results at 25°		
Mol. Percent in sat. sol.		Solid Phase	Mol. Percent in sat. sol.		Solid Phase
ZnO	SO <sub>2</sub>		ZnO	SO <sub>2</sub>	
1.0	2.1	$\text{ZnSO}_3 \cdot 2\frac{1}{2}\text{H}_2\text{O}$	1.0	2.4	$\text{ZnSO}_3 \cdot 2\frac{1}{2}\text{H}_2\text{O}$
2.0	4.0	"	2.0	4.6	"
2.55	5.0	" + $\text{Zn}(\text{HSO}_3)_2(?)$	2.8	6.0	" + $\text{Zn}(\text{HSO}_3)_2(?)$
2.5	6.0	$\text{Zn}(\text{HSO}_3)_2(?)$	2.0	6.4	$\text{Zn}(\text{HSO}_3)_2(?)$
3.0	7.2	"	1.5	7.0	"
4.0	9.1	"	1.3	9.0	"
5.0	10.75	"	1.5	9.0	"
5.6	11.8 <sup>a</sup>	"	2.0	10.0	"
			3.3	11.8 <sup>a</sup>	"

<sup>a</sup>Between 11.8 and 84 Mol. percent SO<sub>2</sub> the mixtures separated into two liquid layers.

100 gms. H<sub>2</sub>O dissolve 0.16 gm.  $\text{ZnSO}_3 \cdot 2\text{H}_2\text{O}$ . (Houston and Trichborne, 1890.)

ZINC SULFATE  $\text{ZnSO}_4$ 

## SOLUBILITY OF ZINC SULFATE IN WATER

(Bury, 1924; Cohen and Hetterschij, 1925; Cohen and Moesveld, 1925)

The very exact determinations of these authors were plotted and the following table constructed from the curves.

t°	Gms. ZnSO <sub>4</sub> per 100 gms. H <sub>2</sub> O	Solid Phase	t°	Gms. ZnSO <sub>4</sub> per 100 gms. H <sub>2</sub> O	Solid Phase
0	41.61	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ (R)	10	58.6	$\text{ZnSO}_4 \cdot 6\text{H}_2\text{O}$
5	44.41	"	15	60.2	"
10	47.25	"	20	61.8	"
15	50.34	"	24.8tp	63.4	" + $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ (M)
20	53.80	"	25	63.5	"
25	57.45	"	30	65.5	"
30	61.30	"	35	68.0	"
35	66.17	"	37.9tp	69.4	" + $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ (R)
37.9tp	69.4	" + $\text{ZnSO}_4 \cdot 6\text{H}_2\text{O}$	40	70.5	$\text{ZnSO}_4 \cdot 6\text{H}_2\text{O}$
10	54.4	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ (M)	45	73.0	"
15	57.0	"	50	76.2	"
20	60.0	"	55	80.0	"
24.8tp	63.4	" + $\text{ZnSO}_4 \cdot 6\text{H}_2\text{O}$	60	85.2	" (cont.)

(M) = monoclinic

(R) = rhombic

tp = transition point



# Zn ZINC

More recent determinations by Rohmer, 1940 and by Schroder, 1936 are as follows:

t°	Density	Gms. ZnSO <sub>4</sub> per 100 gms.		Solid Phase	t°	Density	Gms. ZnSO <sub>4</sub> per 100 gms.		Solid Phase
		Sat.	Sol.				Sat.	Sol.	
0	1.3796	28.58	(S)	7	60	1.5921	42.98	(S)	1
25	1.4921	36.67	(S)	7	60	1.577	41.9		1
30	1.520	38.1		7	65	1.560	41.4		1
32	1.530	38.7		7	70	1.548	40.8		1
33	1.5320	39.17	(S)	7	75	1.535	40.2		1
36	1.553	40.2		7	75	1.5382	40.93	(S)	1
37	1.5502	40.50	(S)	7	85	1.505	39.2		1
37.9	1.561	40.8		7 + 6	86	1.5041	39.26	(S)	1
SO	40	1.590	41.2	6	99	1.4623	37.70	(S)	1
44	1.5836	41.98	(S)	6	100	1.462	37.7		1
45	1.589	42.2		6	54.6	1.627	44.2		6 + 2m
56	1.634	44.6		6m	56	1.624	44.3		2m
60	1.650	45.7		6m	60	1.623	44.2		2m
65	1.672	46.9		6m	65	1.623	44.2		2m
70	1.693	48.2		6m	70	1.623	44.2		2m
75	1.710	49.5		6m	75	1.623	44.2		2m
48.8	1.606	43.0		6 + 1	63.4	1.662	46.5		6 + 4m
56	1.588	42.2		1	65	1.664	46.6		4m
					70	1.674	47.3		4m
					75	1.680	47.9		4m

m = metastable

7, 6, 4, 2, 1 refer to NiSO<sub>4</sub>·7H<sub>2</sub>O, ·6H<sub>2</sub>O, ·4H<sub>2</sub>O, ·2H<sub>2</sub>O and ·H<sub>2</sub>O.

Other determinations in satisfactory agreement with the above are given by Caven and Johnston, 1926, 1928 and Benrath, 1931.

Data for the solubility of ZnSO<sub>4</sub> in water at high pressures are given by Cohen and Sinnige, 1909, 1910.

Additional data on the hydrate transitions is given by D'Ans, Freund and Kaufman, 1957.

## SOLUBILITY OF ZINC SULFATE IN WATER ABOVE 100° (Benrath, 1941)

Gms. ZnSO <sub>4</sub> per		Gms. ZnSO <sub>4</sub> per		Gms. ZnSO <sub>4</sub> per	
t°	100 gms. Sat. Sol.	t°	100 gms. Sat. Sol.	t°	100 gms. Sat. Sol.
90	50	175	35	255	15
115	45	200	26.5 <sup>a</sup>	250	10
145	40	205	25	255	5
		230	20	300	< 0.1 <sup>a</sup>

<sup>a</sup>Lietzke, 1957

Solid Phase ZnSO<sub>4</sub>·H<sub>2</sub>O throughout.

THE SYSTEM ZINC SULFATE - SULFURIC ACID - WATER  
(Copeland and Short, 1940)

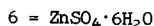
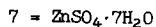
Sat. Sol. Wt. %			Sat. Sol. Wt. %			Sat. Sol. Wt. %		
ZnSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	Solid Phase	ZnSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	Solid Phase	ZnSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	Solid Phase
At -4.5°			At 25°			At 45°		
28.8	0.2	7	36.8	0.1	7	42.0	0.4	6
21.8	7.1	7	29.6	9.8	7	40.1	2.2	6
18.8	11.3	7	26.4	16.4	7	39.4	3.8	6
14.9	16.8	7	25.6	18.2	7 + 6	38.6	4.8	6
11.1	22.6	7	25.1	18.7	6	37.5	6.3	6 + 1
8.8	28.2	7	24.3	20.5	6 + 1	36.4	7.7	1
7.7	34.6	7	22.4	22.3	1	36.0	8.8	1
7.3	38.5	7	20.0	24.9	1	34.9	9.3	1
8.1	38.9	7 + 1	18.1	27.0	1	32.7	10.2	1
6.2	41.5	1	13.3	32.8	1	33.9	10.3	1
3.9	45.1	1	2.2	50.1	1	32.9	10.7	1
1.5	51.2	1	0.7	57.9	1	30.9	12.1	1
0.9	54.6	1	0.8	68.1	1	29.2	14.4	1
0.4	59.1	1	0.8	74.0	1	27.2	16.7	1
			0.7	78.2	1	23.5	20.6	1
			0.2	87.0	1 + 0	18.5	26.0	1
			0.3	89.0	0	15.4	29.0	1
30.6	0.0	7	0.2	91.8	0	6.2	41.8	1
26.7	4.8	7	0.1	94.6	C	2.8	48.8	1
22.9	9.1	7	0.1	95.5	C	0.8	56.6	1
17.3	17.8	7	0.1	96.6	C	0.9	63.9	1
11.5	31.2	7						
11.6	33.8	7	At 35°			At 55°		
11.7	34.5	7 + 1						
10.3	36.1	1	39.5	0.2	7	43.5	0.4	6
8.5	38.2	1	37.3	0.5	7	43.5	0.5	6
6.0	41.8	1	37.0	3.4	7	44.1	0.5	6
1.9	50.2	1	36.1	5.0	7	42.1	0.8	6 + 1
1.0	53.3	1	36.1	5.2	7 + 6	41.8	1.8	1
0.2	65.1	1	35.7	5.9	6	40.0	3.1	1
0.2	66.0	1	35.3	6.4	6	39.0	4.6	1
			35.1	6.7	6	36.5	6.7	1
			34.7	7.1	6	30.9	11.9	1
			33.4	8.6	6	21.7	21.4	1
33.5	0.1	7	31.8	11.8	6	20.8	23.3	1
33.4	0.4	7	30.4	14.1	6 + 1	12.3	33.6	1
29.7	4.2	7	29.4	14.7	1	3.9	46.0	1
27.6	6.9	7	28.3	16.0	1	1.1	55.8	1
21.0	16.7	7	22.6	22.0	1	0.4	67.9	1
18.1	23.8	7	19.1	25.6	1			
17.6	28.0	7 + 1	14.8	30.6	1			
17.0	28.6	1	7.5	39.8	1			
16.1	29.6	1	5.8	42.4	1	7 = ZnSO <sub>4</sub> ·7H <sub>2</sub> O		
15.7	29.8	1	2.1	50.1	1	6 = ZnSO <sub>4</sub> ·6H <sub>2</sub> O		
15.0	30.5	1	0.4	60.8	1	1 = ZnSO <sub>4</sub> ·H <sub>2</sub> O		
8.4	38.4	1				0 = ZnSO <sub>4</sub>		
4.6	43.5	1				C = ZnSO <sub>4</sub> ·H <sub>2</sub> SO <sub>4</sub>		
0.5	57.5	1						

(Cont.)

## THE SYSTEM ZINC SULFATE - SULFURIC ACID - WATER--Cont.

	Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
	ZnSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>		ZnSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	
	At 65°			At 70°		
SO	42.3	0.4	1	41.1	0.3	1
	41.8	0.4	1	41.0	0.3	1
	41.6	0.7	1	37.2	3.3	1
	41.2	1.0	1	36.5	4.9	1
	38.2	3.4	1	33.5	6.8	1
	36.9	4.8	1	33.4	7.6	1
	35.6	5.8	1	27.5	14.5	1
	34.2	7.1	1	20.7	22.2	1
	29.2	12.7	1	15.9	29.0	1
	20.9	22.2	1	7.4	41.4	1
	15.4	29.2	1	1.9	54.4	1
	12.5	32.8	1			
	3.4	48.1	1			
	0.7	58.6	1			
	0.9	59.4	1			

SO

SOLUBILITY OF ZINC SULFATE IN AQUEOUS SOLUTIONS OF SULFURIC ACID  
(Agde and Schimmel, 1928)

t°	Gms. per 100 gms. sat. sol.		Solid Phase	t°	Gms. per 100 gms. sat. sol.		Solid Phase
	ZnSO <sub>4</sub> ·7H <sub>2</sub> O	H <sub>2</sub> SO <sub>4</sub>			ZnSO <sub>4</sub> ·7H <sub>2</sub> O	H <sub>2</sub> SO <sub>4</sub>	
- 6.55	48.25	0.0	Ice+7	+10	57.5	0.0	7
- 6.9	44.2	2.6	Ice+7	+10	48.2	5.4	7
- 8.0	35.75	7.5	Ice+7	+10	41.5	11.0	7
- 8.9	31.6	9.8	Ice+7	+10	36.0	15.4	7
-10.0	28.0	12.5	Ice+7	+10	32.0	20.3	7
-10.0	19.5	19.3	7	+10	28.0	24.75	7
-10.0	12.3	30.0	7	+10	24.4	36.0	7
-10.0	3.5	41.7	7	18.2	38.0	25.4	7 6
0	52.6	0.0	7	28.5	52.5	14.2	7 6
0	48.6	2.5	7	39.1	73.5	0.0	7 6
0	36.5	10.0	7	20	63.1	0.0	6
0	27.7	16.9	7	20	56.0	4.8	6
0	25.0	20.4	7	20	48.7	10.25	6
0	18.6	30.0	7	20	42.75	17.25	6
0	17.0	34.6	7	30	68.4	0.0	6
				30	61.2	5.2	6

SOLUBILITY OF ZINC SULFATE IN AQUEOUS SOLUTIONS OF SULFURIC ACID AT 12.5°  
(Montemartini and Losana, 1928)

d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
	ZnSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>			ZnSO <sub>4</sub>	H <sub>2</sub> SO <sub>4</sub>	
1.4214	33.28	0.0	Zn7	1.4116	5.92	44.36	Zn6+Zn2
1.3930	26.24	7.71	"	1.4620	1.19	58.76	Zn2
1.3786	20.76	16.14	"	1.5578	0.28	64.21	Zn2+Zn
1.3888	17.02	23.64	Zn6	1.6552	0.22	72.26	Zn
1.4131	14.91	28.21	"	1.7664	0.18	81.56	Zn
1.4202	9.62	36.80	"	1.8402	0.16	98.96	Zn

Zn7 = ZnSO<sub>4</sub>·7H<sub>2</sub>O    Zn6 = ZnSO<sub>4</sub>·6H<sub>2</sub>O    Zn2 = ZnSO<sub>4</sub>·2H<sub>2</sub>O    Zn = ZnSO<sub>4</sub>

Activities in the system ZnSO<sub>4</sub> - H<sub>2</sub>SO<sub>4</sub> - H<sub>2</sub>O were determined from vapor pressure and EMF measurements by Tarter, Newschwander, and Ness, 1941. 30

THE SYSTEM ZINC SULFATE - ZINC OXIDE - WATER

Results of Gromov, 1948 at 18°

Saturated Solution

Wt. % ZnSO <sub>4</sub>	Gms. Zn per liter	Density	pH	Solid Phase
34.0	198.0	1.440	5.25	3ZnO·ZnSO <sub>4</sub> ·xH <sub>2</sub> O + ZnSO <sub>4</sub> ·7H <sub>2</sub> O
24.7	183.8	1.390	5.46	3ZnO·ZnSO <sub>4</sub> ·xH <sub>2</sub> O
19.1	103.5	1.2 2	5.58	"
14.4	67.7	1.159	5.71	"
10.8	49.2	1.120	5.82	"
7.6	33.4	1.080	6.00	"
3.7	15.5	1.035	6.20	"
1.7	7.0	1.015	6.37	"
1.6	6.4	1.014	6.40	"
0.7	3.0	1.006	6.52	"
0.3	1.1	1.002	6.70	"
0.0	0.0	1.000	7.20	Zn(OH) <sub>2</sub>

Results of Copeland and Short, 1940 at 25°

Gms. per 100 gms. Sat. Sol.

ZnO	SO <sub>3</sub>	Solid Phase
1.8	1.9	3Zn(OH) <sub>2</sub> ·ZnSO <sub>4</sub> ·4H <sub>2</sub> O
4.4	4.4	"
8.1	8.0	"
10.7	10.7	"
13.6	13.6	"
14.5	14.5	"
17.6	17.6	"
18.3	18.3	3Zn(OH) <sub>2</sub> ·ZnSO <sub>4</sub> ·4H <sub>2</sub> O + ZnSO <sub>4</sub> ·7H <sub>2</sub> O

## Zn ZINC

Additional data in the system  $\text{ZnSO}_4 - \text{ZnO} - \text{H}_2\text{O}$  are given by Aksel'rud and Fialkov, 1950.

Gromov gives results in the system  $\text{ZnSO}_4 - \text{ZnO} - \text{FeSO}_4 - \text{H}_2\text{O}$  at  $18^\circ$ .

The solubility product of  $\text{ZnSO}_4 \cdot 3\text{Zn}(\text{OH})_2$ , determined from potentiometric titration curves is  $10^{-52}$ . (Nikurashin, 1938.)

### THE SYSTEM ZINC SULFATE - AMMONIA - WATER AT $0^\circ$ (Applebey and Windridge, 1932)

30	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase	d. of sat. sol.	Gms. per 100 gms. sat. sol.		Solid Phase
		NH <sub>3</sub>	ZnSO <sub>4</sub>			NH <sub>3</sub>	ZnSO <sub>4</sub>	
	1.435	17.75	42.20	1.4.2	0.956	23.56	4.37	1.4.2
	1.411	18.21	40.98	"	0.917	26.79	1.26	"
	1.292	20.20	37.44	"	0.912	29.30	0.65	"
	1.180	20.83	25.83	"	0.903	30.46	0.40	"
	1.147	21.30	22.52	"	0.900	31.23	0.35	Solid Sol.
	1.097	21.26	16.14	"	0.896	32.86	0.15	"
	1.006	21.80	9.98	"	-	38.52	trace	"
					-	40.50	trace	"

1.4.2 =  $\text{ZnSO}_4 \cdot 4\text{NH}_3 \cdot 2\text{H}_2\text{O}$ ; Solid solution of  $\text{ZnSO}_4 \cdot 4\text{NH}_3 + \text{ZnSO}_4 \cdot 5\text{NH}_3$ .

At  $18^\circ$  the mixtures separate into two liquid layers of the following compositions:

Lower Layer			Upper Layer			
d. of solution	Gms. per 100 gms. solution		d. of solution	Gms. per 100 gms. solution		Solid Phase
	NH <sub>3</sub>	ZnSO <sub>4</sub>		NH <sub>3</sub>	ZnSO <sub>4</sub>	
1.488	19.24	46.22	-	-	-	1.4.2
1.457	20.37	46.02	-	-	-	"
1.395	21.70	42.13	-	-	-	"
1.304	23.32	36.97	0.928	28.74	4.44	"
1.233	23.07	32.20	0.967	26.34	7.82	-
1.201	22.85	29.38	0.995	25.30	10.71	-
-	-	-	0.929	28.68	4.01	1.4.2
-	-	-	0.911	29.07	2.20	"
-	-	-	0.895	30.03	1.23	"
-	-	-	0.887	32.43	0.43	solid sol.
-	-	-	0.880	33.30	0.49	"
-	-	-	-	38.75	0.01	"

Several results similar to the above are given for other temperatures.

ZINC POTASSIUM SULFATE  $\text{ZnK}_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ 

30

100 gms. of a saturated solution in water at 25° contain 11.72 gms.  $\text{ZnK}_2(\text{SO}_4)_2$  (0.3873 moles per liter), and the density is 1.109. (Hill, Burham, and Ricci, 1940)

Additional data in the system  $\text{ZnSO}_4 - \text{K}_2\text{SO}_4 - \text{H}_2\text{O}$  at 25° are reported by Lipscomb and Hulett (1915-16).

ZINC AMMONIUM SULFATE  $\text{Zn}(\text{NH}_4)_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ 

30

100 gms. of a saturated solution in water at 25° contain 12.24 gms.  $\text{Zn}(\text{NH}_4)_2(\text{SO}_4)_2$  (0.4601 moles per liter), and the density is 1.103. (Hill and Taylor, 1938)

SOLUBILITY OF ZINC SULFATE IN AQUEOUS ETHYL ALCOHOL  
(Schiff, 1861)

Concentration of Alcohol	10%	20%	40%
Gms. $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ per 100 Gms. Solution	51.1	39	3.45

SOLUBILITY OF ANHYDROUS ZINC SULFATE IN:  
(Gibson, Driscoll and Jones, 1929)

Methyl Alcohol			Ethyl Alcohol		
t°	Gms. $\text{ZnSO}_4$ per 100 gms. $\text{CH}_3\text{OH}$	Solid Phase	t°	Gms. $\text{ZnSO}_4$ per 100 gms. $\text{CH}_3\text{OH}$	Solid Phase
15	0.485	$\text{ZnSO}_4 \cdot 2\frac{1}{2}\text{CH}_3\text{OH}$	15	0.038	$\text{ZnSO}_4$
25	0.425	"	25	0.034	"
35	0.408	"	35	0.029	"
45	0.420	"	55	0.020	"
55	0.463	$\text{ZnSO}_4 \cdot \text{CH}_3\text{OH} (?)$			

100 ml of solution in methyl alcohol, saturated with  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  at 5°, contain 1.1 gms.  $\text{ZnSO}_4$  (Barber and Ali, 1950)

100 gms. abs. methyl alcohol dissolve 0.65 gm.  $\text{ZnSO}_4$  at 18°, 5.90 gms.  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  at 18°.

100 gms. 50 per cent methyl alcohol dissolve 15.7 gms.  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  at 18°. (deBruyn, 1891.)

100 gms. glycerol dissolve 35 gms. zinc sulfate at 15.5°. (Ossendowski, 1907.)

THE SYSTEM ZINC SULFATE - ACETONE - WATER AT 25°  
(Leaming, 1925)

The binodal curve for this system was determined by the titration method; tie lines or the plait point were not determined. The author's results were plotted and the following values taken from the average curve.

	Gms. per 100 gms. homogeneous liquid			Gms. per 100 gms. homogeneous liquid		
	ZnSO <sub>4</sub>	(CH <sub>3</sub> ) <sub>2</sub> CO	H <sub>2</sub> O	ZnSO <sub>4</sub>	(CH <sub>3</sub> ) <sub>2</sub> CO	H <sub>2</sub> O
50	30.0	4.0	66.0	11.7	17.5	70.8
	27.0	5.0	68.0	9.3	20.0	70.7
	25.0	6.0	69.0	7.5	22.5	70.0
	22.2	7.5	70.3	5.7	25.0	69.3
	19.0	10.0	71.0	4.2	27.5	68.3
	16.4	12.5	71.1	3.0	30.0	67.0
	14.0	15.0	71.0	2.2	32.5	65.1

The composition of the homogeneous mixture mixture (plait point) of the system zinc sulfate + tertiary butyl alcohol + water at 25° was found by Ginnings, Hering and Webb, 1933, to be

6.0 gms. ZnSO<sub>4</sub> + 25.5 gms. (CH<sub>3</sub>)<sub>3</sub>COH + 68.5 gms. H<sub>2</sub>O

The original results for the remaining points on the binodal curve are not given but only the values of a series of constants, calculated by means of empirical equations.

THE SYSTEM ZINC SULFATE - URETHAN - WATER AT 25°  
(Palitzsch, 1928, 1929)

Gms. Mols. per 1000 gms. H <sub>2</sub> O		Solid Phase
ZnSO <sub>4</sub>	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>	
3.59	0.0	ZnSO <sub>4</sub> ·?H <sub>2</sub> O
0.02	49.84	Upper liquid layer
3.51	0.239	Lower liquid layer
0.0	53.09	NH <sub>2</sub> COOC <sub>2</sub> H <sub>5</sub>

Data for the system ZnSO<sub>4</sub> - urea - H<sub>2</sub>O from -20° to +25° are given by Bergman and Sulaimankulov, 1957.

Melting points in the system ZnSO<sub>4</sub> - CsBr are given by Luzhnaya and Vereshchetina, 1956.

50 ZINC SULFAMATE Zn(SO<sub>3</sub>NH<sub>2</sub>)<sub>2</sub>

Cupery (1938) found the solubility to be 115 gms. per 100 gms. of water at 25°.

ZINC SELENITE  $\text{ZnSeO}_3$ 

SeO

The  $K_{sp} [\text{Zn}^{++}] [\text{SeO}_3^{=}]$  is  $2.58 \times 10^{-7}$ . (Chukhlantsev, 1916.)

ZINC SELENATE  $\text{ZnSeO}_4$ 

SeO

SOLUBILITY OF ZINC SELENATE IN WATER  
(Klein, 1940)

t°	Density	Gms. $\text{ZnSeO}_4$ per 100 gms.		Solid Phase
		Sat. Sol.	H <sub>2</sub> O	
- 2	-	17.4	21.0	Ice
- 5.4	-	29.07	40.98	"
- 7.8	-	32.17	47.42	Ice + $\text{ZnSeO}_4 \cdot 6\text{H}_2\text{O}$
0	1.4835	33.05	49.37	$\text{ZnSeO}_4 \cdot 6\text{H}_2\text{O}$
11.5	1.5201	35.34	54.65	"
22	1.5588	37.84	60.87	"
27	1.5796	39.5	65.2	"
34.4	-	41.8	71.8	"
28	-	40.5	68.0	"
29	-	40.8	68.9	$\text{ZnSeO}_4 \cdot 5\text{H}_2\text{O}$
40.3	-	43.1	75.7	"
43.4	1.6594	43.8	77.8	"
52	-	45.8	83.8	"
54.2	-	46.07	85.42	"
47	1.6250	42.95	75.20	$\text{ZnSeO}_4 \cdot \text{H}_2\text{O}$
56.2	1.5728	40.79	68.89	"
60	1.5611	40.44	67.89	"
52	1.6270	43.48	76.92	$\text{ZnSeO}_4$
60	1.5677	40.85	69.29	"
70	1.5061	38.29	62.05	"
80	-	35.63	55.35	"
91	-	33.4	50.1	"
98.5	1.3580	31.61	46.22	"

## ZIRCONIUM Zr

Phase diagrams are given for the systems:

Zr - O - H

(Edwards and Levesque, 1955)

Zr -  $\text{ZrO}_2$

(Cubiciotti, 1951)



## Zr ZIRCONIUM

### Br ZIRCONIUM OXYBROMIDE $\text{ZrOBr}_2 \cdot 8\text{H}_2\text{O}$

SOLUBILITY OF ZIRCONIUM OXY BROMIDE IN AQUEOUS SOLUTIONS  
OF HYDROBROMIC ACID AT 25°  
(v. Hevesy and Wagner, 1930)

d. of sat. sol.	Normality of Aq. HBr	Gms. $\text{ZrO}_2$ per liter sat. sol.	d. of sat. sol.	Normality of Aq. HBr	Gms. $\text{ZrO}_2$ per liter sat. sol.
1.7488	1.046	355.7	1.4900	4.50	125.3
1.7343	1.301	344.5	1.4060	6.44	26.80
1.7139	1.485	329.6	1.3836	8.72	3.654
1.5606	3.488	190.5	1.4861	9.09	3.656
1.5525	3.663	180.2	-	13.17	2.11

### CH ZIRCONIUM CUPFERRATE

Data for the solubility in acidic solutions is given by  
Fujiwara, 1951.

### ZIRCONIUM THENOYL TRIFLUORO ACETONATE

SOLUBILITY IN BENZENE  
(Huffman and Iddings, 1949)

t°	Gms. $\text{ZrTTA}$ per liter
20	17.2
30	25.4
40	38.0

Data for the solubility in the presence of excess thenoyl tri-  
fluoroacetone and in contact with  $\text{HClO}_4$  solutions and  $\text{H}_2\text{O}$  are also  
given.

### SCN ZIRCONIUM THIOCYANATE $\text{Zr}(\text{SCN})_4$

DISTRIBUTION OF ZIRCONIUM THIOCYANATE BETWEEN WATER AND ETHER  
(Fischer and Chalybaeus, 1947)

A 0.5 N solution of  $\text{HSCN}$  containing  $\text{Zr}(\text{CNS})_4$  in ether was shaken  
with aqueous solutions of ammonium salts at room temperature. All data  
are in gms. per liter.

## DISTRIBUTION OF ZIRCONIUM THIOCYANATE BETWEEN WATER AND ETHER--Cont.

Water Phase Before Shaking		ZrO <sub>2</sub> After Shaking	
NH <sub>4</sub> SCN	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Water Phase	Ether Phase
0	0	0.560	0.076
280	0	0.107	.155
0	10	1.60	.020
100	50	1.400	.010
200	50	1.300	.012
280	50	1.670	.038
0	100	3.800	.008
100	100	1.580	.010
280	100	3.500	.029

SCN

ZIRCONIUM TETRACHLORIDE ZrCl<sub>4</sub>

Cl

Data for the extraction of Zr from HCl solutions by tributyl phosphate are reported by Levitt and Freund, 1956.

SOLUBILITY OF ZIRCONIUM TETRA CHLORIDE IN LIQUID SULFUR DIOXIDE  
(Bond and Stephens, 1929)

A monel metal bomb having two chambers communicating by means of a needle valve, was used.

t°	Gm. mol. ZrCl <sub>4</sub> per 1.0 mol. ZrCl <sub>2</sub> + SO <sub>2</sub>
0	0.0138
10	0.0199
20	0.0258

Data for the system ZrCl<sub>4</sub> + POCl<sub>3</sub> are given by Sheka and Voitovich, 1956. Melting points in the system ZrCl<sub>4</sub> + NaCl are given by Morozov and Korshunov, 1956. Other results for ZrCl<sub>4</sub> + NaCl, ZrCl<sub>4</sub> + KCl and for ZrCl<sub>4</sub> + NaCl + KCl are given by Howell, Sommer and Kellogg, 1957.

ZIRCONIUM OXYCHLORIDE ZrOCl<sub>2</sub>·8H<sub>2</sub>OSOLUBILITY OF ZIRCONIUM OXYCHLORIDE IN AQUEOUS HYDROCHLORIC ACID AT 20°  
(v. Hevesy, 1923)

Constant agitation for many hours was employed. The zirconium oxychloride contained 0.4% oxide of hafnium. The solid phase was ZrOCl<sub>2</sub>·8H<sub>2</sub>O up to concentrations of 10 normal HCl.

## Zr ZIRCONIUM

Normality of Aq. HCl	Gms. ZrO <sub>2</sub> per liter sat. sol.	Mols. ZrOClO <sub>2</sub> per liter sat. sol.	Normality of Aq. HCl	Gms. ZrO <sub>2</sub> per liter sat. sol.	Mols. ZrOClO <sub>2</sub> per liter sat. sol.
0.20	358.1	2.91	6.35	12.78	0.1037
1.47	264.5	2.14	8.72	6.74	0.0547
3.72	102.2	0.832	10.14	12.17	0.0988
4.97	40.5	0.329	10.94	25.3	0.205
5.81	19.35	0.157	11.61	41.1	0.334

Results for the addition of concentrated sulfuric and nitric acids to this salt may be found under  $Zr(SO_4)_2$  and  $Zr(NO_3)_4$ , respectively.

C1

Data for the extraction of Zr from  $ClO_4^-$  solutions by various combinations of fluorinated  $\beta$ -diketones are given by Huffman, Iddings and Osborne, 1955.

## F ZIRCONIUM FLUORIDE $ZrF_4$

THE SYSTEM  $ZrF_4 - HF - H_2O$  at  $0.5^\circ$   
(Tananaev, Nikolaev and Buslaev, 1956)

Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
HF	ZrO <sub>2</sub>		HF	ZrO <sub>2</sub>	
2.21	3.14	$ZrOF_2 \cdot 2H_2O$	31.63	0.015	$H_2ZrF_6 \cdot H_2O$
3.95	6.19		84.35	31.95	
5.84	7.92	$ZrF_4 \cdot 3H_2O$	85.81	0.0107	$ZrF_4$
30.00	32.37		99.98	0.015	

Data for the extraction of Zr from aqueous HF solutions (1 - 20M) at  $20^\circ$  by diethyl ether are given by Bock and Harrmann, 1956.

The mole fraction of  $ZrF_4$  in a saturated solution in water at  $25^\circ$  is 0.0016. In hydrogen fluoride at  $12^\circ$  it is 0.00001. (Shept, Hyman and Katz, 1953.)

Data for the solubility of  $ZrF_4$  in 1 - 16 N  $HNO_3$  from  $0 - 80^\circ$  are given by Chapman and Slansky, 1958.

## ZIRCONIUM POTASSIUM HEXA FLUORIDE $ZrK_2F_6$

### SOLUBILITY OF ZIRCONIUM POTASSIUM HEXA FLUORIDE IN AQUEOUS SOLUTIONS OF HYDROFLUORIC ACID AT $20^\circ$

(v. Hevesy, 1925; v. Hevesy, Christiansen and Berglund, 1925)

Normality of aq. HF	0.125	5.89
Mols. $ZrK_2F_6$ per liter	0.0655	0.1298

ZIRCONIUM AMMONIUM FLUORIDES  $\text{Zr}(\text{NH}_4)_2\text{F}_6$  and  $\text{Zr}(\text{NH}_4)_3\text{F}_7$ 

F

## SOLUBILITY OF EACH SEPARATELY IN WATER

(v. Hevesy, 1925; v. Hevesy, Christiansen and Berglund, 1925)

The solutions were saturated by constant shaking in a thermostat.

Compound	t°	d. of sat. sol.	Mol. per liter sat. sol.	
			Zr	NH <sub>3</sub>
Zirconium Ammonium Hexa Fluoride $\text{Zr}(\text{NH}_4)_2\text{F}_6$	0	1.154	0.611	1.226
Zirconium Ammonium Hexa Fluoride $\text{Zr}(\text{NH}_4)_2\text{F}_6$	20	1.154	1.050	2.115
Zirconium Ammonium Hexa Fluoride $\text{Zr}(\text{NH}_4)_2\text{F}_6$	45	-	1.842	3.680
Zirconium Ammonium Hexa Fluoride $\text{Zr}(\text{NH}_4)_2\text{F}_6$	90	-	2.96	5.93
Zirconium Ammonium Hepta Fluoride $\text{Zr}(\text{NH}_4)_3\text{F}_7$	0	-	0.425	1.230
Zirconium Ammonium Hepta Fluoride $\text{Zr}(\text{NH}_4)_3\text{F}_7$	20	1.086	0.588	1.756
Zirconium Ammonium Hepta Fluoride $\text{Zr}(\text{NH}_4)_3\text{F}_7$	45	-	0.788	2.357

SOLUBILITY OF ZIRCONIUM AMMONIUM HEPTA FLUORIDE IN AQUEOUS SOLUTIONS  
OF AMMONIUM FLUORIDE AT 20°

(v. Hevesy, 1925; v. Hevesy, Christiansen and Berglund, 1925)

The mixtures were constantly agitated in a flask of ebonite.

d. of sat. sol.	Mols. per liter			Solid Phase
	NH <sub>4</sub> F	NH <sub>4</sub> (attached to Zr)	Zr	
1.086	0.002	1.655	0.551	$\text{Zr}(\text{NH}_4)_3\text{F}_7$
-	0.462	1.125	0.375	"
-	0.966	0.726	0.242	"
-	1.941	0.292	0.0972	"
1.068	4.872	0.0678	0.0226	"
1.105	9.721	0.0515	0.01716	"

THE SYSTEM  $\text{Zr}(\text{NH}_4)_3\text{F}_7$  -  $\text{Zr}(\text{NH}_4)_2\text{F}_6$  -  $\text{H}_2\text{O}$  AT 20°

(v. Hevesy, 1925; v. Hevesy, Christiansen and Berglund, 1925)

Mols. per liter (found)		Mols. per liter (calculated)		
Zr	NH <sub>3</sub>	$\text{Zr}(\text{NH}_4)_3\text{F}_7$	$\text{Zr}(\text{NH}_4)_2\text{F}_6$	
0.551	1.655	0.551	0.0	$\text{Zr}(\text{NH}_4)_3\text{F}_7$
0.733	1.831	0.365	0.368	"
1.109	2.383	0.165	0.944	" + $\text{Zr}(\text{NH}_4)_2\text{F}_6$
1.050	2.115	0.0	1.05	$\text{Zr}(\text{NH}_4)_2\text{F}_6$

# Zr ZIRCONIUM

## F ZIRCONIUM OXYFLUORIDE $ZrOF_2 \cdot 2HF \cdot 2H_2O$

SOLUBILITY OF ZIRCONIUM OXYFLUORIDE IN AQUEOUS SOLUTIONS OF  
HYDROFLUORIC ACID AT 25°  
(v. Hevesy and Wagner, 1930)

d. of sat. sol.	Normality of Aq. HF	Gms. $ZrO_2$ per liter sat. sol.	d. of sat. sol.	Normality of Aq. HF	Gms. $ZrOx$ per liter sat. sol.
1.489	0	408.5	1.685	10.05	548.5
1.559	1.06	502.2	1.600	15.05	444.3
1.712	6.03	571.8	1.430	20.09	288.3

The salt  $ZrF_4 \cdot 3H_2O$  crystallizes from aqueous hydrofluoric acids of concentrations between 5.0 and 20.0 normal.

## NO ZIRCONIUM NITRATE $Zr(NO_3)_4$

SOLUBILITY OF ZIRCONIUM NITRATE IN  
NITRIC ACID SOLUTIONS AT ROOM TEMPERATURE  
(Falinski, 1941)

The data were obtained by the addition of  $HNO_3$  to  $ZrOCl_2 \cdot 8H_2O$  in varying proportions. The mixtures were stirred at room temperature and atmospheric pressure and both solution and solid were analyzed.

Method of Preparation	Gms. per 100 gms. Sat. Sol.		Solid Phase
	$HNO_3$	$ZrO_2$	
10 g $ZrOCl_2 \cdot 8H_2O$ + 15.5 cc fuming $HNO_3$	59.4	14.8	$Zr(NO_3)_4 \cdot 6H_2O$
20 g $ZrOCl_2 \cdot 8H_2O$ + 50 cc fuming $HNO_3$	59.5	14.6	"
10 g $ZrOCl_2 \cdot 8H_2O$ + 20 cc fuming $HNO_3$	60.9	13.2	"
$Zr(OH)_4$ + $HNO_3$	62.4	13.0	"
$ZrOCl_2 \cdot 8H_2O$ + fuming $HNO_3$	63.0	12.4	$Zr(NO_3)_4 \cdot 5H_2O$
$Zr(OH)_4$ + $HNO_3$	64.9	11.9	"
" "	67.2	12.0	"
$ZrOCl_2 \cdot 8H_2O$ + fuming $HNO_3$	67.7	14.1	"
Concentrated Solution of $ZrO(NO_3)_2$ + Conc. $HNO_3$	70.4	13.1	"
$Zr(NO_3)_4$ + $HNO_3$	70.8	12.8	2 Phases (?)
" "	74	10.8	$Zr(NO_3)_4 \cdot HNO_3 \cdot 4H_2O$ (?)
" "	76	10.5	2 Phases (?)
" "	80	9.6	$Zr(NO_3)_4 \cdot 2HNO_3 \cdot 4H_2O$
" "	83.3	8.06	"
" "	84.8	8.58	"
" "	86.9	9.23	$Zr(NO_3)_4 \cdot 2HNO_3 \cdot 3H_2O$ (?)

100 cc of a saturated solution of zirconium nitrate in ethyl ether, prepared by frequent agitation and allowing to stand over night at about 20°, contain 0.003 gm.  $ZrO_2$ . A saturated ethereal solution prepared as above, but using zirconium titrate which had been dehydrated at 150°, contain 0.004 gm.  $ZrO_2$  per 100 cc. (Wells, 1930.)

Data for the extraction of Zr(IV) from  $HNO_3 + Ca(NO_3)_2$  solutions at 20° by methyl isobutyl ketone is given by Rydberg and Bernstrom, 1957.

### ZIRCONIUM OXYNITRATE $ZrO(NO_3)_2 \cdot 2H_2O$

NO

0.37 gms.  $ZrO(NO_3)_2$  are dissolved in 100 gms. of a saturated solution in isoamyl alcohol at room temperature. Less than 0.1 gms. dissolve in methyl n-hexyl ketone under the same conditions. (Rothschild, Templeton and Hall, 1948).

### ZIRCONIUM HYDROXIDE $Zr(OH)_4$

OH

- The Ksp of  $Zr(OH)_4$  is  $8 \times 10^{-52}$ . (Korenman, 1955)

- Assuming the reaction,  $Zr(OH)_4 \rightleftharpoons Zr(OH)_2^{++} + 2OH^-$ , the Ksp is  $3 \times 10^{-26}$ . (Larsen and Gammill, 1950)

Oka, 1940 found the solubility to be  $8.0 \times 10^{-11}$  moles per liter by potentiometric titration.

Melting points in the system  $ZrO_2 - CaCl_2$  are given by Belozersky and Kucherenko, 1940.

Data for the solubility of  $ZrO_2$  in molten cryolite is given by Kido, 1954.

### ZIRCONIUM PHOSPHATE $ZrO(H_2PO_4)_2$

PO

#### SOLUBILITY OF ZIRCONIUM PHOSPHATE IN AQUEOUS HYDROCHLORIC ACID AT 20° (v. Hevesy and Kimura, 1925)

About 0.1 gm. of the compound was shaken with about 150 cc. of the hydrochloric acid in a thermostat for 3 days. 100 cc. of the sat. solution were evaporated and the residue ignited.

Normality of aq. HCl	Gms. ignited residue from 100 cc. sat. sol.	Mol. $ZrO(H_2PO_4)_2$ per liter sat. sol.
6.01	0.0033	0.00012
10.00	0.0061	0.00023

# Zr ZIRCONIUM

## SO ZIRCONIUM SULFATE $Zr(SO_4)_2$

### SOLUBILITY OF ZIRCONIUM SULFATE IN SULFURIC ACID SOLUTIONS (Falinski, 1941)

Varying amounts of sulfuric acid were added to  $Zr(SO_4)_2 \cdot 4H_2O$  and up to two years were required to reach equilibrium, during which time the %  $ZrO_2$  in solution fell continuously. The solid phases are similar to those found by Hauser (following), but the compositions of the saturated solutions differ somewhat. Additional data was obtained by adding sulfuric acid and oleum to  $ZrOCl_2 \cdot 8H_2O$ , in which cases the solid was changed to a sulfate. Additional data are given by D'Ans and Eick (see below).

Results at 25°			Results at 40°		
Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
ZrO <sub>2</sub>	SO <sub>3</sub>		ZrO <sub>2</sub>	SO <sub>3</sub>	
20.7	27.1 <sup>a</sup>	$Zr(SO_4)_2$	20.2	26.5 <sup>a</sup>	$Zr(SO_4)_2$
19.0	25.0 <sup>a</sup>	$Zr(SO_4)_2 \cdot 4H_2O$	19.5	25.5 <sup>a</sup>	$Zr(SO_4)_2 \cdot 4H_2O$
14.1	26.0	"	13.8	25.8	"
11.3	26.0	"	6.06	28.5	"
7.58	29.1	"	3.74	30.4	"
2.89	30.7	"	1.44	34.7	"
1.10	34.6	"	0.74	38.3	"
0.49	38.1	"	.13	47.1	"
.19	43.2	"	.12	48.9	"
.08	48.1	"	.08	53.0	"
.05	53.1	"	.11	56.9	"
.07	56.8	"	.65	62.4	"
.13	59.9	"	1.51	63.8	"
.33	60.4	"	2.2	64.2	$Zr(SO_4)_2 \cdot 4H_2O +$
.54	63.2	"			$Zr(SO_4)_2 \cdot H_2SO_4 \cdot 2H_2O$
1.53	63.6	"	2.23	64.6	$Zr(SO_4)_2 \cdot H_2SO_4 \cdot 2H_2O$
2.08	63.8	$Zr(SO_4)_2 \cdot 4H_2O +$	1.35	65.9	"
		$Zr(SO_4)_2 \cdot H_2SO_4 \cdot 2H_2O$	1.0	67.7	"
1.99	64.3	$Zr(SO_4)_2 \cdot H_2SO_4 \cdot 2H_2O$	1.12	71.3	"
0.91	66.4	"	1.18	73.0	$Zr(SO_4)_2 \cdot H_2SO_4 \cdot H_2O$
.75	66.6	"	0.19	75.6	$Zr(SO_4)_2 \cdot H_2SO_4$ (?)
.72	67.8	"	.05	78.1	" (?)
.71	71.0	"	.02	79.6	"
.81	72.0	"	.03	80.8	"
.54	74.9	$Zr(SO_4)_2 \cdot H_2SO_4 \cdot H_2O$	.01	82.6	"
.50	75.9	"			
.34	77.7	"			
.02	79.9	$Zr(SO_4)_2 \cdot H_2SO_4$			
.02	81.5	"			
.02	83.1	"			

<sup>a</sup>No  $H_2SO_4$  added

(cont)

Results obtained by addition of  $\text{H}_2\text{SO}_4$  to  $\text{ZrOCl}_2 \cdot 8\text{H}_2\text{O}$  (Room temperature)

cc $\text{H}_2\text{SO}_4$ added per 10 gms. Salt:	Gms. per 100 gms. sat. sol.		Solid Phase
	$\text{ZrO}_2$	$\text{SO}_3$	
12 "Ordinary Concentrated Sulfuric	0.51	61.4	$\text{Zr}(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O}$
14 "	3.0	62.4	Metastable (?)
15 "	2.2	63.3	"
16 "	2.0	63.7	$\text{Zr}(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O} + \text{Zr}(\text{SO}_4)_2 \cdot \text{H}_2\text{SO}_4 \cdot 2\text{H}_2\text{O}$
18 "	0.95	66.0	$\text{Zr}(\text{SO}_4)_2 \cdot \text{H}_2\text{SO}_4 \cdot 2\text{H}_2\text{O}$
20 "	.9	67.7	"
23 "	.75	69.3	"
24.5 "	.85	70.7	"
30 "	1.0	71.8	"
17 "Ac. Nordhausen"	1.2	72.1	$\text{Zr}(\text{SO}_4)_2 \cdot \text{H}_2\text{SO}_4 \cdot 2\text{H}_2\text{O} + \text{Zr}(\text{SO}_4)_2 \cdot \text{H}_2\text{SO}_4 \cdot \text{H}_2\text{O}$
40 Ordinary Concentrated	0.88	72.5	$\text{Zr}(\text{SO}_4)_2 \cdot \text{H}_2\text{SO}_4 \cdot \text{H}_2\text{O}$
20 "A.C. Nordhausen	.88	74.4	"
25 "	.7	75.8	"
30 "	.6	76.6	"
33 Oleum 18.9%	.24	78.6	"
20 " 60%	.24	79.1	$\text{Zr}(\text{SO}_4)_2 \cdot \text{H}_2\text{SO}_4$ (?)
43 " 18.9%	.03	80	"
40 "Ac. Nordhausen"	0.0	80.3	"

SOLUBILITY OF ZIRCONIUM SULFATE IN AQUEOUS SULFURIC ACID AT  $37.5^\circ$   
(Hauser, 1907)

Gms. per 100 gms. sat. sol.		Solid Phase	Gms. per 100 gms. sat. sol.		Solid Phase
$\text{ZrO}_2$	$\text{SO}_3$		$\text{ZrO}_2$	$\text{SO}_3$	
19.5	25.46	$\text{Zr}(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O}$	0.15	56.7	$\text{Zr}(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O}$
18.8	27	"	0.50	57.5	"
16.2	29.1	"	2	59.5	"
9.6	32.3	"	4.4	61.4	" + $\text{Zr}(\text{SO}_4)_2 \cdot \text{H}_2\text{SO}_4 \cdot 3\text{H}_2\text{O}$
5.3	34.7	"	4.55	61.5	$\text{Zr}(\text{SO}_4)_2 \cdot \text{H}_2\text{SO}_4 \cdot 3\text{H}_2\text{O}$
3.51	36.01	"	3.33	63.8	"
1.03	38.2	"	1.80	64.2	"
0.46	39.8	"	1.12	66.8	"
0.33	42.1	"	0.96	68.4	"
0.14	46.8	"	0.10	81.5	$\text{Zr}(\text{SO}_4)_2 \cdot \text{H}_2\text{SO}_4 \cdot \text{H}_2\text{O}$

Results at  $22^\circ$  show only slight differences from the above figures, hence, the temperature coefficient for this salt is quite small. In an earlier paper Hauser (1905) gives data for the basic sulfate  $4\text{ZrO}_2 \cdot 3\text{SO}_2 \cdot 14\text{H}_2\text{O}$ .



## Zr ZIRCONIUM

THE SYSTEM  $\text{ZrO} - \text{SO}_3 - \text{H}_2\text{O}$   
(D'Ans and Eick, 1951)

	Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase	Sat. Sol. Wt. %		Solid Phase
	ZrO <sub>2</sub>	SO <sub>3</sub>		ZrO <sub>2</sub>	SO <sub>3</sub>		ZrO <sub>2</sub>	SO <sub>3</sub>	
	At 39.7°			At 39.7°--Cont.			At 72°		
SO	2.3	63.7	AB	8.6	9.8	D	4.15	31.9	A
	1.75	62.1	A	6.1	7.8	D	22.3	29.5	A
	0.943	61.2	A	5.9	7.6	D	2.07	35.6	AC
	0.205	57.6	A	5.7	7.5	D	3.5	26.7	C
	0.049	56.0	A	3.1	4.9	D	4.38	24.15	C
	0.047	51.2	A	2.9	4.7	D	13.0	17.2	C
	0.165	46.2	A	2.63	4.28	D	15.55	18.4	C
	0.70	39.15	A	2.2	4.0	D	20.3	20.45	C
	1.62	35.7	A	0.64	1.925	D	25.0	24.4	C
	3.12	32.0	A	0.514	1.69	D	35.5	21.2	D
	3.7	31.3	A	0.361	1.227	D	20.9	16.9	D
	8.16	26.7	A	0.264	0.85	D	1.87	1.45	D
	15.5	25.75	A	0.182	0.426	D	11.75	1.2	DE
	22.6	28.5	A	0.16	0.275	DE	15.6	7.68	E
	2.64	32.9	AC	23.4	12.3	E	21.0	10.4	E
	3.1	29.8	C	0.605	0.701	E	12.9	7.3	E
	7.33	19.8	C	0.1785	0.2785	E	8.6	4.5	E
	8.86	18.35	C	0.143	0.273	E	0.0586	0.134	FG
	15.4	19.3	C	0.045	0.130	E	0.0118	0.0574	FG
	16.02	19.35	C	0.022	0.097	E			
	17.83	19.85	C	0.021	0.079	E			
	26.4	23.6	C	0.0037	0.043	E			
	28.2	24.6	CD	0.00145	0.041	E			
	22.16	20.4	D	0.0029	0.0135	E			
	15.74	15.9	D	0.0025	0.0097	E			
	13.52	14.28	D	0.0022	0.0039	E			
	9.79	10.72	D	0.00023	0.0041	E			
	9.17	10.5	D						

A = 1:2:4 =  $\text{ZrO}_2 \cdot 2\text{SO}_3 \cdot 4\text{H}_2\text{O}$ B = 1:3:3 =  $\text{ZrO}_2 \cdot 3\text{SO}_3 \cdot 3\text{H}_2\text{O}$ C = 2:3:5 =  $2\text{ZrO}_2 \cdot 3\text{SO}_3 \cdot 5\text{H}_2\text{O}$ D = 4:3:15 =  $4\text{ZrO}_2 \cdot 3\text{SO}_3 \cdot 15\text{H}_2\text{O}$ E = 3:2:12 =  $3\text{ZrO}_2 \cdot 2\text{SO}_3 \cdot 12\text{H}_2\text{O}$ F = 2:1:9 =  $2\text{ZrO}_2 \cdot \text{SO}_3 \cdot 9\text{H}_2\text{O}$ 

G = a higher basic sulfate

SOLUBILITY OF ZIRCONIUM SULFATE IN WATER AND ZIRCONIUM OXIDE SOLUTIONS  
(Falinski, 1941)

When zirconium sulfate is dissolved in water, the saturated solution contains 44.0 wt. %  $\text{Zr}(\text{SO}_4)_2$  at 25° and 45.0% at 40°. The stable phase is  $\text{Zr}(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O}$ . When much water is added to the salt, such that the solution contains less than about 19%  $\text{Zr}(\text{SO}_4)_2$ , the basic salt  $\text{ZrO}_2 \cdot 5\text{SO}_3 \cdot 30\text{H}_2\text{O}$  precipitates. The system was studied by varying the amounts of water added, and by a large number of dialysis experiments in which the products were separated, analyzed, etc. Prolonged boiling of moderately concentrated  $\text{Zr}(\text{SO}_4)_2$  solutions precipitates  $2\text{ZrO}_2 \cdot 3\text{SO}_3 \cdot 5\text{H}_2\text{O}$ , and when there is a very large amount of water present, there is an indication of the formation of  $2\text{ZrO}_2 \cdot \text{SO}_3 \cdot 7\text{H}_2\text{O}$ . The results below are in grams per 100 gms. of saturated solution and the saturating phase is  $7\text{ZrO}_2 \cdot 5\text{SO}_3 \cdot 30\text{H}_2\text{O}$ .

30

Results at 25°				Results at 40°	
$\text{ZrO}_2$	$\text{SO}_3$	$\text{ZrO}_2$	$\text{SO}_3$	$\text{ZrO}_2$	$\text{SO}_3$
0.5	2.0 <sup>a</sup>	24	19.3	11.9	11.1
2.0	4.4 <sup>a</sup>	26.8	21.0	17.0	14.0
5.0	7.9 <sup>a</sup>	28.0	21.1	20.5	16.6
7.0	9.6 <sup>a</sup>	30.9	22.7	32.9	23.9
8.26	10.6	34.1	24.1	28.5	20.5
14.8	14.9	29.9	26.8	35.2	25.2
21.4	17.8	27.9	26.0	16.6	22.2 <sup>b</sup>

<sup>a</sup>Estimated from the author's curve.

<sup>b</sup>Solid phase  $2\text{ZrO}_2 \cdot 3\text{SO}_3 \cdot 5\text{H}_2\text{O}$ .

ZIRCONIUM THALLIUM SULFATE

SOLUBILITY OF ZIRCONIUM THALLIUM SULFATE IN AQUEOUS 20% SULFURIC ACID  
(Fernandez, 1925)

A solution of zirconium sulfate in aqueous sulfuric acid of about 20 per cent concentration was saturated with thallium sulfate at 100° and this solution cooled to several constant temperatures and the weight of  $\text{ZrO}_2$  present at each temperature determined. The following three double salts are described,  $\text{Zr}(\text{SO}_4)_2 \cdot 2\text{Tl}_2\text{SO}_4 \cdot 4\text{H}_2\text{O}$ ;  $2\text{Zr}(\text{SO}_4)_2 \cdot \text{Tl}_2\text{SO}_4 \cdot 8\text{H}_2\text{O}$  and  $2\text{Zr}(\text{SO}_4)_2 \cdot 7\text{Tl}_2\text{SO}_4$ . The particulier one in contact with each saturated solution is not designated.

t°	Gms. $\text{ZrO}_2$ per 100 cc. $\text{H}_2\text{O}$	t°	Gms. $\text{ZrO}_2$ per 100 cc. $\text{H}_2\text{O}$	t°	Gms. $\text{ZrO}_2$ per 100 cc. $\text{H}_2\text{O}$
0	0.62	40	0.85	80	2.45
10	0.62	50	1.15	90	2.88
20	0.65	60	1.57	100	3.20
30	0.72	70	2.02		

Data for the distribution of zirconium and hafnium sulfates between water and ether containing added ammonium sulfate and thiocyanic acid is given by Fischer and Chalybaeus, 1947.



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Abbreviations used in the index.

alc.	— alcohol	diatr.	— distribution data
aq.	— aqueous	f.p.	— freezing points
corr.	— correction	liq.-vap.	— liquid-vapor
C.S.T.	— critical solution temperature	soln.	— solution
		solv.	— solubility

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$Co$ ammine salts .....	I 823-33	$Co$ diamine salts in $H_2O, CH_3OH$ .....	I 820
$Co$ anthracene sulfonates in $H_2O$ .....	I 794	$Co$ diamine salts in $H_2O, CH_3OH$ .....	I 833
$Co$ anthracene sulfonates in aq. acetic acid .....	I 793	$Co$ dimethylglycine chloride in $H_2O$ .....	I 819
$Co$ benzene sulfonates in $H_2O$ .....	I 794	$Co$ dodecyl tetrahydro phthalate in benzene .....	I 795
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$Co_3Bi_2(NO_3)_{12} \cdot 24H_2O$ in conc. $HNO_3$ .....	I 434	in $H_2O$ , aq. $HF$ .....	I 820
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+ KF + H <sub>2</sub> O	1821	<b>Co rebenzoate</b> in H <sub>2</sub> O, NH <sub>3</sub>	1792
+ NH <sub>4</sub> F + H <sub>2</sub> O	1821	<b>CoS</b> + Bi <sub>2</sub> S <sub>3</sub>	1790
<b>CoF<sub>3</sub></b> in anhyd. HF	1821	+ Co	1790, 841
<b>Co<sub>2</sub>Fe(CN)<sub>6</sub></b> in H <sub>2</sub> O, aq. solns.	1795, 6	+ Co + FeS	1790
<b>3Co<sub>2</sub>Fe(CN)<sub>6</sub>·Co<sub>4</sub>Fe(CN)<sub>6</sub></b>	1796	+ FeO	1842
<b>3Co<sub>2</sub>Fe(CN)<sub>6</sub>·Li<sub>4</sub>Fe(CN)<sub>6</sub></b>	1796	+ FeS	1842
<b>3Co<sub>2</sub>Fe(CN)<sub>6</sub>·Na<sub>4</sub>Fe(CN)<sub>6</sub></b>	1796	in H <sub>2</sub> O, aq. acid	1842
<b>Co flove salts</b> in CH <sub>3</sub> OH	1832	+ NiS	1842
in H <sub>2</sub> O	1829-32	+ NiS + FeS	II 1219
<b>Co formate</b> in H <sub>2</sub> O	1792	+ Sb <sub>2</sub> S <sub>3</sub>	1790
<b>Co<sub>2</sub>Gd(CN)<sub>6</sub>·4H<sub>2</sub>O</b> in aq. HCl	11069	<b>Co<sub>2</sub>S<sub>3</sub></b> + FeS	1842
<b>Co citrate</b> in H <sub>2</sub> O	1793	<b>Co<sub>2</sub>S<sub>3</sub></b> + FeS	1842
<b>Co helianthate</b> in H <sub>2</sub> O	1796	<b>Co(SCN)<sub>2</sub></b> distr. betwn. aq. NH <sub>2</sub> SCN + butylacetate	1797
<b>Co hexacyanides</b> in CH <sub>3</sub> OH, C <sub>2</sub> H <sub>5</sub> OH	1833, 4	extrn. by org. solvents	1796
<b>Co hexamine salts</b> in H <sub>2</sub> O, aq. solns. [Co(NH <sub>3</sub> ) <sub>6</sub> ]X	1824, 5	in H <sub>2</sub> O	1796
<b>Co hexa antipyrine ClO<sub>4</sub></b> in H <sub>2</sub> O	1820	+ KSCN + H <sub>2</sub> O	1796
<b>Co hexa antipyrine ilcoborate</b> in H <sub>2</sub> O	1822	+ methyl thiocyanate	1796
<b>Co hexathiocyanate-pyrimidones</b> in H <sub>2</sub> O	1860	+ Ni(SCN) <sub>2</sub> + H <sub>2</sub> O	II 1206
<b>Co(H<sub>2</sub>SCN)<sub>4</sub></b> + Cd(H <sub>2</sub> SCN) <sub>4</sub>	1708	+ Ni(SCN) <sub>2</sub> + H <sub>2</sub> O	1796
<b>Co(H<sub>2</sub>SCN)<sub>4</sub></b> + Cd(H <sub>2</sub> SCN) <sub>4</sub>	1708	in liq. SO <sub>2</sub>	1797
<b>Co(H<sub>2</sub>SCN)<sub>4</sub></b> in aq. NH <sub>4</sub> Cl	1797	<b>Co(SH)<sub>2</sub></b> in H <sub>2</sub> O	1842
<b>Co(H<sub>2</sub>SCN)<sub>4</sub></b> + AnHg(CNS) <sub>4</sub>	1797	<b>CoSO<sub>4</sub></b> in CH <sub>3</sub> OH, C <sub>2</sub> H <sub>5</sub> OH	1856
<b>Co-δ-hydroxy quonellones</b> in H <sub>2</sub> O, CHCl <sub>3</sub>	1795	+ CdSO <sub>4</sub> + H <sub>2</sub> O	I 751, 2
<b>Co<sub>2</sub></b> in H <sub>2</sub> O	1822	+ CoCl <sub>2</sub>	1818
in liq. SO <sub>2</sub>	1822	+ CoCl <sub>2</sub> + H <sub>2</sub> O	1801
<b>Co(IO<sub>3</sub>)<sub>2</sub></b> in H <sub>2</sub> O	1822	+ CoO + H <sub>2</sub> O	I 646, 7
in aq. NaCl, NaIO <sub>3</sub> , CoSO <sub>4</sub>	1823	+ CuSO <sub>4</sub> + H <sub>2</sub> O	1847
<b>CoK citrate</b> in H <sub>2</sub> O	1793	distr. betwn. butanol + aq. solns.	1855
<b>CoK<sub>2</sub>(CO<sub>3</sub>)<sub>2</sub>·4H<sub>2</sub>O</b> in aq. K <sub>2</sub> CO <sub>3</sub> and KHCO <sub>3</sub>	1796	+ FeSO <sub>4</sub> + H <sub>2</sub> O	1847
<b>CoK malonate</b> in H <sub>2</sub> O	1793	in glycol	1856
<b>CoK<sub>2</sub>(SO<sub>4</sub>)<sub>2</sub></b> in H <sub>2</sub> O	1848	in H <sub>2</sub> O	1843
+ CuK <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> + H <sub>2</sub> O	I 848, 849, 979	in aq. H <sub>2</sub> SO <sub>4</sub>	I 844-6
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<b>Co maleate</b> in H <sub>2</sub> O	1792	+ KCl	1856
<b>Co malonate</b> in H <sub>2</sub> O	1793	+ 2KCl = CoCl <sub>2</sub> + K <sub>2</sub> SO <sub>4</sub>	I 805, 856
<b>Co methanate</b> in H <sub>2</sub> O	1792	+ 2KCl = CoCl <sub>2</sub> + K <sub>2</sub> SO <sub>4</sub> (+ H <sub>2</sub> O)	I 801
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[Co(NH <sub>3</sub> ) <sub>6</sub> ] in Cl <sub>2</sub> in aq. solns.	I 1296	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	I 847, 8
<b>CoNH<sub>4</sub> malonate</b> in H <sub>2</sub> O	1793	+ 2LiCl = CoCl <sub>2</sub> + Li <sub>2</sub> SO <sub>4</sub>	I 818
<b>Co(NH<sub>4</sub>)<sub>2</sub>(SO<sub>4</sub>)<sub>2</sub></b> + Cu(NH <sub>4</sub> ) <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> + H <sub>2</sub> O	I 65, 983, 4	+ Li <sub>2</sub> SO <sub>4</sub>	1856
+ Fe(NH <sub>4</sub> ) <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> + H <sub>2</sub> O	1852	<b>Co(SO<sub>4</sub>)<sub>2</sub></b> + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	I 850
in H <sub>2</sub> O	1850	<b>CoSO<sub>4</sub></b> + Na <sub>2</sub> SO <sub>4</sub>	II 1149
+ Ni(NH <sub>4</sub> ) <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> + H <sub>2</sub> O	1851	+ Na <sub>2</sub> SO <sub>4</sub>	1856
<b>Co(NO<sub>2</sub>)<sub>2</sub></b> in H <sub>2</sub> O	1835	+ Na <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	I 852, 3
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+ t-butanol + H <sub>2</sub> O	1839	+ RbCl	1856
+ Cu(NO <sub>3</sub> ) <sub>2</sub> + H <sub>2</sub> O	I 836, 7	+ Rb <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	1855
distr. betwn. butyl acetate + aq. solns.	1840	+ Tl <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	1856
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dist. betwn. toluene + $H_2O$ .....	I 1222, 3	in various alcohols.....	I 1237
in $D_2O$ .....	I 1206	in mixts. of alcohols.....	I 1237
in ethyl acetate.....	I 1223, 4	in aniline, pyridine, quinoline.....	I 1240
in ethylene diamine, aq. lonic acid, anhyd. lanolin.....	I 1228	in aq. $BaI_2, CaI_2, NaI, SrI_2$ .....	I 363
in ethyl ether.....	I 1218, 20	$+ BaI_2 + H_2O$ .....	I 363
in aq. ethyl ether.....	I 1219, 20	$2HgI_2 + 3B(OH)_3$ in $CCl_4, CHCl_3, benzene, toluene$ .....	I 409
in aq. glycerol, sucrose, urethan.....	I 1225	in $H_2SO_4$ .....	I 409
in aq. $HCl$ .....	I 1206	$HgI_2$ in aq. $CH_3OH$ .....	I 1238
in $H_2O$ .....	I 1205, 6	in aq. $C_2H_5OH$ .....	I 1237, 8
in halogenated hydrocarbons.....	I 1227, 8	$+ CaI_2$ in $H_2O$ .....	I 605
$+ HgBr_2$ .....	I 1189	in carbon disulfide.....	I 1241
$+ HgBr_2 + C_2H_5OH$ .....	I 1185	$+ CdCl_2$ .....	I 728
$+ HgBr_2 + Hal_2$ .....	I 1189	$+ CdI_2$ .....	I 741
$+ HgCl_2 (CH_3)_4NCl + aq. ether (+ alc.)$ .....	I 1220	$+ CdI_2 + H_2O$ .....	I 733
$+ Hal_2$ .....	I 1229	$+ CdI_2 + PbI_2$ .....	I 741
$+ HgI_2 + H_2O$ .....	I 1207	$+ CaI + H_2O$ .....	I 894
in aq. $Hg(NO_3)_2$ .....	I 1206	dist. betwn. aq. $KI + benzene, CS_2, CCl_4$ .....	I 1236
$+ 2HgO$ in aq. $HCl$ .....	I 1229	extr'n. with ether.....	I 1239
$+ HgO + H_2O$ .....	I 1207	in $H_2O$ .....	I 1232
$+ Hg_2SO_4$ .....	I 1229	$+ KI + ethyl ether$ .....	I 233
in anhyd. hydrazine, $SO_2, SeOCl_2$ .....	I 1228	$+ KI + ethyl ether$ .....	I 1235, 6
$+ KCN + H_2O$ .....	I 1207	$Hg_2I_2$ in $H_2O$ , aq. $KI$ .....	I 1231, 2
$+ KCl$ .....	I 1229	$HgI_2 + HgBr_2$ .....	I 1189
$+ KCl + acetone$ .....	I 1223	$+ HgBr_2$ in acetone, $C_2H_5OH$ .....	I 1189
$+ KCl + C_2H_5OH$ .....	I 1215, 8	$+ HgBr_2 + HgCl_2$ .....	I 1189
$+ KCl + H_2O$ .....	II 132	$+ HgCl_2$ .....	I 1229
$+ KCl + H_2O$ .....	I 1208, 9	$+ HgCl_2 + H_2O$ .....	I 1207
$+ KCl + NH_4Cl + H_2O$ .....	I 1209	in aq. $Hg(NO_3)_2$ .....	I 1233
$+ LiCl$ .....	I 1229	$+ H_2SO_4$ .....	I 1243
in aq. $LiCl + AlCl_3$ .....	I 1213	$+ I_2$ .....	I 1243, 1287
in aq. $LiCl + CaCl_2$ .....	I 1213	$+ KI$ .....	I 1243
$+ LiCl + H_2O$ .....	I 1211	$+ KI + acetone$ .....	I 1235
in methyl acetate.....	I 1224	$+ KI + H_2O$ .....	I 1233, 4
$+ MgCl_2 + H_2O$ .....	I 1211	$+ MgI_2 + 7H_2O$ .....	II 505
$+ NH_4Cl$ .....	I 1229	in methylal.....	I 1242
$+ NH_4Cl + H_2O$ .....	II 682	$+ NH_4I$ .....	I 1243
$+ NaCl$ .....	I 1210	$+ 2NH_4I + H_2O$ in $H_2O$ .....	I 1243
$+ NaCl + acetone$ .....	I 1229	$+ NaI$ .....	I 1243
$+ NaCl + C_2H_5OH$ .....	I 1224	in nitro benzene, nitrotoluene.....	I 1241
	I 1216	in oils.....	I 1242

In various org. solvents (except alcohols) .....	I 1238-42
+ RbI + H <sub>2</sub> O .....	I 1236
In anhyd. SO <sub>2</sub> , hydrazine .....	I 1242
+ TiMO <sub>3</sub> .....	I 1243
+ Ti <sub>2</sub> SO <sub>3</sub> .....	I 1243
Hg <sub>2</sub> (IO <sub>3</sub> ) <sub>2</sub> in H <sub>2</sub> O .....	I 1243
Hg methyl Cl in H <sub>2</sub> O .....	I 1230
Hg methyl I in H <sub>2</sub> O .....	I 1243
HgNH <sub>2</sub> Cl in aq. NH <sub>3</sub> .....	I 1229
Hg(NH <sub>2</sub> ) <sub>2</sub> Cl <sub>2</sub> (?) in aq. NH <sub>3</sub> .....	I 1229
Hg(NH <sub>2</sub> ) <sub>2</sub> in aq. NH <sub>3</sub> .....	I 1243
Hg <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> + HNO <sub>3</sub> + H <sub>2</sub> O .....	I 1243, 4
in hydrazine .....	I 1244
Hg(HO <sub>2</sub> ) <sub>2</sub> in ether, lamolin .....	I 1244
Hg <sub>2</sub> O + HNO <sub>3</sub> + H <sub>2</sub> O .....	I 1243, 4
H <sub>2</sub> O in aq. acetic acid + Na acetate .....	I 1247
+ As <sub>2</sub> O <sub>3</sub> + H <sub>2</sub> O .....	I 1180
+ As <sub>2</sub> O <sub>3</sub> + H <sub>2</sub> O .....	I 1180
In aq. HCl .....	I 1246
In aq. HF .....	I 1247
In aq. HNO <sub>3</sub> .....	I 1245, 6
In H <sub>2</sub> O .....	I 1245
Hg(CN) <sub>2</sub> in aq. solns. ....	I 1201
+ H <sub>2</sub> O <sub>2</sub> + H <sub>2</sub> O .....	I 1207
2HgO · Hg <sub>2</sub> Cl <sub>2</sub> in aq. HCl .....	I 1229
H <sub>2</sub> O + HgSO <sub>4</sub> + H <sub>2</sub> O .....	I 1252
2HgO · Hg <sub>2</sub> SO <sub>4</sub> in aq. H <sub>2</sub> SO <sub>4</sub> .....	I 1253
in aq. HCl .....	I 1252
H <sub>2</sub> O in aq. KCl, LiCl, NaCl .....	I 1248
In aq. KOH, LiOH .....	I 1248
In aq. NaOH .....	I 1247, 8
In aq. NaOH + salts .....	I 1248
+ SO <sub>2</sub> + H <sub>2</sub> O .....	I 1252
in sea water .....	I 1249
HgOH in H <sub>2</sub> O .....	I 1245
Hg(OH) <sub>2</sub> in H <sub>2</sub> O .....	I 1245
Hg(OH)BrO <sub>2</sub> in aq. HClO <sub>4</sub> , HNO <sub>3</sub> .....	I 1190
Hg [I] oxalate in H <sub>2</sub> O .....	I 1203
Hg [II] oxalate in H <sub>2</sub> O .....	I 1203
+ K oxalate + H <sub>2</sub> O .....	I 1203
Hg[II]PO <sub>3</sub> in H <sub>2</sub> O .....	I 1249
Hg [II] gluconate in aq. solvents .....	I 1195
Hg phenyl acetate in H <sub>2</sub> O .....	I 1193
Hg phenyl Cl in H <sub>2</sub> O .....	I 1230
Hg phenyl NO <sub>2</sub> in H <sub>2</sub> O .....	I 1244
Hg phenyl NO <sub>2</sub> in aq. NaOH .....	I 1249
Hg <sub>2</sub> PO <sub>3</sub> in H <sub>2</sub> O .....	I 1231
Hg <sub>2</sub> S in H <sub>2</sub> O .....	I 1249
In H <sub>2</sub> O, aq. HClO <sub>4</sub> .....	I 1249
In aq. Na <sub>2</sub> SO <sub>3</sub> .....	I 1250
Hg <sub>2</sub> (SCN) <sub>2</sub> in H <sub>2</sub> O .....	I 1202
Hg(SCN) <sub>2</sub> extr'n. w. ether .....	I 1202
Hg(SCN) <sub>2</sub> in H <sub>2</sub> O .....	I 1202
+ KSCN + H <sub>2</sub> O .....	I 1202
In liq. SO <sub>2</sub> .....	I 1202
Hg <sub>2</sub> SO <sub>3</sub> in H <sub>2</sub> O .....	I 1202
Hg <sub>2</sub> SO <sub>4</sub> in aq. H <sub>2</sub> SO <sub>4</sub> .....	I 1250, 1
+ Hg <sub>2</sub> .....	I 1229
In aq. KI .....	I 1251, 2
In liq. SO <sub>2</sub> .....	I 1252
Hg <sub>2</sub> SO <sub>4</sub> + HgBr <sub>2</sub> .....	I 1189
+ Hg <sub>2</sub> .....	I 1243
+ HgO + H <sub>2</sub> O .....	I 1252
· 2HgO in aq. HgO .....	I 1252
· 2HgO in aq. H <sub>2</sub> O .....	I 1253
Hg <sub>2</sub> SeO <sub>3</sub> in H <sub>2</sub> O .....	I 1253
Hg <sub>2</sub> SeO <sub>3</sub> in aq. Na <sub>2</sub> SeO <sub>3</sub> .....	I 1253
Hg [III] stearate in org. solvents .....	I 1195
Hg [II] tartrate in H <sub>2</sub> O .....	I 1193
Hg [II] trifluoroacetate in H <sub>2</sub> O, benzene .....	I 1193
Hg [III] trifluoroacetate in trifluoroacetic acid .....	I 1193
HgVO <sub>3</sub> in H <sub>2</sub> O .....	I 1253
Hg(YO <sub>3</sub> ) <sub>2</sub> .....	I 1253
Hg xylol NO <sub>2</sub> in H <sub>2</sub> O .....	I 1244
HgZn(CNS) <sub>4</sub> + HgCo(CNS) <sub>4</sub> .....	I 797
HgZn(CNS) <sub>4</sub> in aq. NH <sub>4</sub> Cl .....	I 1202, 3
Hg <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O .....	I 1253
lactic acid-Ca acetate-H <sub>2</sub> O .....	I 509
Hydrazine compounds, see N <sub>2</sub> H <sub>4</sub> .....	
Hydrobaricite in H <sub>2</sub> O (+ gypsum) .....	I 502
Hydroxyapatite in H <sub>2</sub> O .....	I 653
Hydroxy benzoate + NH <sub>3</sub> .....	II 603

I <sub>2</sub> .....	II 1372
in aq. acetic acid .....	I 1278
+ AgI + benzene .....	I 1100
+ As <sub>2</sub> .....	I 229, 1287
In AsCl <sub>3</sub> .....	I 1286
+ AsI <sub>3</sub> .....	I 1231
In aq. BaI <sub>2</sub> , CaI <sub>2</sub> .....	I 1257
+ BaI <sub>2</sub> + H <sub>2</sub> O .....	I 362
+ benzoic acid .....	I 1278
+ benzoic anhydride .....	I 1278
+ Bi .....	I 426
+ Br <sub>2</sub> .....	I 450
+ Br <sub>2</sub> + Cl <sub>2</sub> .....	I 451
+ Br <sub>2</sub> + S .....	II 1403
In C <sub>2</sub> H <sub>5</sub> OH .....	I 1266
In aq. C <sub>2</sub> H <sub>5</sub> OH .....	I 1254, 5
+ CO <sub>2</sub> (PV) .....	I 494
In liq. CO <sub>2</sub> .....	I 1286
+ CaI <sub>2</sub> .....	I 605, 1287
(liquid) + carbon tetrachloride .....	I 1275
+ Cd(NH <sub>3</sub> ) <sub>4</sub> I <sub>2</sub> .....	I 741
+ Cl <sub>2</sub> .....	I 787
+ CaBr + benzene .....	I 874
+ CaBr + toluene .....	I 874
+ CaI .....	I 896
+ CaI + benzene .....	I 894
+ CaI + H <sub>2</sub> O .....	I 890-4
+ CaI + toluene .....	I 895
+ Cu + benzene .....	I 953
+ CuI + H <sub>2</sub> O .....	I 953
+ p-dibromobenzene .....	I 1278
+ p-dinitrobenzene .....	I 1278
distr. betwn. amyl alc. + H <sub>2</sub> O (+ KI) .....	I 1266, 7
distr. betwn. benzene + H <sub>2</sub> O ethylene bromide +	
H <sub>2</sub> O bromoform + H <sub>2</sub> O trichloroethylene + H <sub>2</sub> O .....	I 1272
distr. betwn. CCl <sub>4</sub> + H <sub>2</sub> O .....	I 1268, 9
distr. betwn. CCl <sub>4</sub> + aq. salt solns .....	I 1269
distr. betwn. chloroform + aq. glyoxal .....	I 1284
distr. betwn. chloroform + H <sub>2</sub> O tetrachloroethylene	
+ H <sub>2</sub> O tetrachloroethane + H <sub>2</sub> O pentachloroethane .....	I 1273
+ H <sub>2</sub> O .....	I 1273
distr. betwn. chloroform + aq. starch .....	I 1271
distr. betwn. CS <sub>2</sub> + aq. C <sub>2</sub> H <sub>5</sub> OH .....	I 1271
distr. betwn. CS <sub>2</sub> + H <sub>2</sub> O .....	I 1269, 70
distr. betwn. CS <sub>2</sub> + CCl <sub>4</sub> and H <sub>2</sub> O .....	I 1271
distr. betwn. CS <sub>2</sub> + aq. salt solns .....	I 1270
distr. betwn. CS <sub>2</sub> + KI + mixed solvents conig. CS <sub>3</sub> .....	I 1270
distr. betwn. immisc. org. liquids .....	I 1283, 4
distr. in KBr + KI + H <sub>2</sub> O .....	II 218
distr. in KCl + KI + H <sub>2</sub> O .....	II 218
distr. betwn. nitrobenzene + H <sub>2</sub> O .....	I 1271
distr. betwn. nitrobenzene + aq. iodide solns .....	I 1271, 2
distr. betwn. toluene + H <sub>2</sub> O .....	I 1274
+ ethyl ether + H <sub>2</sub> O .....	I 1273
In ether + H <sub>2</sub> O mixts .....	I 1279
+ FeI <sub>2</sub> in benzene, toluene .....	I 1034
+ Ga .....	I 1065
in gases and vapors .....	I 1288
In aq. glycerol .....	I 1268
In various aq. glycol solns .....	I 1267
In aq. HBr .....	I 1255
In aq. HCl .....	I 1255
In aq. HI .....	I 1254, 5
In aq. HNO <sub>3</sub> , H <sub>2</sub> SO <sub>4</sub> , HClO <sub>4</sub> .....	I 1256
In H <sub>2</sub> O .....	I 1254
+ HgBr <sub>2</sub> + naphthalene .....	I 1189
+ HgI <sub>2</sub> .....	I 1243, 1287
+ ICl .....	I 1290
+ In .....	I 1287
+ Iodoform .....	I 1278
In aq. KBr, NaBr, H <sub>3</sub> BO <sub>3</sub> .....	I 1264
In aq. KBr, NaBr, SrCl <sub>2</sub> , LiCl, HgCl <sub>2</sub> , NaH <sub>2</sub> PO <sub>4</sub> .....	I 1263
In aq. KCl, MgCl, BaCl <sub>2</sub> .....	I 1261, 2
+ KI .....	I 1287
+ KI + H <sub>2</sub> O .....	I 1257-60
+ KI + H <sub>2</sub> O .....	II 219, 20
In aq. KI + KNO <sub>3</sub> , KI + KCl .....	I 1260
+ KNO <sub>3</sub> + N <sub>2</sub> O <sub>3</sub> .....	II 262
+ KSCN + benzene .....	II 80
+ KSCN + toluene .....	II 80
In aq. LiCl, CaCl <sub>2</sub> , Ba(NO <sub>3</sub> ) <sub>2</sub> , MgSO <sub>4</sub> , KNO <sub>3</sub> , Ca(NO <sub>3</sub> ) <sub>2</sub> .....	I 1264

+ LiI .....	I 1289	in $H_2O$ .....	I 1292
in aq. $LiNO_3, K_2SO_4, Li_2SO_4, Mg(NO_3)_2 \cdot 6H_2O$ .....	I 1263	+ $I_2$ .....	I 1287
in aq. $NH_4Br, NH_4Cl, NH_4NO_3, NH_4$ acetate, $(NH_4)_2SO_4, (NH_4)_2C_2O_4$ .....	I 1264	+ $In_2S_3$ .....	I 1292
+ $NH_4I$ .....	II 701	<b>InBr<sub>3</sub></b> + $BaBr_2 + H_2O$ .....	I 1293
+ $NH_4I$ + benzene .....	II 700	+ $CaBr_2 + H_2O$ .....	I 504, 1293
+ $NH_4I + C_6H_5CH_3$ .....	II 700	in aq. $HBr$ .....	I 1293
+ $NH_4I + H_2O$ .....	II 698, 9	in $H_2O$ .....	I 1292
in aq. $NaCl, NaNO_3, Na_2SO_4$ .....	I 1262	+ $LiBr + H_2O$ .....	I 1293
in aq. $NaI$ .....	I 1260, 1	+ $MgBr_2 + H_2O$ .....	I 1293
+ $NaI + H_2O$ .....	II 1047, 8	in organic solvents .....	I 1294
in aq. $NaI$ + other salts .....	I 1261	+ $SrBr_2 + H_2O$ .....	I 1293
+ naphthalene .....	I 1278	+ $TlBr + H_2O$ .....	I 1293
+ $Ni(NH_3)_6I_2$ .....	I 1287	+ $ZnBr_2 + H_2O$ .....	I 1293
in various organic solvents .....	I 1274-78	<b>InCl<sub>3</sub></b> + $AgCl$ .....	I 76, 1296
in mixtures of organic solvents .....	I 1279-83	+ $BaCl_2 + H_2O$ .....	I 1296
+ $PBr_3$ .....	I 1286	+ $CaCl_2 + H_2O$ .....	I 574, 1295, 6
+ $PBr_3$ .....	I 1287	+ $CdCl_2$ .....	I 128, 1296
+ $PCl_3$ .....	I 1287	in aq. $HCl$ .....	I 1295
+ $PCl_3$ .....	I 1287	in $H_2O$ .....	I 1294, 5
+ $P_2I_4$ .....	I 1286	+ $K_4Fe(CN)_6 + H_2O$ .....	I 1296
phenyltrimethyl ammonium iodide f.p. .....	II 704	+ $LiCl + H_2O$ .....	I 1295, 6
in aq. n-propanol .....	I 1266	+ $Li_4Fe(CN)_6 + H_2O$ .....	I 1296
+ pyridine + $H_2O$ .....	II 1278	+ $MgCl_2 + H_2O$ .....	I 1295
+ $HBr + benzene$ .....	II 1356	+ $NaCl$ .....	I 1296
+ $RbI$ .....	II 1372	+ $Na_4Fe(CN)_6 + H_2O$ .....	I 1296
+ $RbI + benzene$ .....	II 1374	in organic solvents .....	I 1296
+ $RbI + toluene$ .....	II 1374	+ $PbCl_2$ .....	I 1296
+ $S$ .....	I 1287	+ $SrCl_2 + H_2O$ .....	I 1295
+ $S + benzene, C_6H_6, CCl_4$ , bromoform .....	I 1285	+ $TlCl + H_2O$ .....	I 1296
in aq. salt solns. (except iodides) .....	I 1261-4	+ $ZnCl_2$ .....	I 1296
+ $Sb$ .....	I 1287	+ $ZnCl_2 + H_2O$ .....	I 1296
+ $Sb$ .....	II 1422	<b>Ie</b> $(Co(NH_3)_6)Cl_4$ in aq. solns. .....	I 1296
+ $Sb + As$ .....	II 1422	<b>Ie</b> $(SO_4)_2$ in $H_2O$ .....	I 902
+ $SbCl_3$ .....	I 1286	<b>InF<sub>3</sub></b> in $H_2O$ .....	I 1297
+ $SbCl_3$ .....	I 1286	in organic solvents .....	I 1297
+ $SbCl_5$ .....	II 1438	<b>Ie<sub>3</sub>(Fe(CN)<sub>6</sub>)<sub>4</sub></b> in $H_2O$ .....	I 1294
+ $Se$ .....	I 1287	in $\delta$ -hydroxy sebacate in $H_2O, CHCl_3$ .....	I 1284
+ $Se + C_6H_6$ .....	I 1285	<b>Ial<sub>3</sub></b> + $BaI_2 + H_2O$ .....	I 1296
in $SiCl_4, TiCl_4$ .....	I 1285	+ $CaI_2 + H_2O$ .....	I 604, 1298
+ $Sn$ .....	I 1287	in aq. $HI$ .....	I 1298
+ $Te$ .....	I 1287	in $H_2O$ .....	I 1297
+ $Te$ .....	II 1528	+ $LiI + H_2O$ .....	I 1298
+ tetramethyl ammonium iodide f.p. .....	II 701	+ $MgI_2 + H_2O$ .....	I 1298
+ tetramethyl ammonium iodide .....	I 1278	in organic solvents .....	I 1299
+ $Tl$ .....	I 1287	+ $SrI_2 + H_2O$ .....	I 1298
+ $TlCl$ .....	II 1578	+ $TlI + H_2O$ .....	I 1298
+ $TlCl + toluene$ .....	II 1581	+ $ZnI_2 + H_2O$ .....	I 1298
+ $TlI + benzene$ .....	II 1581	<b>In(O<sub>2</sub>)<sub>2</sub></b> in aq. $HNO_3$ .....	I 1299
+ toluene + tetramethyl ammonium iodide .....	I 1283	<b>3InO<sub>5</sub>·10H<sub>2</sub>O</b> in aq. soln. .....	I 1299
+ trimethyl phenyl ammonium iodide .....	I 1278	<b>3InO<sub>5</sub>·In(OH)<sub>3</sub></b> in aq. soln. .....	I 1299
+ $Zn(NH_4)_2I_2$ .....	II 1668	<b>4InO<sub>5</sub>·In(OH)<sub>3</sub>·5H<sub>2</sub>O</b> in aq. soln. .....	I 1299
<b>IBr</b> + $AlBr_3$ .....	I 162	<b>InK<sub>2</sub>Cl<sub>6</sub></b> in $H_2O$ .....	I 1303
+ $KBr$ .....	I 1288	<b>InK<sub>2</sub>·4H<sub>2</sub>O</b> .....	I 1300
+ $KBr + nitrobenzene$ .....	I 1288	<b>InLi<sub>3</sub>·LiOH·9H<sub>2</sub>O</b> .....	I 1300
+ $KI$ .....	I 1288	<b>InLi<sub>3</sub>·LiOH·2LiCl</b> .....	I 1300
+ $PBr_3$ .....	I 1288	<b>InLi<sub>3</sub>·4LiOH·LiCl·10H<sub>2</sub>O</b> .....	I 1300
+ $PBr_3$ .....	I 1288	<b>In<sub>2</sub>(NH<sub>4</sub>)<sub>2</sub>(SO<sub>4</sub>)<sub>4</sub>·24H<sub>2</sub>O</b> in $H_2O$ .....	I 1301
<b>ICN</b> distr. betwn. $CCl_4 + H_2O$ .....	I 1288	<b>InH<sub>2</sub>F<sub>6</sub></b> in $H_2O$ .....	I 1297
in $H_2O$ .....	I 1288	<b>InH<sub>2</sub> hydrides</b> in aq. soln. .....	I 1300
<b>ICl</b> + acetamide .....	I 1290	<b>In(OH)<sub>3</sub></b> in $H_2O$ .....	I 1300
+ acetic acid .....	I 1289	<b>In(OH)<sub>3</sub>·3InO<sub>5</sub></b> in aq. soln. .....	I 1299
+ $AlBr_3$ .....	I 1290	<b>In(OH)<sub>3</sub>·4InO<sub>5</sub>·5H<sub>2</sub>O</b> in aq. soln. .....	I 1299
+ $AlCl_3$ .....	I 176, 177, 1290	in extn. in $H_2O$ , chloroform .....	I 1294
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K diisobutyrate in H <sub>2</sub> O	II 59	2KF + Li <sub>2</sub> CO <sub>3</sub> = 2LiF + K <sub>2</sub> CO <sub>3</sub>	II 101	K diisobutyrate in H <sub>2</sub> O	II 59	KF + LiCl	II 212	K dipicrylamine in H <sub>2</sub> O	II 59	+ LiF	II 211	KDy EDTA in H <sub>2</sub> O	11003	+ LiI	II 417	KEr EDTA in H <sub>2</sub> O	11003	+ LiI	II 212	KF + acetone + H <sub>2</sub> O	II 208	2KF + Li <sub>2</sub> SiO <sub>3</sub> = 2LiF + K <sub>2</sub> SiO <sub>3</sub>	II 211	+ AlF <sub>3</sub>	1186	KF + Li <sub>2</sub> TiO <sub>3</sub>	II 440	+ AlF <sub>3</sub> + H <sub>2</sub> O	1182	+ methyl ethyl ketone + H <sub>2</sub> O	II 208	+ allyl alc. + H <sub>2</sub> O	II 207	+ NaF	II 211	+ BaCl <sub>2</sub>	1353	+ NaF <sub>2</sub> + NaF	II 211	+ BaCl <sub>2</sub> + CaCl <sub>2</sub> + NaF	1353	+ NaF <sub>2</sub> + RbF	II 211	+ BaF <sub>2</sub>	1360	+ NaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ BaTiO <sub>3</sub>	1400	+ MoO <sub>3</sub>	II 211	+ BeF <sub>2</sub>	II 211	+ NH <sub>4</sub> F + H <sub>2</sub> O	II 204	+ BeF <sub>2</sub> + H <sub>2</sub> O	1406	+ Na = K + NaF	II 2	+ BeF <sub>2</sub> in H <sub>2</sub> O	1408	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = 2NaF + K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211		
K diisobutyrate in H <sub>2</sub> O	II 59	KF + LiCl	II 212	K dipicrylamine in H <sub>2</sub> O	II 59	+ LiF	II 211	KDy EDTA in H <sub>2</sub> O	11003	+ LiI	II 417	KEr EDTA in H <sub>2</sub> O	11003	+ LiI	II 212	KF + acetone + H <sub>2</sub> O	II 208	2KF + Li <sub>2</sub> SiO <sub>3</sub> = 2LiF + K <sub>2</sub> SiO <sub>3</sub>	II 211	+ AlF <sub>3</sub>	1186	KF + Li <sub>2</sub> TiO <sub>3</sub>	II 440	+ AlF <sub>3</sub> + H <sub>2</sub> O	1182	+ methyl ethyl ketone + H <sub>2</sub> O	II 208	+ allyl alc. + H <sub>2</sub> O	II 207	+ NaF	II 211	+ BaCl <sub>2</sub>	1353	+ NaF <sub>2</sub> + NaF	II 211	+ BaCl <sub>2</sub> + CaCl <sub>2</sub> + NaF	1353	+ NaF <sub>2</sub> + RbF	II 211	+ BaF <sub>2</sub>	1360	+ NaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ BaTiO <sub>3</sub>	1400	+ MoO <sub>3</sub>	II 211	+ BeF <sub>2</sub>	II 211	+ NH <sub>4</sub> F + H <sub>2</sub> O	II 204	+ BeF <sub>2</sub> + H <sub>2</sub> O	1406	+ Na = K + NaF	II 2	+ BeF <sub>2</sub> in H <sub>2</sub> O	1408	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = 2NaF + K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211						
K dipicrylamine in H <sub>2</sub> O	II 59	+ LiF	II 211	KDy EDTA in H <sub>2</sub> O	11003	+ LiI	II 417	KEr EDTA in H <sub>2</sub> O	11003	+ LiI	II 212	KF + acetone + H <sub>2</sub> O	II 208	2KF + Li <sub>2</sub> SiO <sub>3</sub> = 2LiF + K <sub>2</sub> SiO <sub>3</sub>	II 211	+ AlF <sub>3</sub>	1186	KF + Li <sub>2</sub> TiO <sub>3</sub>	II 440	+ AlF <sub>3</sub> + H <sub>2</sub> O	1182	+ methyl ethyl ketone + H <sub>2</sub> O	II 208	+ allyl alc. + H <sub>2</sub> O	II 207	+ NaF	II 211	+ BaCl <sub>2</sub>	1353	+ NaF <sub>2</sub> + NaF	II 211	+ BaCl <sub>2</sub> + CaCl <sub>2</sub> + NaF	1353	+ NaF <sub>2</sub> + RbF	II 211	+ BaF <sub>2</sub>	1360	+ NaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ BaTiO <sub>3</sub>	1400	+ MoO <sub>3</sub>	II 211	+ BeF <sub>2</sub>	II 211	+ NH <sub>4</sub> F + H <sub>2</sub> O	II 204	+ BeF <sub>2</sub> + H <sub>2</sub> O	1406	+ Na = K + NaF	II 2	+ BeF <sub>2</sub> in H <sub>2</sub> O	1408	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = 2NaF + K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211										
KDy EDTA in H <sub>2</sub> O	11003	+ LiI	II 417	KEr EDTA in H <sub>2</sub> O	11003	+ LiI	II 212	KF + acetone + H <sub>2</sub> O	II 208	2KF + Li <sub>2</sub> SiO <sub>3</sub> = 2LiF + K <sub>2</sub> SiO <sub>3</sub>	II 211	+ AlF <sub>3</sub>	1186	KF + Li <sub>2</sub> TiO <sub>3</sub>	II 440	+ AlF <sub>3</sub> + H <sub>2</sub> O	1182	+ methyl ethyl ketone + H <sub>2</sub> O	II 208	+ allyl alc. + H <sub>2</sub> O	II 207	+ NaF	II 211	+ BaCl <sub>2</sub>	1353	+ NaF <sub>2</sub> + NaF	II 211	+ BaCl <sub>2</sub> + CaCl <sub>2</sub> + NaF	1353	+ NaF <sub>2</sub> + RbF	II 211	+ BaF <sub>2</sub>	1360	+ NaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ BaTiO <sub>3</sub>	1400	+ MoO <sub>3</sub>	II 211	+ BeF <sub>2</sub>	II 211	+ NH <sub>4</sub> F + H <sub>2</sub> O	II 204	+ BeF <sub>2</sub> + H <sub>2</sub> O	1406	+ Na = K + NaF	II 2	+ BeF <sub>2</sub> in H <sub>2</sub> O	1408	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = 2NaF + K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211														
KEr EDTA in H <sub>2</sub> O	11003	+ LiI	II 212	KF + acetone + H <sub>2</sub> O	II 208	2KF + Li <sub>2</sub> SiO <sub>3</sub> = 2LiF + K <sub>2</sub> SiO <sub>3</sub>	II 211	+ AlF <sub>3</sub>	1186	KF + Li <sub>2</sub> TiO <sub>3</sub>	II 440	+ AlF <sub>3</sub> + H <sub>2</sub> O	1182	+ methyl ethyl ketone + H <sub>2</sub> O	II 208	+ allyl alc. + H <sub>2</sub> O	II 207	+ NaF	II 211	+ BaCl <sub>2</sub>	1353	+ NaF <sub>2</sub> + NaF	II 211	+ BaCl <sub>2</sub> + CaCl <sub>2</sub> + NaF	1353	+ NaF <sub>2</sub> + RbF	II 211	+ BaF <sub>2</sub>	1360	+ NaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ BaTiO <sub>3</sub>	1400	+ MoO <sub>3</sub>	II 211	+ BeF <sub>2</sub>	II 211	+ NH <sub>4</sub> F + H <sub>2</sub> O	II 204	+ BeF <sub>2</sub> + H <sub>2</sub> O	1406	+ Na = K + NaF	II 2	+ BeF <sub>2</sub> in H <sub>2</sub> O	1408	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = 2NaF + K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																		
KF + acetone + H <sub>2</sub> O	II 208	2KF + Li <sub>2</sub> SiO <sub>3</sub> = 2LiF + K <sub>2</sub> SiO <sub>3</sub>	II 211	+ AlF <sub>3</sub>	1186	KF + Li <sub>2</sub> TiO <sub>3</sub>	II 440	+ AlF <sub>3</sub> + H <sub>2</sub> O	1182	+ methyl ethyl ketone + H <sub>2</sub> O	II 208	+ allyl alc. + H <sub>2</sub> O	II 207	+ NaF	II 211	+ BaCl <sub>2</sub>	1353	+ NaF <sub>2</sub> + NaF	II 211	+ BaCl <sub>2</sub> + CaCl <sub>2</sub> + NaF	1353	+ NaF <sub>2</sub> + RbF	II 211	+ BaF <sub>2</sub>	1360	+ NaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ BaTiO <sub>3</sub>	1400	+ MoO <sub>3</sub>	II 211	+ BeF <sub>2</sub>	II 211	+ NH <sub>4</sub> F + H <sub>2</sub> O	II 204	+ BeF <sub>2</sub> + H <sub>2</sub> O	1406	+ Na = K + NaF	II 2	+ BeF <sub>2</sub> in H <sub>2</sub> O	1408	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = 2NaF + K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																						
+ AlF <sub>3</sub>	1186	KF + Li <sub>2</sub> TiO <sub>3</sub>	II 440	+ AlF <sub>3</sub> + H <sub>2</sub> O	1182	+ methyl ethyl ketone + H <sub>2</sub> O	II 208	+ allyl alc. + H <sub>2</sub> O	II 207	+ NaF	II 211	+ BaCl <sub>2</sub>	1353	+ NaF <sub>2</sub> + NaF	II 211	+ BaCl <sub>2</sub> + CaCl <sub>2</sub> + NaF	1353	+ NaF <sub>2</sub> + RbF	II 211	+ BaF <sub>2</sub>	1360	+ NaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ BaTiO <sub>3</sub>	1400	+ MoO <sub>3</sub>	II 211	+ BeF <sub>2</sub>	II 211	+ NH <sub>4</sub> F + H <sub>2</sub> O	II 204	+ BeF <sub>2</sub> + H <sub>2</sub> O	1406	+ Na = K + NaF	II 2	+ BeF <sub>2</sub> in H <sub>2</sub> O	1408	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = 2NaF + K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																										
+ AlF <sub>3</sub> + H <sub>2</sub> O	1182	+ methyl ethyl ketone + H <sub>2</sub> O	II 208	+ allyl alc. + H <sub>2</sub> O	II 207	+ NaF	II 211	+ BaCl <sub>2</sub>	1353	+ NaF <sub>2</sub> + NaF	II 211	+ BaCl <sub>2</sub> + CaCl <sub>2</sub> + NaF	1353	+ NaF <sub>2</sub> + RbF	II 211	+ BaF <sub>2</sub>	1360	+ NaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ BaTiO <sub>3</sub>	1400	+ MoO <sub>3</sub>	II 211	+ BeF <sub>2</sub>	II 211	+ NH <sub>4</sub> F + H <sub>2</sub> O	II 204	+ BeF <sub>2</sub> + H <sub>2</sub> O	1406	+ Na = K + NaF	II 2	+ BeF <sub>2</sub> in H <sub>2</sub> O	1408	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = 2NaF + K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																														
+ allyl alc. + H <sub>2</sub> O	II 207	+ NaF	II 211	+ BaCl <sub>2</sub>	1353	+ NaF <sub>2</sub> + NaF	II 211	+ BaCl <sub>2</sub> + CaCl <sub>2</sub> + NaF	1353	+ NaF <sub>2</sub> + RbF	II 211	+ BaF <sub>2</sub>	1360	+ NaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ BaTiO <sub>3</sub>	1400	+ MoO <sub>3</sub>	II 211	+ BeF <sub>2</sub>	II 211	+ NH <sub>4</sub> F + H <sub>2</sub> O	II 204	+ BeF <sub>2</sub> + H <sub>2</sub> O	1406	+ Na = K + NaF	II 2	+ BeF <sub>2</sub> in H <sub>2</sub> O	1408	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = 2NaF + K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																		
+ BaCl <sub>2</sub>	1353	+ NaF <sub>2</sub> + NaF	II 211	+ BaCl <sub>2</sub> + CaCl <sub>2</sub> + NaF	1353	+ NaF <sub>2</sub> + RbF	II 211	+ BaF <sub>2</sub>	1360	+ NaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ BaTiO <sub>3</sub>	1400	+ MoO <sub>3</sub>	II 211	+ BeF <sub>2</sub>	II 211	+ NH <sub>4</sub> F + H <sub>2</sub> O	II 204	+ BeF <sub>2</sub> + H <sub>2</sub> O	1406	+ Na = K + NaF	II 2	+ BeF <sub>2</sub> in H <sub>2</sub> O	1408	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = 2NaF + K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																						
+ BaCl <sub>2</sub> + CaCl <sub>2</sub> + NaF	1353	+ NaF <sub>2</sub> + RbF	II 211	+ BaF <sub>2</sub>	1360	+ NaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ BaTiO <sub>3</sub>	1400	+ MoO <sub>3</sub>	II 211	+ BeF <sub>2</sub>	II 211	+ NH <sub>4</sub> F + H <sub>2</sub> O	II 204	+ BeF <sub>2</sub> + H <sub>2</sub> O	1406	+ Na = K + NaF	II 2	+ BeF <sub>2</sub> in H <sub>2</sub> O	1408	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = 2NaF + K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																										
+ BaF <sub>2</sub>	1360	+ NaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ BaTiO <sub>3</sub>	1400	+ MoO <sub>3</sub>	II 211	+ BeF <sub>2</sub>	II 211	+ NH <sub>4</sub> F + H <sub>2</sub> O	II 204	+ BeF <sub>2</sub> + H <sub>2</sub> O	1406	+ Na = K + NaF	II 2	+ BeF <sub>2</sub> in H <sub>2</sub> O	1408	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = 2NaF + K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																														
+ BaTiO <sub>3</sub>	1400	+ MoO <sub>3</sub>	II 211	+ BeF <sub>2</sub>	II 211	+ NH <sub>4</sub> F + H <sub>2</sub> O	II 204	+ BeF <sub>2</sub> + H <sub>2</sub> O	1406	+ Na = K + NaF	II 2	+ BeF <sub>2</sub> in H <sub>2</sub> O	1408	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = 2NaF + K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																		
+ BeF <sub>2</sub>	II 211	+ NH <sub>4</sub> F + H <sub>2</sub> O	II 204	+ BeF <sub>2</sub> + H <sub>2</sub> O	1406	+ Na = K + NaF	II 2	+ BeF <sub>2</sub> in H <sub>2</sub> O	1408	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = 2NaF + K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																						
+ BeF <sub>2</sub> + H <sub>2</sub> O	1406	+ Na = K + NaF	II 2	+ BeF <sub>2</sub> in H <sub>2</sub> O	1408	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = 2NaF + K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																										
+ BeF <sub>2</sub> in H <sub>2</sub> O	1408	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = 2NaF + K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																														
2KF + BeF <sub>2</sub> in H <sub>2</sub> O	1408, 9	KF + NaBr	II 947	KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																		
KF + BiTiO <sub>3</sub>	1439	+ NaBr	II 212	in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																						
in BrF <sub>3</sub>	II 210	+ NaBr = KBr + NaF	II 31	+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																										
+ t-butyl alc. + H <sub>2</sub> O	II 207	2KF + Na <sub>2</sub> CO <sub>3</sub> = 2NaF + K <sub>2</sub> CO <sub>3</sub>	II 101	2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																														
2KF + CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	II 168	KF + NaCl	II 212	+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																		
+ CaCl <sub>2</sub> = CaF <sub>2</sub> + 2KCl	1597	+ NaCl = NaF + KCl	II 169	KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																						
KF + CaF <sub>2</sub>	1603	2KF + Na <sub>2</sub> CrO <sub>4</sub> = 2NaF + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																										
+ CaF <sub>2</sub> + NaF	1603	KF + NaF	II 211	+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																														
+ CaF <sub>2</sub> + SiO <sub>2</sub>	II 211	+ NaF + LiF	II 211	+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																		
+ CdF <sub>2</sub> + H <sub>2</sub> O	1731	+ NaI	II 1055	+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																						
+ CeF <sub>3</sub>	1769	+ NaI	II 212	+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																										
+ (CH <sub>3</sub> ) <sub>2</sub> COH + H <sub>2</sub> O	II 207	+ NaI = NaF + KI	II 234	+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																														
+ CoF <sub>2</sub> + H <sub>2</sub> O	1821	2KF + Na <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + 2NaF	II 211	+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																		
+ CrF <sub>3</sub> + H <sub>2</sub> O	1863	KF + NaNO <sub>3</sub> = KNO <sub>3</sub> + NaF	II 211	+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																						
+ CeBr	1875	2KF + Na <sub>2</sub> TiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + 2NaF	II 211	+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																										
+ CeBr	II 212	+ Na <sub>2</sub> TiO <sub>3</sub> = 2NaF + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																														
+ CeCl	II 212	2KF + Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> = K <sub>2</sub> B <sub>4</sub> O <sub>7</sub> + 2NaF	II 11	+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																		
+ CeCl	1886	KF + NaVO <sub>3</sub> = KVO <sub>3</sub> + NaF	II 211	+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																						
+ CaI	II 212	2KF + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + 2NaF	II 211	+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																										
+ CaI	1896	KF + NiF <sub>2</sub>	II 211	+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																														
+ CuF <sub>2</sub> + H <sub>2</sub> O	1951	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 1213	+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																		
+ EuF <sub>3</sub>	II 211	+ NiF <sub>2</sub> + H <sub>2</sub> O	II 205	+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																						
+ ethanol + H <sub>2</sub> O	II 205	in organic solvents	II 209	+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																										
+ ethyl-ethanol + H <sub>2</sub> O	II 209	+ PbF <sub>2</sub>	II 211	+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																														
+ FeF <sub>3</sub> + H <sub>2</sub> O	11032	2KF + PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbF <sub>2</sub>	II 211	2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																		
2KF + FeF <sub>3</sub> + H <sub>2</sub> O in H <sub>2</sub> O	11032	KF + PbTiO <sub>3</sub>	II 1337	KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																						
KF + HF	II 210	+ PbTiO <sub>3</sub> + BaTiO <sub>3</sub>	II 1337	+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																										
+ HF	11124	+ PrF <sub>3</sub>	II 211	in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																														
in HF	II 210	+ propoxy-ethanol + H <sub>2</sub> O	II 209	+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																		
+ HF + H <sub>2</sub> O	II 202, 3	+ propyl alc. + H <sub>2</sub> O	II 206	+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																						
+ HF + K <sub>2</sub> NbF <sub>7</sub> + H <sub>2</sub> O	II 214	+ pyridine + H <sub>2</sub> O	II 207	3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																										
3KF + HF + PbF <sub>4</sub> in H <sub>2</sub> O, H <sub>2</sub> F <sub>2</sub>	II 1299	+ RbBr	II 212	KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																														
KF in H <sub>2</sub> O	II 202	+ RbCl	II 212	+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																		
+ isopropyl alc.	II 206	+ RbF	II 211	+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																						
+ K	II 2	+ SmF <sub>3</sub>	II 211	+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																										
+ KBF <sub>4</sub>	II 8	in SO <sub>2</sub> (liq.)	II 210	+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																														
+ K <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	II 11	+ ThF <sub>4</sub> + RbF	II 211	+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																																		
+ KBr	II 30	+ ThF <sub>4</sub>	II 211	+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																																						
+ K <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 101	+ TiO <sub>2</sub> + K <sub>2</sub> TiO <sub>3</sub>	II 339	+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																																										
+ KCl	II 169	+ UF <sub>4</sub>	II 211	+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																																														
+ KCl + H <sub>2</sub> O	II 124	+ VO <sub>2</sub> (NO <sub>2</sub> ) <sub>2</sub> = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O	II 205	+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																																																		
+ KCl + K <sub>2</sub> CrO <sub>4</sub>	II 196	+ WO <sub>3</sub>	II 211	+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																																																						
+ KCl + K <sub>2</sub> SO <sub>4</sub>	II 169	+ YF <sub>3</sub>	II 211	+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																																																										
+ K <sub>2</sub> CrO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> + KMnO <sub>4</sub> + H <sub>2</sub> O	II 8	+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																																																														
+ K <sub>2</sub> CrO <sub>4</sub> + KCl	II 196	K <sub>2</sub> F <sub>2</sub> (CN) <sub>4</sub> + t-butyl alc. + H <sub>2</sub> O	II 74	+ KI + H <sub>2</sub> O	II 204	in H <sub>2</sub> O	II 73, 4	+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																																																																		
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+ K <sub>2</sub> MnO <sub>4</sub>	II 211	in hydrazine	II 74	+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																																																																										
+ K <sub>2</sub> MnO <sub>4</sub> O <sub>13</sub>	II 211	in KOH	II 74	+ KNO <sub>3</sub>	II 211	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																																																																														
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in KOCl	II 210	+ K <sub>4</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ KOH	II 211	in methyl alc.	II 74	+ KPO <sub>3</sub>	II 211	K <sub>4</sub> Fe(CN) <sub>6</sub> + InCl <sub>3</sub> + H <sub>2</sub> O	II 1296	+ K <sub>2</sub> PO <sub>4</sub>	II 211	in aq. ethyl alc.	II 73	+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 211	in aq. KOH	II 70	+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																																																																																						
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+ K <sub>2</sub> SO <sub>4</sub>	II 211	in H <sub>2</sub> O	II 69, 70	+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																																																																																																										
+ K <sub>2</sub> SiO <sub>3</sub>	II 211	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ K <sub>2</sub> Fe(CN) <sub>6</sub> + KOH	II 72	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 71	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in methyl alc.	II 73	+ K <sub>2</sub> TiO <sub>3</sub>	II 211	in aq. NH <sub>3</sub>	II 70	+ KVO <sub>3</sub>	II 211	+ Na <sub>2</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 73	+ K <sub>2</sub> WO <sub>4</sub>	II 211	K <sub>2</sub> F <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 304	+ LaF <sub>3</sub>	II 211																																																																																																																																																																																																																																																																																														
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<b>K<sub>2</sub>MoO<sub>4</sub></b> in aq. acetone	II 243	+ Al(NO <sub>3</sub> ) <sub>3</sub> + HNO <sub>3</sub> + H <sub>2</sub> O	I 191
+ Ba(MnO <sub>4</sub> ) <sub>2</sub> + H <sub>2</sub> O	I 368	+ Al(NO <sub>3</sub> ) <sub>3</sub> + NaNO <sub>3</sub> + H <sub>2</sub> O	I 192
+ BaSO <sub>4</sub> + H <sub>2</sub> O	I 393	in aq. alc	II 270
<b>2K<sub>2</sub>MoO<sub>4</sub></b> + BaSO <sub>4</sub> = Ba(MnO <sub>4</sub> ) <sub>2</sub> + K <sub>2</sub> SO <sub>4</sub> (in H <sub>2</sub> O)	I 393	+ Ba(NO <sub>3</sub> ) <sub>2</sub>	I 377
<b>K<sub>2</sub>MoO<sub>4</sub></b> + K <sub>2</sub> CO <sub>3</sub> + H <sub>2</sub> O	II 89	+ Ba(NO <sub>3</sub> ) <sub>2</sub> + Ca(NO <sub>3</sub> ) <sub>2</sub>	I 372, 3
+ KClO <sub>4</sub> + H <sub>2</sub> O	II 180	<b>2KNO<sub>3</sub></b> + Ba(NO <sub>3</sub> ) <sub>2</sub> = 2KNO <sub>2</sub> + Ba(NO <sub>3</sub> ) <sub>2</sub>	II 274
in D <sub>2</sub> O solns	II 240	+ Ba(NO <sub>3</sub> ) <sub>2</sub> + LiNO <sub>3</sub>	I 377
in H <sub>2</sub> O	II 240	+ Ba(NO <sub>3</sub> ) <sub>2</sub> + NaNO <sub>3</sub>	I 377
in hydrazine	II 243	+ Ba(NO <sub>3</sub> ) <sub>2</sub> + Sr(NO <sub>3</sub> ) <sub>2</sub>	I 377
in aq. K <sub>2</sub> CO <sub>3</sub>	II 241	+ CaCl <sub>2</sub> = Ca(NO <sub>3</sub> ) <sub>2</sub> + 2KCl (aq.)	I 587, 588, 624
in aq. KCl	II 241	<b>KNO<sub>2</sub></b> + Ca(NO <sub>3</sub> ) <sub>2</sub>	II 274
+ KFB <sub>4</sub> + H <sub>2</sub> O	II 6	+ Ca(NO <sub>3</sub> ) <sub>2</sub>	I 629
in aq. KOH	II 241, 4	+ Ca(NO <sub>3</sub> ) <sub>2</sub> + H <sub>2</sub> O	I 620
+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 242	+ CaCrO <sub>4</sub> = Ca(NO <sub>3</sub> ) <sub>2</sub> + K <sub>2</sub> CrO <sub>4</sub>	I 600
+ Na <sub>2</sub> SO <sub>4</sub>	II 243	<b>2KNO<sub>3</sub></b> + Ca(NO <sub>3</sub> ) <sub>2</sub> = 2KNO <sub>2</sub> + Ca(NO <sub>3</sub> ) <sub>2</sub>	II 274
+ RbMnO <sub>4</sub> + H <sub>2</sub> O	II 242	+ Ca(NO <sub>3</sub> ) <sub>2</sub> + Mg(NO <sub>3</sub> ) <sub>2</sub>	I 629
in aq. salts	II 242, 3	+ Ca(NO <sub>3</sub> ) <sub>2</sub> + NaNO <sub>3</sub>	I 629
<b>K<sub>2</sub>MoO<sub>4</sub></b> + BiTiO <sub>3</sub>	I 439	+ Ca(NO <sub>3</sub> ) <sub>2</sub> + NaNO <sub>3</sub> + H <sub>2</sub> O	I 624
in H <sub>2</sub> O	II 244	+ Ca(NO <sub>3</sub> ) <sub>2</sub> + NaNO <sub>3</sub> + Mg(NO <sub>3</sub> ) <sub>2</sub>	I 629
+ KCl	II 169	+ Cd(NO <sub>3</sub> ) <sub>2</sub>	I 744
+ K <sub>2</sub> CrO <sub>4</sub>	II 196	+ Cd(NO <sub>3</sub> ) <sub>2</sub> + AgNO <sub>3</sub>	I 123
+ K <sub>2</sub> CrO <sub>4</sub> + H <sub>2</sub> O	II 192	+ Cd(NO <sub>3</sub> ) <sub>2</sub> + RbNO <sub>3</sub>	I 744
+ KF	II 211	<b>KNO<sub>3</sub></b> distr. betwn. methyl-n-hexyl ketone + H <sub>2</sub> O	II 250
+ KIO <sub>3</sub> + H <sub>2</sub> O	II 245	in D <sub>2</sub> O	II 250
in KOH solns	II 245	in ethanol + H <sub>2</sub> O	II 269, 70
+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 292	in ethylenediamine	II 272
+ K <sub>2</sub> SO <sub>4</sub>	II 246	+ Fe(NO <sub>3</sub> ) <sub>3</sub> + H <sub>2</sub> O	I 1036, 7
+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 245	+ Fe(NO <sub>3</sub> ) <sub>3</sub> + HNO <sub>3</sub> + H <sub>2</sub> O	I 1037
+ K <sub>2</sub> TiO <sub>3</sub>	II 339	+ H <sub>3</sub> BO <sub>3</sub> + H <sub>2</sub> C	II 253
+ K <sub>2</sub> WO <sub>4</sub>	II 246	in aq. HCl	II 129
+ K <sub>2</sub> W <sub>2</sub> O <sub>7</sub>	II 246	+ HCl = KCl + HNO <sub>3</sub> (+ H <sub>2</sub> O)	II 129
+ Li <sub>2</sub> SO <sub>4</sub>	II 246	+ HNO <sub>3</sub>	II 273
+ Li <sub>2</sub> SO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + Li <sub>2</sub> MoO <sub>4</sub>	II 246	+ HNO <sub>3</sub>	II 1131
+ MoO <sub>3</sub>	II 246	+ HNO <sub>3</sub> + H <sub>2</sub> O	II 251, 2, 3
+ 2NaCl = 2KCl + Na <sub>2</sub> MoO <sub>4</sub>	II 246	in H <sub>2</sub> O	II 318, 250
+ 2NaCl = Na <sub>2</sub> MoO <sub>4</sub> + 2KCl	II 169	in H <sub>2</sub> O + H <sub>2</sub> O <sub>2</sub>	II 251
+ 2NaF = Na <sub>2</sub> MoO <sub>4</sub> + 2KF	II 211	in hydrazine	II 274
<b>2K<sub>2</sub>MoO<sub>4</sub></b> + Na <sub>2</sub> P <sub>2</sub> O <sub>7</sub> = K <sub>4</sub> P <sub>2</sub> O <sub>7</sub> + 2Na <sub>2</sub> MoO <sub>4</sub>	II 246	in isopropyl alc. + H <sub>2</sub> O	II 271, 2
<b>K<sub>2</sub>MoO<sub>4</sub></b> + Na <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + Na <sub>2</sub> MoO <sub>4</sub>	II 246	+ KBr	II 30
+ PbSO <sub>4</sub> = K <sub>2</sub> SO <sub>4</sub> + PbMoO <sub>4</sub>	II 246	+ KBr + H <sub>2</sub> O	II 20
+ PbTiO <sub>3</sub>	II 1337	+ KBr + KCl	II 31
+ PbTiO <sub>3</sub> = K <sub>2</sub> TiO <sub>3</sub> + PbMoO <sub>4</sub>	II 246	+ KBrO <sub>3</sub> + H <sub>2</sub> O	II 33
+ WO <sub>3</sub>	II 246	+ K <sub>2</sub> CO <sub>3</sub> + H <sub>2</sub> O	II 88
<b>K<sub>2</sub>MnO<sub>7</sub></b> + K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	II 202	in K <sub>2</sub> CO <sub>3</sub> solns	II 255
<b>K<sub>2</sub>MoO<sub>4</sub></b> + KF	II 211	+ K <sub>2</sub> CO <sub>3</sub> + Na <sub>2</sub> CO <sub>3</sub> + NaNO <sub>3</sub>	II 86
<b>KMn<sub>2</sub></b> in alc	II 247	+ KCl + H <sub>2</sub> O	II 255
in benzene	II 247	+ KCl + H <sub>2</sub> O + HCl + KOH	II 129
in H <sub>2</sub> O	II 247	+ KCl + K <sub>2</sub> CrO <sub>4</sub> + H <sub>2</sub> O	II 130

- $+ \text{KCl} + \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$ ..... II 130  
 $+ \text{KCl} + \text{NH}_3 + \text{H}_2\text{O}$ ..... II 129  
 $+ \text{KCl} + \text{NH}_4\text{H}_2\text{PO}_4 + \text{H}_2\text{O}$ ..... II 132  
 $+ \text{KClO}_3$ ..... II 178  
 $+ \text{KClO}_3 + \text{H}_2\text{O}$ ..... II 174  
 $+ \text{KClO}_4 + \text{H}_2\text{O}$ ..... II 181  
 $+ \text{K}_2\text{CrO}_4$ ..... II 196  
 $+ \text{K}_2\text{CrO}_4 + \text{H}_2\text{O}$ ..... II 192  
 $+ \text{K}_2\text{Cr}_2\text{O}_7$ ..... II 202  
 $+ \text{K}_2\text{Cr}_2\text{O}_7 + \text{H}_2\text{O}$ ..... II 196  
 $+ \text{KF}$ ..... II 211  
 $\text{in KHC}_2\text{O}_4$  solns..... II 255  
 $+ \text{KH}_2\text{PO}_4 + \text{H}_2\text{O}$ ..... II 256  
 $+ \text{KIO}_3 + \text{H}_2\text{O}$ ..... II 236  
 $+ \text{KNO}_2$ ..... II 250  
 $+ \text{KNO}_3 + \text{H}_2\text{O}$ ..... II 248  
 $+ \text{KOH}$ ..... II 274  
 $\text{in aq. KOH}$ ..... II 254  
 $+ \text{KSCN} + \text{H}_2\text{O}$ ..... II 76  
 $+ \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$ ..... II 257  
 $+ \text{K}_2\text{SO}_4 + \text{K}_2\text{CrO}_4$ ..... II 196  
  
 $2\text{KNO}_3 + \text{K}_2\text{SO}_4 \rightleftharpoons \text{K}_2\text{SO}_4 + 2\text{NaNO}_3 + \text{H}_2\text{O}$ ..... II 264  
 $\text{KNO}_3 + \text{K}_2\text{SO}_4 + \text{Ti}_2\text{Cl}_2$ ..... II 274  
 $+ \text{KVO}_3 + \text{H}_2\text{O}$ ..... II 258  
 $+ \text{K}_2\text{WO}_4$ ..... II 274  
 $+ \text{Li acetate} \rightleftharpoons \text{LiNO}_3 + \text{K acetate}$ ..... II 38  
 $+ \text{LiNO}_3$ ..... II 274  
 $+ \text{LiNO}_3 + \text{Ca(NO}_3)_2$ ..... I 744  
 $+ \text{LiNO}_3 + \text{TiNO}_3$ ..... II 274  
 $+ \text{LiOH} \rightleftharpoons \text{KOH} + \text{LiNO}_3$ ..... II 274  
 $2\text{KNO}_3 + \text{Li}_2\text{SO}_4 \rightleftharpoons 2\text{LiNO}_3 + \text{K}_2\text{SO}_4$ ..... II 326  
 $\text{KNO}_3$  in aq. methanol..... II 268  
 $2\text{KNO}_3 + \text{MgCl}_2 \rightleftharpoons 2\text{KCl} + \text{Mg(NO}_3)_2 (+ \text{H}_2\text{O})$ ..... II 259, 60  
 $\text{KNO}_3 + \text{Mg(NO}_3)_2$ ..... II 274  
 $+ \text{Mg(NO}_3)_2 + \text{H}_2\text{O}$ ..... II 258, 9  
 $+ \text{Mg(NO}_3)_2 + \text{NaNO}_3$ ..... II 274  
 $\text{K}_2\text{(NO}_3)_2 + \text{MgSO}_4 \rightleftharpoons \text{K}_2\text{SO}_4 + \text{Mg(NO}_3)_2$ ..... II 311  
 $+ \text{MgSO}_4 \rightleftharpoons \text{Mg(NO}_3)_2 + \text{K}_2\text{SO}_4 (+ \text{H}_2\text{O})$ ..... II 513  
 $(\text{KNO}_3)_2 + \text{MgSO}_4 \rightleftharpoons \text{Mg(NO}_3)_2 + \text{K}_2\text{SO}_4 (+ \text{H}_2\text{O})$ ..... II 259  
 $\text{KNO}_3$  in  $\text{NH}_4\text{(liq.)}$ ..... II 274  
 $+ \text{NH}_4\text{ClO}_4 \rightleftharpoons \text{NH}_4\text{NO}_3 + \text{KClO}_4$ ..... II 181  
 $+ \text{N}_2\text{H}_4 \cdot \text{HNO}_3$ ..... II 274  
 $\text{in NH}_3$  solns..... II 254  
 $+ \text{NH}_4\text{Cl} \rightleftharpoons \text{KCl} + \text{NH}_4\text{NO}_3$ ..... II 261  
 $+ \text{NH}_4\text{Cl} \rightleftharpoons \text{NH}_4\text{NO}_3 + \text{KCl} (+ \text{H}_2\text{O})$ ..... II 131, 146  
 $+ \text{NH}_4\text{Cl} \rightleftharpoons \text{NH}_4\text{NO}_3 + \text{KCl}$ ..... II 169  
 $+ \text{N}_2\text{H}_4 \cdot \text{HNO}_3$ ..... II 786  
 $+ \text{NH}_4\text{H}_2\text{PO}_4 \rightleftharpoons \text{NH}_4\text{NO}_3 + \text{KH}_2\text{PO}_4 (+ \text{H}_2\text{O})$ ..... II 289  
 $+ \text{NH}_4\text{H}_2\text{PO}_4 \rightleftharpoons \text{NH}_4\text{NO}_3 + \text{KH}_2\text{PO}_4$ ..... II 256  
 $+ \text{NH}_4\text{NO}_3$ ..... II 274  
 $+ \text{NH}_4\text{NO}_3 + \text{H}_2\text{O}$ ..... II 260, 1  
 $+ \text{NH}_4\text{NO}_3 + \text{NaNO}_3$ ..... II 274  
 $+ \text{NH}_4\text{NO}_3 + \text{Pb(NO}_3)_2$ ..... II 274  
  
 $2\text{KNO}_3 + (\text{NH}_4)_2\text{SO}_4 \rightleftharpoons \text{K}_2\text{SO}_4 + 2\text{NH}_4\text{NO}_3 (+ \text{H}_2\text{O})$ ..... II 261  
 $+ (\text{NH}_4)_2\text{SO}_4 \rightleftharpoons 2\text{NH}_4\text{NO}_3 + \text{K}_2\text{SO}_4 (+ \text{H}_2\text{O})$ ..... II 315  
  
 $\text{KNO}_3 + \text{Na acetate} \rightleftharpoons \text{K acetate} + \text{NaNO}_3$ ..... II 274  
 $+ \text{NaBr} \rightleftharpoons \text{NaNO}_3 + \text{KBr}$ ..... II 31  
 $+ \text{NaCl} + \text{H}_2\text{O}$ ..... II 265, 6  
 $+ \text{NaClO}_3$ ..... II 274  
 $+ \text{NaClO}_3 \rightleftharpoons \text{KClO}_4 + \text{NaNO}_3 (+ \text{H}_2\text{O})$ ..... II 183  
 $+ \text{NaCl} \rightleftharpoons \text{NaNO}_3 + \text{KCl} (+ \text{H}_2\text{O})$ ..... II 131, 2  
  
 $2\text{KNO}_3 + \text{Na}_2\text{CrO}_4 \rightleftharpoons 2\text{NaNO}_3 + \text{K}_2\text{CrO}_4$ ..... II 196  
 $+ \text{Na}_2\text{Cr}_2\text{O}_7 \rightleftharpoons 2\text{NaNO}_3 + \text{K}_2\text{Cr}_2\text{O}_7$ ..... II 202  
  
 $\text{KNO}_3 + \text{NaF} \rightleftharpoons \text{NaNO}_3 + \text{KF}$ ..... II 211  
 $+ \text{NaNO}_3$ ..... II 274  
 $+ \text{NaNO}_3$  in  $\text{H}_2\text{O}$ ..... II 1078  
 $+ \text{NaNO}_3 + \text{Al(NO}_3)_3 + \text{H}_2\text{O}$ ..... II 264  
 $+ \text{NaNO}_3 + \text{H}_2\text{O}$ ..... II 261, 2, 3  
 $+ \text{NaNO}_3$  in aq.  $\text{HNO}_3$ ..... II 264  
 $+ \text{NaNO}_3 + \text{I}$ ..... II 262  
 $+ \text{NaNO}_3 \rightleftharpoons \text{KNO}_2 + \text{NaNO}_3$ ..... II 250, 274  
 $+ \text{NaNO}_3$  in aq.  $\text{KOH}$ ,  $\text{NaOH}$ ..... II 264  
 $+ \text{NaNO}_3 + \text{NH}_4\text{NO}_3$ ..... II 728  
 $+ \text{NaNO}_3 + \text{NaCl} + \text{H}_2\text{O}$ ..... II 265  
 $+ \text{NaNO}_3 + \text{Pb(NO}_3)_2$ ..... II 274  
 $+ \text{NaNO}_3 + \text{Sr(NO}_3)_2$ ..... II 1083  
 $+ \text{NaNO}_3 + \text{Sr(NO}_3)_2$ ..... II 274  
 $+ \text{NaNO}_3 + \text{TiNO}_3$ ..... II 274  
 $+ \text{NaOH}$ ..... II 274  
  
 $2\text{KNO}_3 + \text{Na}_2\text{SO}_4 \rightleftharpoons \text{K}_2\text{SO}_4 + 2\text{NaNO}_3$ ..... II 274  
 $\text{KNO}_3 + \text{Na}_2\text{SO}_4 + \text{Na}_2\text{Cr}_2\text{O}_7$ ..... II 274
- $+ \text{Pb(NO}_3)_2 + \text{H}_2\text{O}$ ..... II 1309, 266  
 $+ \text{Pb(NO}_3)_2 + \text{Pb}_3\text{O}_4$ ..... II 274  
 $+ \text{RbNO}_3$ ..... II 274  
 $+ \text{Sr(NO}_3)_2$ ..... II 274  
 $+ \text{Sr(NO}_3)_2 + \text{H}_2\text{O}$ ..... II 267  
 $+ \text{sugar in H}_2\text{O}$ ..... II 272  
 $+ \text{TiBr}$ ..... II 274  
 $+ \text{TiNO}_3$ ..... II 274  
 $+ \text{TiNO}_3 + \text{H}_2\text{O}$ ..... II 1589, 267  
  
 $2\text{KNO}_3 + \text{Ti}_2\text{SO}_4 \rightleftharpoons 2\text{TiNO}_3 + \text{K}_2\text{SO}_4$ ..... II 274  
 $\text{KNO}_3$  in trichloroethylene..... II 273  
 $+ \text{UO}_2(\text{NO}_3)_2 + \text{H}_2\text{O}$ ..... II 267, 8  
 $+ \text{urea}$ ..... II 273  
 $+ \text{urea} + \text{H}_2\text{O}$ ..... II 272  
 $\text{in aq. urethane}$ ..... II 272  
  
 $2\text{KNO}_3 + \text{VO}_2\text{F}_2 \rightleftharpoons \text{VO}_2(\text{NO}_3)_2 + \text{KF} (+ \text{H}_2\text{O})$ ..... II 205  
 $\text{KNO}_3\text{H}(\text{SO}_3)_2$  in  $\text{H}_2\text{O}$ ..... II 295  
 $\text{K asphthalene sulfonates in H}_2\text{O}$ ..... II 61  
 $\text{K asphthylamine sulfonates in H}_2\text{O}$ ..... II 61  
 $(\text{KNO}_3)_2 \cdot 2\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$ ..... II 330  
 $\text{KNa nitrate in aq. alc.}$ ..... II 50  
 $\text{in H}_2\text{O}$ ..... II 49  
 $+ \text{NaOH} + \text{H}_2\text{O}$ ..... II 49  
 $+ \text{PbO} + \text{H}_2\text{O}$ ..... II 50  
  
 $\text{KNO}_3 + \text{HF} + \text{H}_2\text{O}$ ..... II 212  
 $+ \text{KNO}_3 + \text{HF} + \text{H}_2\text{O}$ ..... II 213  
 $+ \text{K}_2\text{TaF}_7 + \text{HF} + \text{H}_2\text{O}$ ..... II 214  
 $\text{KNO}_3$  in  $\text{H}_2\text{O}$ ..... II 275  
 $+ \text{KTAO}_3$ ..... II 275  
 $+ \text{NaNO}_3$ ..... II 275  
  
 $\text{K}_2\text{NO}_3\text{F} \cdot \text{H}_2\text{O}$  in  $\text{HF}$  solns..... II 214  
 $+ \text{K}_2\text{TaF}_7 + \text{H}_2\text{O} (+ \text{HF})$ ..... II 214  
  
 $\text{KNO}_3$  in  $\text{H}_2\text{O}$ ..... II 318  
 $\text{KNO}_3$  in  $\text{H}_2\text{O}$ ..... II 337  
 $\text{KNO}_3$  in  $\text{H}_2\text{O}$ ..... II 1200  
 $\text{KNO}_3$  in  $\text{H}_2\text{O}$ ..... II 319  
 $+ \text{K}_2\text{Cu(SO}_4)_2 + \text{H}_2\text{O}$ ..... II 981  
  
 $\text{K nitrate in H}_2\text{O}$ ..... II 59  
 $\text{K nitrate diphenyl ethylsuccinate acid in H}_2\text{O}$ ..... II 66  
 $\text{K}_2\text{O} + \text{As}_2\text{O}_3 + \text{B}_2\text{O}_3$ ..... II 126  
 $\text{K}_2\text{O} + \text{Al}_2\text{O}_3 + \text{H}_2\text{O}$ ..... II 2  
  
 $\text{K}_2\text{O} + \text{As}_2\text{O}_3 + \text{H}_2\text{O}$ ..... II 2  
 $+ \text{As}_2\text{O}_3 + \text{H}_2\text{O}$ ..... II 3  
 $+ \text{B}_2\text{O}_3$ ..... II 11  
 $+ \text{B}_2\text{O}_3 + \text{H}_2\text{O}$ ..... II 8  
 $+ \text{B}_2\text{O}_3 + \text{KBr}$ ..... II 11  
 $+ \text{B}_2\text{O}_3 + \text{KCl}$ ..... II 11  
 $+ 2\text{B}_2\text{O}_3$ ..... II 9  
 $+ 5\text{B}_2\text{O}_3$  in  $\text{H}_2\text{O}$ ..... II 9, 10  
 $+ \text{BaO} \cdot 4\text{B}_2\text{O}_3 \cdot 14\text{H}_2\text{O}$ ..... II 10  
 $+ \text{CaO} + \text{Al}_2\text{O}_3 + \text{CaSO}_4 + \text{H}_2\text{O}$ ..... I 497  
 $+ 2\text{CaO} \cdot \text{As}_2\text{O}_3$  in aq.  $\text{KCl}$ ..... I 500  
 $+ \text{CaO} + \text{CO}_2 + \text{Na}_2\text{O} + \text{TiO}_2 + \text{SiO}_2$ ..... I 556  
 $+ \text{CaO} \cdot \text{SiO}_2 + 2\text{CaO} \cdot \text{SiO}_2$ ..... I 630  
 $+ \text{CrO}_3 + \text{H}_2\text{O}$ ..... II 189  
 $+ \text{CrO}_3 \cdot \text{H}_2\text{O}$ ..... II 190  
 $+ \text{Fe}_2\text{O}_3 + \text{SO}_3 + \text{H}_2\text{O}$ ..... I 1064  
 $+ \text{GeO}_2$ ..... I 1075  
 $+ \text{MgO} + \text{B}_2\text{O}_3 + \text{H}_2\text{O}$ ..... II 444  
 $+ \text{Nb}_2\text{O}_5$ ..... II 280  
 $+ \text{P}_2\text{O}_5 + \text{H}_2\text{O}$ ..... II 281, 2, 3, 4  
 $+ \text{Ta}_2\text{O}_5$ ..... II 280  
 $+ \text{V}_2\text{O}_5$ ..... II 280  
  
 $3\text{K}_2\text{O} \cdot \text{Cr}_2\text{O}_3 \cdot 12\text{MgO} \cdot 20\text{H}_2\text{O}$ ..... II 246  
 $\text{K}_2\text{O} \cdot \text{MgO} \cdot 2\text{B}_2\text{O}_3 \cdot 15\text{H}_2\text{O}$ ..... II 10  
 $\text{K}_2\text{O} \cdot 4\text{MgO} \cdot 11\text{B}_2\text{O}_3 \cdot 18\text{H}_2\text{O}$ ..... II 10  
 $\text{K}_2\text{O} \cdot \text{MgO} \cdot \text{Cr}_2\text{O}_3 \cdot 10\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$ ..... II 275  
  
 $\text{KOH}$  in alic mixtures..... II 75  
 $\text{in benzene}$ ..... II 75  
 $\text{in NH}_3\text{(liq.)}$ ..... II 75  
 $\text{in POCl}_3$ ..... II 75  
  
 $\text{KOH}$  in aq. acetic acid..... II 278  
 $+ \text{acetone} + \text{H}_2\text{O}$ ..... II 278  
 $+ \text{Al}_2\text{O}_3 + \text{H}_2\text{O}$ ..... II 2  
 $+ \text{dioxane} + \text{H}_2\text{O}$ ..... II 278  
 $\text{in ethyl alc.}$ ..... II 280  
 $\text{in aq. ethyl alc.}$ ..... II 278  
 $+ \text{ethyl alc.} + \text{H}_2\text{O}$ ..... II 277  
 $+ \text{H}_2\text{O}$ ..... II 276  
 $+ \text{H}_2\text{Br}_2 + \text{H}_2\text{O}$ ..... I 1181  
 $+ \text{H}_2\text{OCl}_2 + \text{H}_2\text{O}$ ..... I 1205

- + hydrazine +  $H_2O$ ..... II 280  
 + KBr..... II 30  
 +  $K_2CrO_4$ ..... II 196  
 + KF..... II 211  
 + KI..... II 280  
 +  $KIO_4 + H_2O$ ..... II 239  
 +  $KNO_2$ ..... II 250  
 +  $KNO_3$ ..... II 274  
 +  $K_2SO_3 + H_2O$ ..... II 294  
 +  $K_3SbS_4 + H_2O$ ..... II 333  
 + K tartrate +  $H_2O$ ..... II 277  
 + K tartrate + ethanol +  $H_2O$ ..... II 279  
 + K tartrate +  $H_2O$ ..... II 48  
**2KOH** +  $K_2Zn(CN)_4 = Zn + 4KCN + O + H_2O$ ..... II 1644  
**KOH** + LiBr  $\rightleftharpoons$  LiOH + KBr..... II 169  
 + LiCl  $\rightleftharpoons$  LiOH + KCl..... II 169  
**2KOH** +  $Li_2CrO_4 \rightleftharpoons 2LiOH + K_2CrO_4$ ..... II 196  
**KOH** +  $LiNO_3 \rightleftharpoons LiOH + KNO_3$ ..... II 274  
 + LiOH..... II 280  
 in methyl alc..... II 280  
 +  $NH_3 + H_2O$ ..... II 276  
**K<sub>2</sub>O** +  $NH_3 + P_2O_5 + H_2O$ ..... II 739  
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 + NaBr  $\rightleftharpoons$  NaOH + KBr..... II 31  
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 +  $Na_2CrO_4 \rightleftharpoons 2NaOH + K_2CrO_4$ ..... II 196  
**KOH** + NaNO<sub>2</sub>..... II 1069  
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**2KOH** +  $Na_2SO_4 \rightleftharpoons K_2SO_4 + 2NaOH$ ..... II 280  
**KOH** + phenol +  $H_2O$ ..... II 53, 279  
 + phenolphthalein +  $H_2O$ ..... II 64  
 + pyridine +  $H_2O$ ..... II 278  
 + RbOH..... II 280  
 + rescinol +  $H_2O$ ..... II 55  
 + urea +  $H_2O$ ..... II 279  
**K oleate** in ethanol..... II 66  
 + KOH, iso-octane..... II 66  
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**K oxalate** + Hg [II] oxalate +  $H_2O$ ..... I 1203  
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**K palmitate** in aq. ethanol..... II 66  
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**K picrate** in aq. acetone..... II 53, 4  
 in aq. alc..... II 53, 4  
 in  $H_2O$ ..... II 53  
 distr. betwn. iso propyl ketone and  $H_2O$ ..... II 54  
**KPO<sub>3</sub>** +  $Ba_2B_4O_7$ ..... II 292  
 +  $BiTiO_3$ ..... I 439  
 in  $H_2O$ ..... II 292  
 +  $KBO_3$ ..... II 11  
 + KF..... II 211  
 +  $K_4P_2O_7$ ..... II 292  
 +  $K_2SO_4$ ..... II 292  
 +  $LiPO_3$ ..... II 292  
**2KPO<sub>3</sub>** +  $Li_2SO_4 \rightleftharpoons K_2SO_4 + 2LiPO_3$ ..... II 292  
**KPO<sub>3</sub>** + NaPO<sub>3</sub>..... II 292  
**4KPO<sub>3</sub>** +  $Na_4P_2O_7 \rightleftharpoons K_4P_2O_7 + 4NaPO_3$ ..... II 292  
**K<sub>3</sub>PO<sub>3</sub>** +  $K_2TiO_3 + K_4P_2O_7$ ..... II 292  
**K<sub>3</sub>PO<sub>4</sub>** in  $H_2O$ ..... II 284  
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**2K<sub>3</sub>PO<sub>4</sub>** +  $3Li_2SO_4 \rightleftharpoons 3K_2SO_4 + 2Li_3PO_4$ ..... II 326  
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 +  $BiTiO_3$ ..... I 439  
 +  $K_2CrO_4$ ..... II 292  
 + KF..... II 211  
 +  $KPO_3$ ..... II 292  
 +  $K_2MoO_4$ ..... II 292  
 +  $K_3PO_4 + K_2TiO_3$ ..... II 292  
 +  $K_2SO_4$ ..... II 292  
 +  $K_2WO_4$ ..... II 292, 340  
 +  $Li_2TiO_3$ ..... II 440  
 +  $4LiTiO_3 \rightleftharpoons 4KTiO_3 + Li_4P_2O_7$ ..... II 292  
 +  $2Na_2MoO_4 \rightleftharpoons Na_4P_2O_7 + 2K_2MoO_4$ ..... II 246  
 +  $4Na_2P_2O_7 \rightleftharpoons Na_4P_2O_7 + 4KPO_3$ ..... II 292  
 +  $Na_4P_2O_7$ ..... II 1107  
**K<sub>2</sub>P<sub>2</sub>O<sub>7</sub>** +  $2Na_2WO_4 \rightleftharpoons 2K_2WO_4 + Na_4P_2O_7$ ..... II 292, 340  
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**K phenyl acetate** + phenyl acetic acid..... II 60  
**K phenyl sulfates** in  $H_2O$ , alc..... II 328  
**K phthalate** in aics..... II 59  
 + phthalic acid +  $H_2O$ ..... II 57, 8  
**K picrolonate** in  $H_2O$ ..... II 59  
**K propyl malonate** +  $K_2CO_3 + H_2O$ ..... II 99  
**K propionate** in methyl alc..... II 38  
 + Na acetate  $\rightleftharpoons$  Na propionate + K acetate..... II 859  
**K<sub>2</sub>Pt(CN)<sub>4</sub>** in  $H_2O$ ..... II 75  
 +  $Li_2Pt(CN)_4 + H_2O$ ..... II 383  
**K<sub>2</sub>PtCl<sub>6</sub>** in aq. ethanol..... II 1949  
 in isobutyl alc..... II 1350  
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**KReBr<sub>6</sub>** in HBr..... II 293  
**KReCl<sub>6</sub>** in HCl..... II 293  
**K<sub>2</sub>ReCl<sub>6</sub>** in aq. HCl..... II 149  
**KReO<sub>4</sub>** distr. betwn. nitromethane and  $H_2O$ ..... II 293  
 in ethyl alc..... II 293  
 in  $H_2O$ ..... II 293  
 + KCl +  $H_2O$ ..... II 133  
**K<sub>4</sub>Re<sub>2</sub>OCl<sub>10</sub>** in aq. HCl..... II 149  
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 + S..... II 293  
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 +  $AgSCN + H_2O$ ..... I 55, 56  
 +  $Ba(SCN)_2 + H_2O$ ..... I 326  
 + t-butyl alc. +  $H_2O$ ..... II 78  
 +  $Ca(SCN)_2 + H_2O$ ..... I 531, 2  
 +  $Co(SCN)_2 + H_2O$ ..... I 796  
 in  $D_2O$ ..... II 76  
 distr. betwn.  $H_2O$  + amyl alc..... II 79  
 in ethylenediamine..... II 80  
 in  $H_2O$ ..... II 76  
 +  $Hg(SCN)_2 + H_2O$ ..... I 1202  
 +  $I_2 + benzene$ ..... II 80  
 +  $I_2 + toluene$ ..... II 80  
 + KBr, KI, KCl, NiBr<sub>2</sub>, CdI<sub>2</sub>, ZnI<sub>2</sub>, CoCl<sub>2</sub>..... II 80  
 + K butyrate..... II 80  
 + K formate..... II 80  
 +  $KNO_2$ ..... II 80  
 +  $KNO_3 + H_2O$ ..... II 76  
 +  $K_2SO_4 + H_2O$ ..... II 77  
 +  $NH_4SCN$  f.p..... II 638  
 +  $NH_4SCN$ ..... II 80  
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 + Na butyrate  $\rightleftharpoons$  K butyrate + NaSCN..... II 89  
 + NaCl  $\rightleftharpoons$  NaSCN + KCl..... II 169  
 + Na formate  $\rightleftharpoons$  K formate + NaSCN..... II 80  
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 in organic solvents..... II 79  
 in POCl<sub>3</sub>..... II 80  
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 + RbSCN..... II 80  
 in  $SO_2$  (liq.)..... II 80
- K<sub>2</sub>SO<sub>3</sub>** in aq. t-butyl alc..... II 295  
 in  $H_2O$ ..... II 294  
 +  $H_2SO_4 + H_2O$ ..... II 295  
 + KOH + H<sub>2</sub>O..... II 295  
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 in aq. acetone..... II 323  
 in aq. solns..... II 324  
 +  $Ag_2SO_4$ ..... I 143  
 +  $Ag_2SO_4 + H_2O$ ..... I 136, 7  
 +  $Al_2(SO_4)_3 + H_2O$ ..... I 216  
**3K<sub>2</sub>SO<sub>4</sub>** +  $2Al_2(SeO_4)_3 \rightleftharpoons 2Al_2(SO_4)_3$   
 +  $3K_2SeO_4$  (+  $H_2O$ )..... I 226  
**K<sub>2</sub>SO<sub>4</sub>** +  $BaCO_3 \rightleftharpoons BaSO_4 + K_2CO_3$ ..... II 94  
 +  $BaCO_3 \rightleftharpoons K_2CO_3 + BaSO_4$  (+  $H_2O$ )..... II 302  
 +  $Ba(MnO_4)_2 \rightleftharpoons BaSO_4 + 2KMnO_4$  in  $H_2O$ ..... I 393  
 +  $BaSO_4$ ..... I 393  
 +  $BaSO_4 + H_2O$ ..... I 393

+ BeSO <sub>4</sub> + H <sub>2</sub> O	I 419, 20
+ Bi <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> + H <sub>2</sub> O	I 438
+ CaCl <sub>2</sub> = CaSO <sub>4</sub> + 2KCl	II 168
+ CaCl <sub>2</sub> + CaSO <sub>4</sub> + 2KCl(+ H <sub>2</sub> O)	I 596, 678
+ CaSO <sub>4</sub>	II 326
+ CaSO <sub>4</sub>	I 687
+ CaSO <sub>4</sub> + H <sub>2</sub> O	II 303
+ CaSO <sub>4</sub> + H <sub>2</sub> O	I 671-3
+ CaSO <sub>4</sub> + MgSO <sub>4</sub>	II 326
+ CaSO <sub>4</sub> + MgSO <sub>4</sub>	II 687
+ CaSO <sub>4</sub> + MgSO <sub>4</sub> + H <sub>2</sub> O	II 303
+ CaSO <sub>4</sub> + Na <sub>2</sub> SO <sub>4</sub>	I 687
+ CdSO <sub>4</sub>	I 762
+ CdSO <sub>4</sub> + H <sub>2</sub> O	I 753, 4
+ CdSO <sub>4</sub> in H <sub>2</sub> O	I 754
+ Ce <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> + H <sub>2</sub> O	I 776, 7
in aq. chloral hydrate	II 323
+ CoCl <sub>2</sub> = CoSO <sub>4</sub> + 2KCl	I 856
+ CoCl <sub>2</sub> = CoSO <sub>4</sub> + 2KCl(+ H <sub>2</sub> O)	I 801, 05
+ CoSO <sub>4</sub>	I 856
+ CoSO <sub>4</sub> + H <sub>2</sub> O	I 847, 8
+ CsCl	I 885
+ Cs <sub>2</sub> SO <sub>4</sub>	I 903
+ CuSO <sub>4</sub>	I 997
+ CuSO <sub>4</sub> + H <sub>2</sub> O	I 977, 8
+ CuSO <sub>4</sub> in H <sub>2</sub> O	I 978
+ CuSO <sub>4</sub> + CuCl <sub>2</sub> + KCl + H <sub>2</sub> O	I 974
+ CuSO <sub>4</sub> + Na <sub>2</sub> SO <sub>4</sub>	I 997
+ CuSO <sub>4</sub> + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	I 983
+ Di <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> ·2H <sub>2</sub> O in H <sub>2</sub> O	I 1001
in aq. ethylene glycol	II 322
in aq. ethyl alc.	II 321
in ethyl alc. + benzene	II 321
+ FeSO <sub>4</sub> ·6H <sub>2</sub> O in H <sub>2</sub> O	I 1053
+ Fe <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> + H <sub>2</sub> O	I 1064
in formic acid	II 324
in aq. glycerol	II 323
+ H <sub>3</sub> BO <sub>3</sub> + H <sub>2</sub> O	II 299, 300
+ H <sub>3</sub> BO <sub>3</sub> + H <sub>2</sub> O	I 271
in H <sub>2</sub> O	II 318, 296
+ H <sub>2</sub> O <sub>2</sub>	I 1148
+ H <sub>2</sub> O <sub>2</sub> + H <sub>2</sub> O	II 297
+ H <sub>2</sub> SO <sub>4</sub>	II 324
+ H <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 297, 8
in K acetate	II 301
+ KBO <sub>2</sub>	II 11
+ K <sub>2</sub> BeF <sub>4</sub>	II 212
+ KBr	II 30
+ KBr + H <sub>2</sub> O	II 302
+ KBrO <sub>3</sub> + H <sub>2</sub> O	II 33
+ K <sub>2</sub> CO <sub>3</sub>	II 101
+ K <sub>2</sub> CO <sub>3</sub> + KHCO <sub>3</sub> + H <sub>2</sub> O	II 86
+ KCl + H <sub>2</sub> O	II 133, 4, 5
+ KCl + KBr	II 31
in KCl, KBr, KI	II 301
+ KCl + K <sub>2</sub> CO <sub>3</sub> + H <sub>2</sub> O	II 87
+ KCl + KNO <sub>3</sub> + H <sub>2</sub> O	II 130
+ KCl + NaCl + Na <sub>2</sub> SO <sub>4</sub> + Na <sub>2</sub> CO <sub>3</sub> + K <sub>2</sub> CO <sub>3</sub>	II 94
+ KClO <sub>3</sub> + H <sub>2</sub> O	II 175
+ K <sub>2</sub> CrO <sub>4</sub>	II 196
+ K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> + H <sub>2</sub> O	II 199
+ KF	II 211
+ KF + K <sub>2</sub> CO <sub>3</sub>	II 101
+ KF + KCl	II 169
+ K <sub>4</sub> Fe(CN) <sub>6</sub> + H <sub>2</sub> O	II 71
+ KHCO <sub>3</sub> + H <sub>2</sub> O	II 103
+ KH <sub>2</sub> PO <sub>4</sub> + H <sub>2</sub> O	II 287
+ KI	II 234
+ KI + H <sub>2</sub> O	II 219
+ KIO <sub>3</sub> + H <sub>2</sub> O	II 237
+ KMnO <sub>4</sub> + H <sub>2</sub> O	II 242
+ K <sub>2</sub> MoO <sub>4</sub>	II 246
+ K <sub>2</sub> MoO <sub>4</sub> + H <sub>2</sub> O	II 245
+ KNO <sub>3</sub> + H <sub>2</sub> O	II 257
+ KNO <sub>3</sub> + K <sub>2</sub> CrO <sub>4</sub>	II 196
in aq. KOH	II 300
+ KPO <sub>3</sub>	II 292
+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 292
+ KSCN + H <sub>2</sub> O	II 77
+ K <sub>2</sub> S	II 293
+ KSO <sub>3</sub> NH <sub>2</sub> + H <sub>2</sub> O	II 331
+ K <sub>2</sub> TiO <sub>3</sub>	II 339

+ KVO <sub>3</sub> + H <sub>2</sub> O	II 302
+ K <sub>2</sub> WO <sub>4</sub>	II 324
+ La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> + H <sub>2</sub> O	II 358
+ 2LiBO <sub>3</sub> = Li <sub>2</sub> SO <sub>4</sub> + 2KBO <sub>2</sub>	II 11
+ 2LiCl = Li <sub>2</sub> SO <sub>4</sub> + 2KCl	II 169
+ Li <sub>2</sub> CrO <sub>4</sub> = Li <sub>2</sub> SO <sub>4</sub> + K <sub>2</sub> CrO <sub>4</sub>	II 196
+ Li <sub>2</sub> MoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + Li <sub>2</sub> SO <sub>4</sub>	II 246
+ 2LiNO <sub>3</sub> = 2KNO <sub>3</sub> + Li <sub>2</sub> SO <sub>4</sub>	II 326
<b>3K<sub>2</sub>SO<sub>4</sub> + 2Li<sub>3</sub>PO<sub>4</sub> = 2K<sub>3</sub>PO<sub>4</sub> + 3Li<sub>2</sub>SO<sub>4</sub></b>	II 326
<b>K<sub>2</sub>SO<sub>4</sub> + 2LiPO<sub>3</sub> = Li<sub>2</sub>SO<sub>4</sub> + 2KPO<sub>3</sub></b>	II 292
+ Li <sub>2</sub> SO <sub>4</sub>	II 326, 439
+ Li <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 304, 5
+ Li <sub>2</sub> SO <sub>4</sub> + CdSO <sub>4</sub>	II 326
+ Li <sub>2</sub> SO <sub>4</sub> + Na <sub>2</sub> SO <sub>4</sub>	II 326
+ Li <sub>2</sub> SO <sub>4</sub> + Ti <sub>2</sub> SO <sub>4</sub>	II 326
+ Li <sub>2</sub> WO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + Li <sub>2</sub> SO <sub>4</sub>	II 326
in aq. methyl alc.	II 321
+ methanol + H <sub>2</sub> O	II 322
+ MgCl <sub>2</sub> = 2KCl + MgSO <sub>4</sub>	II 169
+ MgCl <sub>2</sub> = 2KCl + MgSO <sub>4</sub> (+ H <sub>2</sub> O)	II 311, 138
+ MgCl <sub>2</sub> = MgSO <sub>4</sub> + KCl	II 494
+ MgCl <sub>2</sub> = MgSO <sub>4</sub> + 2KCl (+ H <sub>2</sub> O)	II 487
+ Mg(NO <sub>3</sub> ) <sub>2</sub> = MgSO <sub>4</sub> + K <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> (+ H <sub>2</sub> O)	II 513
+ Mg(NO <sub>3</sub> ) <sub>2</sub> = MgSO <sub>4</sub> + K <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>	II 311
+ Mg(NO <sub>3</sub> ) <sub>2</sub> = MgSO <sub>4</sub> + (KNO <sub>3</sub> ) <sub>2</sub> (+ H <sub>2</sub> O)	II 259
+ MgSO <sub>4</sub>	II 326, 538
+ MgSO <sub>4</sub> + H <sub>2</sub> O	II 305, 6, 7, 8
+ MgSO <sub>4</sub> + H <sub>3</sub> BO <sub>3</sub> + H <sub>2</sub> O	II 309, 10
+ MgSO <sub>4</sub> + Mg(OH) <sub>2</sub> + H <sub>2</sub> O	II 309
+ MgSO <sub>4</sub> + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 310, 11
+ MgSO <sub>4</sub> + Na <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 310, 11
+ MnSO <sub>4</sub>	II 571
+ MnSO <sub>4</sub> + H <sub>2</sub> O	II 312
in aq. NH <sub>3</sub>	II 301
+ 2NH <sub>4</sub> Cl = KCl + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> (+ H <sub>2</sub> O)	II 135, 6
+ (NH <sub>4</sub> ) <sub>2</sub> CrO <sub>4</sub> = K <sub>2</sub> CrO <sub>4</sub> + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> (+ H <sub>2</sub> O)	II 315
+ NH <sub>4</sub> NO <sub>3</sub>	II 324
+ 2NH <sub>4</sub> NO <sub>3</sub> = 2KNO <sub>3</sub> + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> (+ H <sub>2</sub> O)	II 315
+ 2NH <sub>4</sub> NO <sub>3</sub> = (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + 2KNO <sub>3</sub> (+ H <sub>2</sub> O)	II 261
+ (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	II 326
+ (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 313
+ (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + Na <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 314
+ 2NH <sub>4</sub> SO <sub>3</sub> NH <sub>2</sub> = (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + 2KSO <sub>3</sub> NH <sub>2</sub> (+ H <sub>2</sub> O)	II 328
+ Na <sub>2</sub> CO <sub>3</sub> = Na <sub>2</sub> SO <sub>4</sub> + K <sub>2</sub> CO <sub>3</sub> (+ H <sub>2</sub> O)	II 92, 3
+ NaCl	II 325
+ NaCl + K <sub>2</sub> CO <sub>3</sub>	II 101
+ 2NaCl = Na <sub>2</sub> SO <sub>4</sub> + 2KCl	II 169
+ 2NaCl = Na <sub>2</sub> SO <sub>4</sub> + 2KCl (+ H <sub>2</sub> O)	II 136, 7, 8
+ Na <sub>2</sub> CrO <sub>4</sub> = Na <sub>2</sub> SO <sub>4</sub> + K <sub>2</sub> CrO <sub>4</sub> (+ H <sub>2</sub> O)	II 193
+ NaF + K <sub>2</sub> CO <sub>3</sub>	II 101
+ 2NaHSO <sub>4</sub> = Na <sub>2</sub> SO <sub>4</sub> + 2KHCO <sub>3</sub>	II 104
+ 2NaI = Na <sub>2</sub> SO <sub>4</sub> + 2KI	II 234
+ 2NaNO <sub>3</sub> = Na <sub>2</sub> SO <sub>4</sub> + 2KNO <sub>3</sub> (+ H <sub>2</sub> O)	II 264
+ 2NaNO <sub>3</sub> = Na <sub>2</sub> SO <sub>4</sub> + 2KNO <sub>3</sub>	II 274
+ 2NaOH = Na <sub>2</sub> SO <sub>4</sub> + 2KOH	II 280
+ Na <sub>2</sub> SO <sub>4</sub>	II 325
+ Na <sub>2</sub> SO <sub>4</sub> + CdSO <sub>4</sub>	II 326
+ Na <sub>2</sub> SO <sub>4</sub> + K <sub>2</sub> CO <sub>3</sub> + Na <sub>2</sub> CO <sub>3</sub> + H <sub>2</sub> O	II 318
+ Na <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 315, 6, 7
+ Na <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> SO <sub>4</sub>	II 318
+ Na <sub>2</sub> SO <sub>4</sub> + MgSO <sub>4</sub>	II 326
+ Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> + H <sub>2</sub> O	II 1192
+ NiSO <sub>4</sub> + H <sub>2</sub> O	II 1222, 319
+ PbSO <sub>4</sub>	II 1334, 325
+ PbSO <sub>4</sub> in H <sub>2</sub> O	II 319
+ PbSO <sub>4</sub> + Na <sub>2</sub> SO <sub>4</sub>	II 325
+ PbWO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + PbSO <sub>4</sub>	II 328
in aq. phenol	II 324
+ Pr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> + H <sub>2</sub> O	II 320
in pyridine	II 323
+ PbF <sub>2</sub> = PbSO <sub>4</sub> + 2KF	II 211
+ PbMoO <sub>4</sub> = K <sub>2</sub> MoO <sub>4</sub> + PbSO <sub>4</sub>	II 246
+ RbCl	II 325
+ Rb <sub>2</sub> SO <sub>4</sub>	II 325
in steam	II 296
in aq. sugar	II 322
+ SrSO <sub>4</sub>	II 325
+ SrSO <sub>4</sub> in H <sub>2</sub> O	II 319
+ Ti <sub>2</sub> Cl <sub>2</sub> + KNO <sub>3</sub>	II 274
+ Ti <sub>2</sub> Cl <sub>2</sub> + Ti <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>	II 326
+ 2TiNO <sub>3</sub> = Ti <sub>2</sub> SO <sub>4</sub> + 2KNO <sub>3</sub>	II 274
+ Ti <sub>2</sub> SO <sub>4</sub> + CuSO <sub>4</sub> + H <sub>2</sub> O	I 994



- $+ \text{UO}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 320  
 $+ \text{urea} + \text{H}_2\text{O}$  ..... II 325  
 $+ \text{urethane} + \text{H}_2\text{O}$  ..... II 324  
 $+ \text{V}_2\text{O}_5$  ..... II 326  
 $+ \text{ZnCl}_2 = \text{ZnSO}_4 + 2\text{KCl}$  ..... II 153, 4, 169  
 $+ \text{ZnSO}_4 + \text{H}_2\text{O}$  ..... II 320, 1687  
 **$2\text{K}_2\text{SO}_4 \cdot \text{Na}_2\text{SO}_4$**  ..... II 193  
 **$\text{K}_2\text{SO}_4 \cdot \text{UO}_2\text{SO}_4 \cdot 2\text{H}_2\text{O}$**  in  $\text{H}_2\text{O}$  ..... II 1624  
 **$\text{K}_2\text{S}_2\text{O}_3$**  in  $\text{H}_2\text{O}$  ..... II 329  
 **$\text{K}_2\text{S}_2\text{O}_5$**  in  $\text{H}_2\text{O}$  ..... II 295  
in  $\text{SO}_2(\text{liq.})$  ..... II 295  
 **$\text{K}_2\text{S}_2\text{O}_8$**  +  $\text{BaS}_2\text{O}_8 + \text{H}_2\text{O}$  ..... I 396  
+  $\text{BiTiO}_3$  ..... I 439  
 **$\text{K}_2\text{S}_2\text{O}_7$**  in aq. salts ..... II 329  
in  $\text{H}_2\text{O}$  ..... II 328  
+  $\text{KHSO}_4$  ..... II 326  
+  $\text{V}_2\text{O}_5$  ..... II 326  
 **$\text{K}_2\text{S}_2\text{O}_8$**  in furtural ..... II 329  
 **$\text{K}_2\text{S}_3\text{O}_6$**  +  $\text{K}_2\text{S}_4\text{O}_6 + \text{H}_2\text{O}$  ..... II 330  
+  $\text{K}_2\text{S}_5\text{O}_6 + \text{H}_2\text{O}$  ..... II 331  
 **$\text{K}_2\text{S}_3\text{O}_8$**  +  $\text{K}_2\text{S}_5\text{O}_8 + \text{H}_2\text{O}$  ..... II 330  
+  $\text{K}_2\text{S}_5\text{O}_8 + \text{H}_2\text{O}$  ..... II 330  
 **$\text{K}_2\text{S}_5\text{O}_6$**  +  $\text{K}_2\text{S}_3\text{O}_8 + \text{H}_2\text{O}$  ..... II 330  
+  $\text{K}_2\text{S}_4\text{O}_6 + \text{H}_2\text{O}$  ..... II 330  
 **$\text{K}_4(\text{SO}_3)_2\text{N}(\text{SO}_3)_2$**  in  $\text{H}_2\text{O}$  ..... II 247  
 **$\text{KSO}_3\text{NH}_2$**  +  $\text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 331  
 **$2\text{KSO}_3\text{NH}_2$**  +  $(\text{NH}_4)_2\text{SO}_4 \rightleftharpoons \text{K}_2\text{SO}_4$   
+  $2\text{NH}_4\text{SO}_3\text{NH}_2 (+ \text{H}_2\text{O})$  ..... II 328  
 **$\text{KSO}_3\text{NH}_2$**  +  $\text{NH}_4\text{SO}_3\text{NH}_2 + \text{H}_2\text{O}$  ..... II 331, 2  
in  $\text{H}_2\text{O}$  ..... II 331  
 **$\text{K}_3\text{SbS}_4$**  in aq. ethyl alc ..... II 333, 4  
in  $\text{H}_2\text{O}$  ..... II 332  
+  $\text{KOH} + \text{H}_2\text{O}$  ..... II 333  
in aq. methyl alc ..... II 333  
 **$\text{K}_2\text{SeO}_3$**  in  $\text{H}_2\text{O}$  ..... II 333  
 **$3\text{K}_2\text{SeO}_4 + 2\text{Al}_2(\text{SO}_4)_3 \rightleftharpoons 2\text{Al}_2(\text{SeO}_4)_3 + 3\text{K}_2\text{SO}_4$**   
(+  $\text{H}_2\text{O}$ ) ..... I 226  
 **$\text{K}_2\text{SeO}_4$**  +  $\text{Al}_2(\text{SeO}_4)_3 + \text{H}_2\text{O}$  ..... I 228  
+  $\text{CaSeO}_4 + \text{H}_2\text{O}$  ..... I 690  
in  $\text{H}_2\text{O}$  ..... II 336  
+  $\text{H}_2\text{O}_2 + \text{H}_2\text{O}$  ..... II 336  
+  $\text{MgSeO}_4 + \text{H}_2\text{O}$  ..... II 331  
+  $\text{Na}_2\text{SeO}_4 + \text{H}_2\text{O}$  ..... II 337  
 **$\text{K}_2\text{Se}_2\text{O}_5$**  in  $\text{H}_2\text{O}$  ..... II 335  
 **$\text{K}_2\text{SiF}_6$**  in aq. ethanol ..... II 338  
in  $\text{H}_2\text{O}$  ..... II 337  
+  $\text{KBr} + \text{H}_2\text{O}$  ..... II 338  
in aq.  $\text{KCl}$  ..... II 338  
in  $\text{KNO}_3$  solns ..... II 338  
in aq. methyl alc +  $\text{KCl}$  ..... II 338  
in aq. methyl alc +  $\text{KCl} + \text{HCl}$  ..... II 338  
 **$\text{K}_2\text{SiO}_3$**  +  $\text{BiTiO}_3$  ..... I 439  
+  $\text{H}_2\text{O}$  ..... II 339  
+  $\text{KF}$  ..... II 211  
+  $2\text{LiF} \rightleftharpoons \text{Li}_2\text{SiO}_3 + 2\text{KF}$  ..... II 211  
+  $\text{Li}_2\text{SiO}_3$  ..... II 440  
+  $\text{PbTiO}_3$  ..... II 1337  
+  $\text{SiO}_2 + \text{H}_2\text{O}$  ..... II 339  
+  $\text{SiO}_2$  ..... II 339  
 **$\text{K}_2\text{Si}_2\text{O}_5$**  +  $\text{H}_2\text{O}$  ..... II 339  
 **$\text{K}(\text{Sm-edta})$**  +  $\text{K}(\text{La-edta}) + \text{H}_2\text{O}$  ..... II 63  
 **$\text{KSnBr}_3$**  in  $\text{H}_2\text{O}$  ..... II 31  
 **$\text{K}_4\text{SnBr}_4$**  in  $\text{H}_2\text{O}$  ..... II 31, 2  
 **$\text{KSnCl}_3 \cdot \text{H}_2\text{O}$**  in  $\text{H}_2\text{O}$  ..... II 150  
 **$\text{K}_2\text{SnCl}_4 \cdot \text{H}_2\text{O}$**  in  $\text{H}_2\text{O}$  ..... II 150  
 **$\text{K}_4\text{SnCl}_6 \cdot \text{H}_2\text{O}$**  in  $\text{H}_2\text{O}$  ..... II 151  
in aq.  $\text{HCl}$  ..... II 151  
 **$\text{K}_2\text{SnO}_3 \cdot 3\text{H}_2\text{O}$**  ..... II 339  
 **$\text{K}_2\text{Sn}(\text{OH})_6$**  ..... II 339  
 **$\text{K}$  salts** +  $\text{K}_2\text{C}_2\text{O}_4$  in  $\text{H}_2\text{O}$  ..... II 109  
 **$\text{K}$  sodium ammonium borates** ..... II 11  
 **$\text{K}$  stearate** in aq. ethyl alc ..... II 66  
 **$\text{K}$  styphnate** in  $\text{H}_2\text{O}$  ..... II 59  
 **$\text{K}$  succinate** in methyl alc ..... II 51  
 **$\text{K}_2\text{ToF}_7$**  in  $\text{HF}$  solns ..... II 215  
+  $\text{HF} + \text{H}_2\text{O}$  ..... II 214, 5  
+  $\text{HF} + \text{K}_2\text{NbF}_7 + \text{H}_2\text{O}$  ..... II 214  
+  $\text{K}_2\text{NbOF}_5 \cdot \text{H}_2\text{O} + \text{H}_2\text{O} (+ \text{HF})$  ..... II 214  
 **$\text{KTaO}_3$**  in  $\text{H}_2\text{O}$  ..... II 339  
+  $\text{KNO}_3$  ..... II 275  
 **$\text{K}$  tartrate esters** ..... II 50  
 **$\text{K}$  tartrate** in aq. electrolytes ..... II 45  
in  $\text{H}_2\text{O}$  ..... II 47  
+  $\text{K}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 48  
+  $\text{KOH} + \text{ethanol} + \text{H}_2\text{O}$  ..... II 279  
+  $\text{KOH} + \text{H}_2\text{O}$  ..... II 48, 277  
in methanol ..... II 46  
+  $\text{Na}$  tartarate +  $\text{H}_2\text{O}$  ..... II 48  
..... II 60  
 **$\text{K}$  tetrachlorophthalate** in  $\text{H}_2\text{O}$  ..... II 7  
 **$\text{K}$  tetraphenyl borate** in  $\text{H}_2\text{O}$  ..... II 339  
 **$\text{K}_2\text{TeO}_4$**  in  $\text{H}_2\text{O}$  ..... II 215  
 **$\text{K}_2\text{ThF}_6$**  in  $\text{H}_2\text{O}$  ..... II 330  
 **$\text{K}$  thionates** in  $\text{H}_2\text{O}$  ..... II 216  
 **$\text{K}_2\text{TiF}_6$**  in ethyl alc ..... II 215, 6  
in  $\text{H}_2\text{O}$  ..... II 169  
+  $\text{KCl}$  ..... II 169  
+  $\text{NaCl} + \text{KCl}$  ..... II 169  
 **$4\text{KTiO}_3 + \text{Li}_4\text{P}_2\text{O}_7 \rightleftharpoons 4\text{LiTiO}_3 + \text{K}_4\text{P}_2\text{O}_7$**  ..... II 292  
 **$\text{K}_2\text{TiO}_3 + \text{KCl}$**  ..... II 339  
+  $\text{K}_2\text{CrO}_4$  ..... II 339  
+  $\text{KF}$  ..... II 211  
+  $\text{KF} + \text{TiO}_2$  ..... II 339  
+  $\text{K}_2\text{MoO}_4$  ..... II 339  
+  $\text{K}_3\text{PO}_4 + \text{K}_4\text{P}_2\text{O}_7$  ..... II 292  
+  $\text{K}_2\text{SO}_4$  ..... II 339  
+  $\text{KVO}_3$  ..... II 339  
+  $\text{K}_2\text{WO}_4$  ..... II 339  
+  $\text{Li}_2\text{TiO}_3$  ..... II 440  
+  $\text{NaCl}$  ..... II 339  
+  $\text{NaF}$  ..... II 339  
+  $2\text{NaF} \rightleftharpoons 2\text{KF} + \text{Na}_2\text{TiO}_3$  ..... II 339  
+  $2\text{NaF} \rightleftharpoons \text{Na}_2\text{TiO}_3 + 2\text{KF}$  ..... II 211  
+  $\text{PbMoO}_4 \rightleftharpoons \text{PbTiO}_3 + \text{K}_2\text{MoO}_4$  ..... II 246  
+  $\text{TiO}_2$  ..... II 339  
+  $\text{TiO}_2 + \text{K}_4\text{P}_2\text{O}_7$  ..... II 292  
 **$\text{K}_2\text{Ti}_2\text{O}_5 + \text{KF}$**  ..... II 211  
 **$\text{K}$  tri fluoro acetate** ..... II 38  
 **$\text{K}(\text{UO}_2)\text{AsO}_4$**  in  $\text{H}_2\text{O} + \text{H}_2\text{SO}_4 + \text{HNO}_3$  ..... II 7  
 **$\text{K}$  urate** in  $\text{H}_2\text{O}$  ..... II 51  
 **$\text{KVO}_3 + \text{KCl} + \text{H}_2\text{O}$**  ..... II 340  
+  $\text{KF}$  ..... II 211  
+  $\text{KNO}_3 + \text{H}_2\text{O}$  ..... II 258  
+  $\text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 302  
+  $\text{K}_2\text{TiO}_3$  ..... II 339  
+  $\text{NaCl} \rightleftharpoons \text{NaVO}_3 + \text{KCl}$  ..... II 169  
+  $\text{NaF} \rightleftharpoons \text{NaVO}_3 + \text{KF}$  ..... II 211  
+  $\text{PbTiO}_3$  ..... II 1337  
+  $\text{V}_2\text{O}_5$  ..... II 340  
 **$\text{K}_3\text{V}_5\text{O}_{14} \cdot 5\text{H}_2\text{O}$**  in  $\text{H}_2\text{O}$  ..... II 340  
 **$\text{K}_2\text{WO}_4 + \text{KBO}_2$**  ..... II 11  
+  $\text{KCl}$  ..... II 169  
+  $\text{KCl} + \text{KBO}_2$  ..... II 11  
+  $\text{K}_2\text{CrO}_4$  ..... II 196  
+  $\text{KF}$  ..... II 211  
+  $\text{K}_2\text{MoO}_4$  ..... II 246  
+  $\text{KNO}_3$  ..... II 274  
+  $\text{K}_4\text{P}_2\text{O}_7$  ..... II 292, 340  
+  $\text{K}_2\text{SO}_4$  ..... II 324  
+  $\text{K}_2\text{TiO}_3$  ..... II 339  
+  $2\text{LiBO}_2 \rightleftharpoons \text{Li}_2\text{WO}_4 + 2\text{KBO}_2$  ..... II 326  
+  $\text{Li}_2\text{SO}_4 \rightleftharpoons \text{Li}_2\text{WO}_4 + \text{K}_2\text{SO}_4$  ..... II 441, 340  
+  $\text{Li}_2\text{WO}_4$  ..... II 169  
+  $2\text{NaCl} \rightleftharpoons \text{Na}_2\text{WO}_4 + 2\text{KCl}$  ..... II 211  
+  $2\text{NaF} \rightleftharpoons \text{Na}_2\text{WO}_4 + 2\text{KF}$  ..... II 211  
+  $\text{Na}_2\text{MoO}_4 \rightleftharpoons \text{Na}_2\text{WO}_4 + \text{K}_2\text{MoO}_4$  ..... II 246  
 **$2\text{K}_2\text{WO}_4 + \text{Na}_2\text{P}_2\text{O}_7 \rightleftharpoons \text{K}_4\text{P}_2\text{O}_7 + 2\text{Na}_2\text{WO}_4$**  ..... II 340  
+  $\text{Na}_4\text{P}_2\text{O}_7 \rightleftharpoons 2\text{Na}_2\text{WO}_4 + \text{K}_4\text{P}_2\text{O}_7$  ..... II 292  
 **$\text{K}_2\text{WO}_4 + \text{Na}_2\text{WO}_4$**  ..... II 340  
+  $\text{Na}_2\text{WO}_4 + \text{WO}_3 + \text{W}$  ..... II 340  
+  $\text{PbSO}_4 \rightleftharpoons \text{PbWO}_4 + \text{K}_2\text{SO}_4$  ..... II 326  
+  $\text{WO}_3$  ..... II 340  
+  $\text{WO}_3 + \text{W}$  ..... II 340  
 **$\text{K}_2\text{W}_2\text{O}_7 + \text{K}_2\text{Cr}_2\text{O}_7$**  ..... II 202  
+  $\text{K}_2\text{MoO}_4$  ..... II 246  
 **$\text{K}_2\text{Zn}(\text{CN})_4$**  in  $\text{H}_2\text{O}$  ..... II 75  
+  $2\text{KOH} = \text{Zn} + 4\text{KCN} + \text{O} + \text{H}_2\text{O}$  ..... II 1644  
 **$\text{K}_2\text{Zn}_3\text{F}(\text{CH}_3)_2$**  in  $\text{H}_2\text{O}$  ..... II 1656  
 **$\text{K}_2\text{Zn}(\text{SO}_4)_2$**  in  $\text{H}_2\text{O}$  ..... II 321  
+  $\text{K}_2\text{Cu}(\text{SO}_4)_2 + \text{H}_2\text{O}$  ..... I 980  
 **$\text{K}_2\text{Zn}(\text{SO}_4)_2 + \text{K}_2\text{Fe}(\text{SO}_4)_2 + \text{H}_2\text{O}$**  ..... I 1054  
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+ <b>MgF<sub>2</sub></b> .....	II 498
+ <b>MgF<sub>2</sub></b> .....	II 414
+ <b>MgF<sub>2</sub></b> + <b>NaF</b> .....	II 414
+ <b>MoO<sub>3</sub></b> .....	II 414
+ <b>NaBr</b> = <b>NaF</b> + <b>LiBr</b> .....	II 371
<b>2LiF</b> + <b>Na<sub>2</sub>CO<sub>3</sub></b> = <b>2NaF</b> + <b>Li<sub>2</sub>CO<sub>3</sub></b> .....	II 390
<b>LiF</b> + <b>NaF</b> .....	II 414
+ <b>NaF</b> + <b>KF</b> .....	II 211
<b>2LiF</b> + <b>Na<sub>2</sub>SO<sub>4</sub></b> = <b>Li<sub>2</sub>SO<sub>4</sub></b> + <b>2NaF</b> .....	II 414
+ <b>Na<sub>2</sub>TiO<sub>3</sub></b> = <b>NaF</b> + <b>Li<sub>2</sub>TiO<sub>3</sub></b> .....	II 1040
<b>LiF</b> + <b>PbSO<sub>4</sub></b> = <b>PbF<sub>2</sub></b> + <b>Li<sub>2</sub>SO<sub>4</sub></b> .....	II 1299
<b>2LiF</b> + <b>Rb<sub>2</sub>CO<sub>3</sub></b> = <b>2RbF</b> + <b>Li<sub>2</sub>CO<sub>3</sub></b> .....	II 390
<b>LiF</b> + <b>RbF</b> .....	II 414
in several solvents .....	II 413
<b>2LiF</b> + <b>SrCl<sub>2</sub></b> = <b>SrF<sub>2</sub></b> + <b>2LiCl</b> .....	II 406
<b>LiF</b> + <b>SrF<sub>2</sub></b> .....	II 414
+ <b>UF<sub>2</sub></b> .....	II 1609
+ <b>WO<sub>3</sub></b> .....	II 414
+ <b>YF<sub>3</sub></b> .....	II 414
<b>Li<sub>4</sub>Fe(CN)<sub>6</sub>·3C<sub>2</sub>O<sub>2</sub>Fe(CN)<sub>6</sub></b> .....	I 796
+ <b>InCl<sub>3</sub></b> + <b>H<sub>2</sub>O</b> .....	I 1296
<b>Li formate</b> + formic acid .....	II 372
+ <b>H<sub>2</sub>O</b> .....	II 372
+ <b>NaNO<sub>3</sub></b> = <b>Na formate</b> + <b>LiNO<sub>3</sub></b> .....	II 853
<b>Li<sub>2</sub>GeF<sub>6</sub></b> in <b>H<sub>2</sub>O</b> .....	I 1073
<b>LiGeO<sub>3</sub></b> .....	II 414
<b>LiH(AlO<sub>2</sub>)<sub>2</sub>·SH<sub>2</sub>O</b> in <b>H<sub>2</sub>O</b> .....	II 362
<b>LiHCO<sub>3</sub></b> + <b>Li<sub>2</sub>CO<sub>3</sub></b> + <b>H<sub>2</sub>O</b> .....	II 384
<b>LiH</b> + <b>Li</b> .....	II 362
<b>LiH<sub>2</sub>PO<sub>4</sub></b> in <b>H<sub>2</sub>O</b> .....	II 431
<b>Li<sub>2</sub>HPO<sub>3</sub></b> in <b>H<sub>2</sub>O</b> .....	II 431

<b>Li hippurate</b> in <b>H<sub>2</sub>O</b> .....	II 378
<b>Li hydroxybenzoates</b> in <b>H<sub>2</sub>O</b> .....	II 378
<b>LiI</b> + <b>AgI</b> .....	II 416
+ <b>BiI<sub>3</sub></b> + <b>H<sub>2</sub>O</b> .....	I 432
+ <b>CsBr</b> .....	II 417
+ <b>CsBr</b> .....	I 875
+ <b>CsCl</b> .....	II 417
+ <b>CsCl</b> .....	I 886
+ <b>CsF</b> .....	II 417
+ <b>CsF</b> .....	I 889
dist. betw. ethylene glycol + ethyl acetate .....	II 416
dist. betw. <b>H<sub>2</sub>O</b> + nitrobenzene .....	II 416
in <b>H<sub>2</sub>O</b> .....	II 414
<b>2LiI·HgI<sub>2</sub></b> in <b>H<sub>2</sub>O</b> .....	II 416
+ <b>I<sub>2</sub></b> .....	I 1287
+ <b>InI<sub>3</sub></b> + <b>H<sub>2</sub>O</b> .....	I 1298
<b>LiI</b> + <b>KCl</b> .....	II 417
+ <b>KF</b> .....	II 212
+ <b>KF</b> .....	II 417
+ <b>LiOH</b> .....	II 431
+ <b>NH<sub>4</sub>I</b> .....	II 416
+ <b>NaBr</b> .....	II 417
+ <b>NaCl</b> .....	II 417
+ <b>NaF</b> .....	II 417
+ <b>PbI</b> + <b>H<sub>2</sub>O</b> .....	II 415
<b>Li propionate</b> + <b>NaNO<sub>3</sub></b> = <b>Na propionate</b> + <b>LiNO<sub>3</sub></b> .....	II 860, 862
<b>LiI</b> + <b>RbCl</b> .....	II 417
+ <b>RbF</b> .....	II 417
+ <b>SbI<sub>3</sub></b> + <b>H<sub>2</sub>O</b> .....	II 415
in several solvents .....	II 416
<b>LiIe<sub>2</sub>·LiOH·9H<sub>2</sub>O</b> .....	I 1300
+ <b>LiOH·2LiCl</b> .....	I 1300
<b>4LiIe<sub>2</sub>·2LiOH·LiCl·10H<sub>2</sub>O</b> .....	I 1300
<b>LiIO<sub>3</sub></b> + <b>AgIO<sub>3</sub></b> + <b>H<sub>2</sub>O</b> .....	I 104
in <b>H<sub>2</sub>O</b> .....	II 417
+ <b>HI</b> + <b>H<sub>2</sub>O</b> .....	II 418
<b>Li isurate</b> in <b>H<sub>2</sub>O</b> .....	II 382
<b>Li mandelate</b> + mandelic acid + <b>H<sub>2</sub>O</b> .....	II 380, 1
<b>Li methionate</b> in <b>H<sub>2</sub>O</b> .....	II 372
<b>Lime</b> see <b>CaO</b> , <b>Ca(OH)<sub>2</sub></b>	
<b>LiMeO<sub>4</sub></b> in <b>H<sub>2</sub>O</b> .....	II 419
<b>Li<sub>2</sub>MeO<sub>4</sub></b> + <b>Ag<sub>2</sub>SO<sub>4</sub></b> = <b>Li<sub>2</sub>SO<sub>4</sub></b> + <b>Ag<sub>2</sub>MoO<sub>4</sub></b> .....	II 419
+ <b>CaCl<sub>2</sub></b> = <b>2LiCl</b> + <b>CdMoO<sub>4</sub></b> .....	II 419
in <b>H<sub>2</sub>O</b> .....	II 419
+ <b>K<sub>2</sub>MoO<sub>4</sub></b> .....	II 246
+ <b>K<sub>2</sub>SO<sub>4</sub></b> = <b>Li<sub>2</sub>SO<sub>4</sub></b> + <b>K<sub>2</sub>MoO<sub>4</sub></b> .....	II 246
+ <b>LiF</b> .....	II 414
+ <b>Li<sub>2</sub>SO<sub>4</sub></b> .....	II 439
+ <b>MoO<sub>3</sub></b> .....	II 419
+ <b>Na<sub>2</sub>MoO<sub>4</sub></b> .....	II 419
<b>Li myristate</b> in <b>H<sub>2</sub>O</b> .....	II 382
<b>LiH<sub>3</sub></b> in <b>H<sub>2</sub>O</b> .....	II 420
<b>LiNH<sub>4</sub>SO<sub>4</sub></b> in <b>H<sub>2</sub>O</b> .....	II 437
<b>LiNH<sub>4</sub> d-tartrate</b> + <b>LiNH<sub>4</sub> l-tartrate</b> + <b>H<sub>2</sub>O</b> .....	II 376
<b>LiNO<sub>2</sub></b> in <b>H<sub>2</sub>O</b> .....	II 420, 1
<b>LiNO<sub>3</sub></b> + <b>AgNO<sub>3</sub></b> .....	I 123
+ acetic acid .....	II 426
+ <b>AgCl</b> = <b>AgNO<sub>3</sub></b> + <b>LiCl</b> .....	I 78
+ <b>Ba(NO<sub>3</sub>)<sub>2</sub></b> .....	I 377
+ <b>Ba(NO<sub>3</sub>)<sub>2</sub></b> + <b>KNO<sub>3</sub></b> .....	I 377
+ t-butyl alc + <b>H<sub>2</sub>O</b> .....	II 425
+ <b>Ca(NO<sub>3</sub>)<sub>2</sub></b> .....	II 629
+ <b>Cd(NO<sub>3</sub>)<sub>2</sub></b> .....	I 744
+ <b>Cd(NO<sub>3</sub>)<sub>2</sub></b> + <b>KNO<sub>3</sub></b> .....	I 744
+ <b>CaNO<sub>3</sub></b> .....	I 899
+ dioxane + <b>H<sub>2</sub>O</b> .....	II 425
+ ethanol + <b>H<sub>2</sub>O</b> .....	II 424, 5
extr. by ether .....	II 425
+ guanidine nitrate + <b>NH<sub>4</sub>NO<sub>3</sub></b> .....	II 728
+ guanidine nitrate .....	II 427
in <b>H<sub>2</sub>O</b> .....	II 421
in <b>H<sub>2</sub>O<sub>2</sub></b> + <b>H<sub>2</sub>O</b> .....	II 422
in <b>HNO<sub>3</sub></b> .....	II 427
+ <b>K acetate</b> = <b>Li acetate</b> + <b>KNO<sub>3</sub></b> .....	II 38
+ <b>KNO<sub>3</sub></b> .....	II 274
+ <b>KOH</b> = <b>LiOH</b> + <b>KNO<sub>3</sub></b> .....	II 276
<b>2LiNO<sub>3</sub></b> + <b>K<sub>2</sub>SO<sub>4</sub></b> = <b>2KNO<sub>3</sub></b> + <b>Li<sub>2</sub>SO<sub>4</sub></b> .....	II 326
<b>LiNO<sub>3</sub></b> + <b>LiCl</b> .....	II 406
+ <b>LiCl</b> in dioxane + iso amyl alc. .....	II 403
+ <b>LiClO<sub>4</sub></b> .....	II 427
+ <b>LiOH</b> .....	II 427
+ <b>Li<sub>2</sub>SO<sub>4</sub></b> .....	II 427

- $+ \text{Li}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 422  
 $+ \text{NH}_3$  ..... II 427  
 $+ \text{NH}_4\text{NO}_3$  ..... II 427  
 $+ \text{NH}_4\text{NO}_3$  ..... II 727  
 $+ \text{NH}_4\text{NO}_3 + \text{H}_2\text{O}$  ..... II 423  
 $+ \text{NH}_4\text{NO}_3 + \text{NaNO}_3$  ..... II 727  
 $+ \text{N}_2\text{H}_4 \cdot \text{HNO}_3$  ..... II 427  
 $+ \text{N}_2\text{H}_4\text{HNO}_3$  ..... II 786  
 $+ \text{Na acetate} \rightleftharpoons \text{Li acetate} + \text{NaNO}_3$  ..... II 373  
 $+ \text{Na butyrate} \rightleftharpoons \text{NaNO}_3 + \text{Li butyrate}$  ..... II 862  
 $+ \text{NaCl}$  ..... II 427  
 $+ \text{NaCl} \rightleftharpoons \text{NaNO}_3 + \text{LiCl}$  ..... II 406  
 $+ \text{Na formate} \rightleftharpoons \text{NaNO}_3 + \text{Li formate}$  ..... II 853  
 $+ \text{NaNO}_3$  ..... II 427  
 $+ \text{NaNO}_3 + \text{Cd}(\text{NO}_3)_2$  ..... II 744  
 $+ \text{NaNO}_3 + \text{NH}_4\text{NO}_3$  ..... II 427  
 $+ \text{NaOH} \rightleftharpoons \text{LiOH} + \text{NaNO}_3$  ..... II 427  
**2LiNO<sub>3</sub> + Na<sub>2</sub>SO<sub>4</sub>  $\rightleftharpoons$  Li<sub>2</sub>SO<sub>4</sub> + 2NaNO<sub>3</sub>** ..... II 427  
**LiNO<sub>3</sub> + PbNC<sub>3</sub> + H<sub>2</sub>O** ..... II 424  
 $+ \text{Na propionate} \rightleftharpoons \text{NaNO}_3 + \text{Li propionate}$  ..... II 860  
 $+ \text{RbNO}_3$  ..... II 427  
 $+ \text{RbNO}_3 + \text{AgNO}_3$  ..... II 1377  
**2LiNO<sub>3</sub> + SrCl<sub>2</sub>  $\rightleftharpoons$  SrCl<sub>2</sub> + 2LiCl** ..... II 1502  
**LiNO<sub>3</sub> + Sr(NO<sub>3</sub>)<sub>2</sub>** ..... II 1513  
 $+ \text{TINO}_3$  ..... II 427  
 $+ \text{TINO}_3 + \text{KNO}_3$  ..... II 274  
 $+ \text{urea}$  ..... II 426  
in various solvents ..... II 426  
in H<sub>2</sub>O ..... II 427  
**Li nitrile diphenyl ethyl succinate in H<sub>2</sub>O** ..... II 381  
**Li<sub>2</sub>O + As<sub>2</sub>O<sub>3</sub> + H<sub>2</sub>O** ..... II 362  
 $+ \text{B}_2\text{O}_3$  ..... II 431  
 $+ \text{B}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 363, 4  
 $+ \text{B}_2\text{O}_5$  ..... II 431  
 $+ \text{BeO} + \text{B}_2\text{O}_3$  ..... I 400  
 $+ \text{CrO}_3 + \text{H}_2\text{O}$  ..... II 412  
 $+ \text{I}_2\text{O}_7 + \text{H}_2\text{O}$  ..... II 418, 9  
 $+ \text{P}_2\text{O}_5 + \text{H}_2\text{O}$  ..... II 431, 2  
 $+ \text{SiO}_2$  ..... II 431  
 $+ \text{TeO}_3 + \text{H}_2\text{O}$  ..... II 441  
 $+ \text{V}_2\text{O}_5$  ..... II 431  
**LiOH + acetone H<sub>2</sub>O** ..... II 430  
 $+ \text{dioxane} + \text{H}_2\text{O}$  ..... II 430  
in H<sub>2</sub>O ..... II 428  
 $+ \text{H}_2\text{O}_2 + \text{H}_2\text{O}$  ..... II 428, 9  
 $+ \text{KBr} \rightleftharpoons \text{KOH} + \text{LiBr}$  ..... II 31  
 $+ \text{KOH}$  ..... II 280  
 $+ \text{KCl} \rightleftharpoons \text{KOH} + \text{LiCl}$  ..... II 169  
**2LiOH + K<sub>2</sub>CrO<sub>4</sub>  $\rightleftharpoons$  2KOH + Li<sub>2</sub>CrO<sub>4</sub>** ..... II 196  
**LiOH + KNO<sub>3</sub>  $\rightleftharpoons$  KOH + LiNO<sub>3</sub>** ..... II 274  
 $+ \text{LiBr}$  ..... II 371  
 $+ \text{LiCl}$  ..... II 405  
 $+ \text{Li}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 385  
 $+ \text{Li}_2\text{CrO}_4$  ..... II 411  
 $+ \text{LiF}$  ..... II 414  
 $+ \text{LiI}$  ..... II 431  
 $+ \text{LiInS}_2 \cdot 2\text{LiCl}$  ..... I 1300  
 $+ \text{LiInS}_2 \cdot 9\text{H}_2\text{O}$  ..... I 1300  
**4LiOH · 4LiInS<sub>2</sub> · LiCl · 10H<sub>2</sub>O** ..... I 1300  
**LiOH + LiNO<sub>3</sub>** ..... II 427  
 $+ \text{Li}_3\text{SbS}_4 + \text{H}_2\text{O}$  ..... II 429  
**2LiOH + Na<sub>2</sub>CrO<sub>4</sub>  $\rightleftharpoons$  2NaOH + Li<sub>2</sub>CrO<sub>4</sub>** ..... II 411  
 $+ \text{NaOH}$  ..... II 431  
 $+ \text{NaNO}_3 \rightleftharpoons \text{NaOH} + \text{LiNO}_3$  ..... II 427  
 $+ \text{phenol} + \text{H}_2\text{O}$  ..... II 430  
**Li oleate in H<sub>2</sub>O** ..... II 382  
**2LiPO<sub>3</sub> + K<sub>2</sub>SO<sub>4</sub>  $\rightleftharpoons$  Li<sub>2</sub>SO<sub>4</sub> + 2KPO<sub>3</sub>** ..... II 292  
**LiPO<sub>3</sub> + KPO<sub>3</sub>** ..... II 292  
 $+ \text{Li}_2\text{SO}_4$  ..... II 439  
**Li<sub>2</sub>PO<sub>3</sub> in H<sub>2</sub>O** ..... II 432  
**Li<sub>3</sub>PO<sub>4</sub> in H<sub>2</sub>O** ..... II 431  
**2Li<sub>3</sub>PO<sub>4</sub> + 3K<sub>2</sub>SO<sub>4</sub>  $\rightleftharpoons$  2K<sub>3</sub>PO<sub>4</sub> + Li<sub>2</sub>SO<sub>4</sub>** ..... II 326  
**Li<sub>4</sub>P<sub>2</sub>O<sub>6</sub> in H<sub>2</sub>O** ..... II 432  
**Li<sub>4</sub>P<sub>2</sub>O<sub>7</sub> + 4K<sub>2</sub>TiO<sub>3</sub>  $\rightleftharpoons$  4LiTiO<sub>3</sub> + K<sub>4</sub>P<sub>2</sub>O<sub>7</sub>** ..... II 292  
**Li<sub>2</sub>P(CN)<sub>4</sub> in H<sub>2</sub>O** ..... II 383  
 $+ \text{K}_2\text{P(CN)}_4 + \text{H}_2\text{O}$  ..... II 383  
**Li palmitate in H<sub>2</sub>O** ..... II 382  
**Li periodates** ..... II 418  
**Li phenyl acetate + phenyl acetic acid** ..... II 374  
**Li phenyl acetate + phenyl acetic anhydride** ..... II 374  
**Li phthalate + Mg phthalate + H<sub>2</sub>O** ..... II 380  
 $+ \text{phthalic acid} + \text{H}_2\text{O}$  ..... II 379  
**LiReO<sub>4</sub> distr. between nitromethane + H<sub>2</sub>O** ..... II 433  
in H<sub>2</sub>O ..... II 433  
**Li<sub>2</sub>S + S** ..... II 433  
**LiSCN in H<sub>2</sub>O** ..... II 384  
**Li<sub>2</sub>SO<sub>4</sub> in acetic acid** ..... II 435  
 $+ 2\text{AgCl} \rightleftharpoons \text{Ag}_2\text{SO}_4 + 2\text{LiCl}$  ..... II 406  
 $+ 2\text{AgCl} \rightleftharpoons \text{Ag}_2\text{SO}_4 + 2\text{LiCl}$  ..... I 78  
 $+ \text{Ag}_2\text{MoO}_4 \rightleftharpoons \text{Ag}_2\text{SO}_4 + \text{Li}_2\text{MoO}_4$  ..... II 419  
 $+ \text{Ag}_2\text{SO}_4$  ..... II 439  
 $+ \text{Ag}_2\text{SO}_4$  ..... I 143  
 $+ \text{Ag}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... I 137  
 $+ \text{Al}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$  ..... I 217, 218  
in aq. alc. .... II 438  
 $+ \text{BaSO}_4$  ..... I 393  
 $+ \text{Bi}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$  ..... I 439  
 $+ \text{BiTiO}_3$  ..... I 349  
 $+ \text{CaSO}_4$  ..... I 687, 762  
 $+ \text{CdCl}_2 \rightleftharpoons \text{CdSO}_4 + 2\text{LiCl}$  ..... I 728  
 $+ \text{CdSO}_4 + \text{H}_2\text{O}$  ..... I 754  
 $+ \text{CdSO}_4 + \text{K}_2\text{SO}_4 + 2\text{LiCl}$  ..... II 326  
 $+ \text{CoCl}_2 \rightleftharpoons \text{CoSO}_4 + 2\text{LiCl}$  ..... I 818  
 $+ \text{CoSO}_4$  ..... I 856  
 $+ 2\text{CsCl} \rightleftharpoons \text{Cs}_2\text{SO}_4 + 2\text{LiCl}$  ..... I 885  
 $+ \text{Cs}_2\text{SO}_4$  ..... I 903  
 $+ \text{CuSO}_4 + \text{H}_2\text{O}$  ..... I 988  
 $+ \text{CuSO}_4 + (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  ..... I 983  
 $+ \text{FeSO}_4 + \text{H}_2\text{O}$  ..... I 1054  
in H<sub>2</sub>O ..... II 434  
in H<sub>2</sub>O<sub>2</sub> + H<sub>2</sub>O ..... II 435  
 $+ \text{H}_2\text{SO}_4$  ..... II 439  
in H<sub>2</sub>SO<sub>4</sub> solns ..... II 435  
 $+ 2\text{KBO}_2 \rightleftharpoons \text{K}_2\text{SO}_4 + 2\text{LiBO}_3$  ..... II 11  
 $+ 2\text{KCl} \rightleftharpoons \text{K}_2\text{SO}_4 + 2\text{LiCl}$  ..... II 169  
 $+ \text{K}_2\text{CrO}_4 \rightleftharpoons \text{K}_2\text{SO}_4 + \text{Li}_2\text{CrO}_4$  ..... II 196  
 $+ \text{K}_2\text{MoO}_4 \rightleftharpoons \text{K}_2\text{SO}_4 + \text{Li}_2\text{MoO}_4$  ..... II 246  
 $+ 2\text{KNO}_3 \rightleftharpoons 2\text{LiNO}_3 + \text{K}_2\text{SO}_4$  ..... II 326  
 $+ 2\text{KPO}_3 \rightleftharpoons \text{K}_2\text{SO}_4 + 2\text{LiPO}_3$  ..... II 293  
**2Li<sub>2</sub>SO<sub>4</sub> + 2K<sub>3</sub>PO<sub>4</sub>  $\rightleftharpoons$  2Li<sub>3</sub>PO<sub>4</sub> + 3K<sub>2</sub>SO<sub>4</sub>** ..... II 326  
**Li<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>SO<sub>4</sub>** ..... II 326  
 $+ \text{K}_2\text{SO}_4$  ..... II 439  
 $+ \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 304, 5  
 $+ \text{K}_2\text{SO}_4 + \text{Ti}_2\text{SO}_4$  ..... II 326  
 $+ \text{K}_2\text{WO}_4 \rightleftharpoons \text{Li}_2\text{WO}_4 + \text{K}_2\text{SO}_4$  ..... II 326  
 $+ \text{LiBO}_2 \rightleftharpoons \text{Li}_2\text{WO}_4 + \text{Li}_2\text{CrO}_4$  ..... II 366  
 $+ \text{LiCl}$  ..... II 405  
 $+ \text{LiCl}$  ..... II 439  
 $+ \text{LiCl} + \text{H}_2\text{O}$  ..... II 436  
 $+ \text{LiCl} + \text{Li}_2\text{CO}_3$  ..... II 390  
 $+ \text{Li}_2\text{CO}_3$  ..... I 390  
 $+ \text{Li}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 386  
 $+ \text{Li}_2\text{MoO}_4$  ..... II 439  
 $+ \text{LiNO}_3$  ..... II 427  
 $+ \text{LiNO}_3 + \text{H}_2\text{O}$  ..... II 422  
 $+ \text{LiPO}_3$  ..... II 439  
 $+ \text{Li}_2\text{WO}_4$  ..... II 439  
 $+ \text{Li}_2\text{WO}_4 + \text{LiCl}$  ..... II 406  
 $+ \text{MnSO}_4$  ..... II 439  
 $+ (\text{NH}_4)_2\text{SO}_4 + \text{alc.} + \text{H}_2\text{O}$  ..... II 437  
 $+ (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 436, 7  
 $+ (\text{NH}_4)_2\text{SO}_4 + \text{FeSO}_4 + \text{H}_2\text{O}$  ..... I 1054  
 $+ (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 437  
 $+ \text{Na}_2\text{CO}_3 \rightleftharpoons \text{Na}_2\text{SO}_4 + \text{Li}_2\text{CO}_3$  ..... II 390  
 $+ \text{NaCl} + \text{KCl}$  ..... II 169  
 $+ 2\text{NaCl} \rightleftharpoons \text{Na}_2\text{SO}_4 + 2\text{LiCl}$  ..... II 406  
 $+ 2\text{NaF} \rightleftharpoons \text{Na}_2\text{SO}_4 + 2\text{LiF}$  ..... II 414  
 $+ 2\text{NaNO}_3 \rightleftharpoons \text{Na}_2\text{SO}_4 + 2\text{LiNO}_3$  ..... II 427  
 $+ \text{Na}_2\text{SO}_4$  ..... II 439  
 $+ \text{Na}_2\text{SO}_4$  ..... II 1149  
 $+ \text{Na}_2\text{SO}_4 + \text{CaSO}_4$  ..... II 1149  
 $+ \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 438  
 $+ \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1136, 7  
 $+ \text{Na}_2\text{SO}_4 + \text{K}_2\text{SO}_4$  ..... II 326  
 $+ \text{PbF}_2 \rightleftharpoons \text{PbSO}_4 + 2\text{LiF}$  ..... II 1299  
 $+ \text{PbSO}_4$  ..... II 439  
 $+ \text{PbWO}_4 \rightleftharpoons \text{Li}_2\text{WO}_4 + \text{PbSO}_4$  ..... II 439  
 $+ \text{SrCl}_2 \rightleftharpoons \text{SrSO}_4 + 2\text{LiCl}$  ..... II 1502  
 $+ \text{SrSO}_4$  ..... II 439  
 $+ 2\text{TiCl} \rightleftharpoons \text{Ti}_2\text{SO}_4 + 2\text{LiCl}$  ..... II 1578  
 $+ \text{ZnCl}_2 \rightleftharpoons 2\text{LiCl} + \text{ZnSO}_4$  ..... II 406  
 $+ \text{ZnSO}_4$  ..... II 439  
**Li<sub>3</sub>SbS<sub>4</sub> in aq. alc.** ..... II 433  
in H<sub>2</sub>O ..... II 433

+ LiOH + H <sub>2</sub> O	II 429
4Li <sub>2</sub> SeO <sub>3</sub> in H <sub>2</sub> O	II 439
Li <sub>2</sub> SeO <sub>4</sub>	II 439
+ H <sub>2</sub> O <sub>2</sub> + H <sub>2</sub> O	II 439
Li <sub>2</sub> SiO <sub>3</sub> + BaF <sub>2</sub> = 2LiF + BaSi <sub>2</sub> C <sub>3</sub>	II 440
+ BaSiC <sub>3</sub>	I 400
+ BiTiC <sub>3</sub>	I 439
+ CaF <sub>2</sub>	I 603
+ CaF <sub>2</sub> = CaSiC <sub>3</sub> + 2LiF	I 603
+ CoSiC <sub>3</sub>	I 693
+ 2KF = 2LiF + K <sub>2</sub> SiC <sub>3</sub>	II 211
+ K <sub>2</sub> SiC <sub>3</sub>	II 440
+ Li <sub>2</sub> BC <sub>2</sub>	II 366
+ LiF	II 414
+ Na <sub>2</sub> SiC <sub>3</sub>	II 440
Li <sub>2</sub> SiO <sub>4</sub> + Ca <sub>2</sub> SiO <sub>4</sub>	II 440
+ ZrSiC <sub>4</sub>	II 440
Li <sub>2</sub> Se(OH) <sub>4</sub> in H <sub>2</sub> O	II 440
+ 2H <sub>2</sub> O in H <sub>2</sub> C	II 440
Li salicylate in aq. ethanol	II 378
in propyl alc.	II 378
Li stearate + cetane	II 383
in decalin	II 383
in H <sub>2</sub> C	II 382
Li <sub>2</sub> TiF <sub>6</sub> in ethyl alc.	II 414
in H <sub>2</sub> O	II 413
LiTaO <sub>3</sub> in H <sub>2</sub> O	II 440
4LiTiO <sub>3</sub> + K <sub>4</sub> P <sub>2</sub> O <sub>7</sub> = 4KTiC <sub>3</sub> + Li <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 292
Li <sub>2</sub> TiO <sub>3</sub>	II 440
+ KF	II 440
+ K <sub>4</sub> P <sub>2</sub> O <sub>7</sub>	II 440
+ K <sub>2</sub> TiC <sub>3</sub>	II 440
in Li salts	II 440
+ NaF	II 440
+ NaF	II 1040
+ NaF = Na <sub>2</sub> TiC <sub>3</sub> + 2LiF	II 1040
+ Na <sub>2</sub> TiO <sub>3</sub>	II 440
+ Na <sub>2</sub> TiO <sub>3</sub>	II 1171
+ RbF	II 440
Li tartrate derivatives in H <sub>2</sub> C	II 375
Li tartrate in H <sub>2</sub> C	II 374
+ NH <sub>4</sub> tartrate + H <sub>2</sub> O	II 375, 6
Li tellurates	II 441
Li(UO <sub>2</sub> ) <sub>2</sub> AsO <sub>4</sub> in H <sub>2</sub> SO <sub>4</sub> + HNC <sub>3</sub>	II 363
LiVO <sub>3</sub> + LiCl	II 406
+ LiF	II 414
Li <sub>2</sub> VO <sub>4</sub> in H <sub>2</sub> O	II 441
2Li <sub>2</sub> VO <sub>4</sub> + 3PbCl <sub>2</sub> = Pb <sub>3</sub> (VO <sub>4</sub> ) <sub>2</sub> + 6LiCl	II 406
Li <sub>2</sub> WO <sub>4</sub> + 2KBC <sub>2</sub> = K <sub>2</sub> WO <sub>4</sub> + 2LiBO <sub>2</sub>	II 11
+ K <sub>2</sub> SO <sub>4</sub> = K <sub>2</sub> WO <sub>4</sub> + Li <sub>2</sub> SO <sub>4</sub>	II 326
+ K <sub>2</sub> WO <sub>4</sub>	II 340
+ K <sub>2</sub> WO <sub>4</sub>	II 441
+ LiBC <sub>2</sub>	II 366
+ LiCl	II 405
+ LiCl + Li <sub>2</sub> SO <sub>4</sub>	II 406
+ Li <sub>2</sub> CrO <sub>4</sub>	II 411
+ LiF	II 414
+ Li <sub>2</sub> SO <sub>4</sub>	II 439
+ Na <sub>2</sub> WO <sub>4</sub>	II 441
+ PbSO <sub>4</sub> = PbWO <sub>4</sub> + Li <sub>2</sub> SO <sub>4</sub>	II 439
+ WO <sub>3</sub>	II 441
Li <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 441
Leitidine + SO <sub>2</sub>	II 1421
Malachite in H <sub>2</sub> O, aq. CO <sub>2</sub>	I 924
Mandelic acid + Cs mandelate + H <sub>2</sub> O	I 878
Mandelic acid + K mandelate + H <sub>2</sub> O	II 56, 7
+ Li mandelate + H <sub>2</sub> O	II 380, 1
+ Mg mandelates + H <sub>2</sub> O	II 460
+ Na mandelate + H <sub>2</sub> O	II 884
+ NH <sub>3</sub> mandelate + H <sub>2</sub> O	II 629, 30
+ NH <sub>4</sub> mandelate + H <sub>2</sub> O	II 629
+ Rb mandelate + H <sub>2</sub> O	II 1360
+ Sr mandelate + H <sub>2</sub> O	II 1490
+ Tl mandelate + H <sub>2</sub> O	II 1560
Mannitol + H <sub>3</sub> BO <sub>3</sub> + H <sub>2</sub> O	I 278
Mannitol + NH <sub>4</sub> NO <sub>3</sub>	II 728
Mesitylene + HBr	I 1105
+ SbBr <sub>3</sub>	II 1425
+ SbCl <sub>3</sub>	II 1432
Metal oxides in NaPO <sub>3</sub>	II 1109
in Na <sub>2</sub> P <sub>2</sub> O <sub>7</sub> melts	II 1108
Metal sulfides in H <sub>2</sub> O	II 1680

Methane + Kr	II 343
+ CO <sub>2</sub> (L-V)	I 491
+ H <sub>2</sub>	I 1095
+ H <sub>2</sub> + ethane	I 1095
+ H <sub>2</sub> + N <sub>2</sub>	I 1095
+ N <sub>2</sub>	I 1095
+ N <sub>2</sub> in liq. NH <sub>3</sub>	II 588
+ NH <sub>3</sub> + N <sub>2</sub>	II 589
Methanol + air	II 1420
+ Br <sub>2</sub>	I 1450
+ CO <sub>2</sub>	II 1420
+ CC <sub>2</sub> (v.p.)	I 1484
+ Cl <sub>2</sub>	I 787
+ HBr	I 1105
+ HCl	II 1420
+ HCl	I 1121
+ H <sub>2</sub> O <sub>2</sub>	I 1147
+ H <sub>2</sub> SO <sub>4</sub> + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	II 771
+ K <sub>2</sub> CCl <sub>3</sub> + H <sub>2</sub> O	II 94, 5
+ KI + NaI	II 231
+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O	II 322
+ LiBr	II 369
+ NH <sub>3</sub>	II 603
+ N <sub>2</sub> H <sub>4</sub> f.p.	II 785
+ NaBr + cyclohexane	II 844
+ NaOH + H <sub>2</sub> O	II 1087
+ SO <sub>2</sub>	II 1420
+ SO <sub>2</sub> + propionic acid	II 1420
+ xenon	II 1634
Methacryhumic acid - Ca acetate - H <sub>2</sub> O	I 509
Methylamine hydrochloride + NH <sub>4</sub> NO <sub>3</sub>	II 728
Methylammonium chloride + LiCl	II 402
+ NH <sub>4</sub> Cl + ZnCl <sub>2</sub> + LiCl + H <sub>2</sub> O	II 673
Methylaniline + SO <sub>2</sub>	II 1420
Methyl acetate + Cl <sub>2</sub>	I 787
+ TiCl <sub>4</sub>	II 1552
Methyl bromide + GaCl <sub>3</sub>	I 1066
Methyl chloride + BCl <sub>3</sub>	I 257
+ BF <sub>3</sub>	I 259
+ CO <sub>2</sub> (P-V)	I 494
+ Cl <sub>2</sub>	I 787
+ GaCl <sub>3</sub>	I 1066
+ HBr	I 1105
+ HCl	I 1121
+ NH <sub>3</sub>	II 603
+ NO	II 793
+ xenon	II 1634
Methyl ethyl alc. + NaCl + H <sub>2</sub> O	II 1002
Methyl ethyl ketone + CaCl <sub>2</sub> + H <sub>2</sub> O	I 591, 2
+ KF + H <sub>2</sub> O	II 208
Methyl iodine + GaCl <sub>3</sub>	I 1066
+ N <sub>2</sub> O <sub>4</sub> f.p.	II 793
Methyl isobutyl ketone + UO <sub>2</sub> (NC <sub>3</sub> ) <sub>2</sub> + H <sub>2</sub> O	II 1616
Methyl Mgl + MgI + (C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	II 502
Methyl thiocyanate + Co(SCN) <sub>2</sub>	I 796
Methylene blue + Ba(NO <sub>3</sub> ) <sub>2</sub>	II 669
Methylene dichloride + Cl <sub>2</sub>	I 787
3Mg + 2AlCl <sub>3</sub> = 3MgCl <sub>2</sub> + 2Al	I 177
Methylene iodide + S	II 1402
Magnesite in aq. salt and H <sub>2</sub> O	II 469
Mg + CaCl <sub>2</sub> = MgCl <sub>2</sub> + Ca	I 495
+ Hg	II 442
+ MgCl <sub>2</sub>	II 442
+ PbCl <sub>2</sub> = MgCl <sub>2</sub> + Pb	II 442
in aq. salts	II 442
in aq. salts, sea H <sub>2</sub> O	II 441
Mg Acetate in H <sub>2</sub> O	II 456
in methyl alc.	II 456
Mg alkyl sulfonates in H <sub>2</sub> O	II 462
Mg alloys in aq. salts	II 442
Mg eliminate	II 442
Mg anthracene sulfonates in H <sub>2</sub> O	II 463
Mg anthraquinone sulfonates in H <sub>2</sub> O	II 464
Mg arsenites	II 442
Mg <sub>3</sub> (AsO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 443

- $\text{Mg}_3\text{Bi}_2(\text{NO}_3)_{12} \cdot 24\text{H}_2\text{O}$  in conc.  $\text{HNO}_3$  ..... I 434  
 $\text{Mg}$  benzene sulfonate in aq. benzene sulfonic acid ..... II 463  
 $\text{Mg}$  benzene sulfonates in  $\text{H}_2\text{O}$  ..... II 463  
 $\text{Mg}$  benzoate in acetone ..... II 458  
 $\text{Mg}$  benzoate alcoholate in alcohol ..... II 459  
 $\text{Mg}$  benzoate in  $\text{H}_2\text{O}$  ..... II 458  
 $\text{Mg}$  borate salts ..... II 443  
 $\text{MgBr}_2$  in acetone ..... II 450  
  +  $\text{AlBr}_3$  ..... I 162  
  in ethyl ether ..... II 445  
  + ether + benzene ..... II 446  
  + ethyl ether +  $\text{H}_2\text{O}$  ..... II 445  
  in aq.  $\text{HBr}$  ..... II 444  
  in  $\text{H}_2\text{O}$  ..... II 444  
  +  $\text{InBr}_3 + \text{H}_2\text{O}$  ..... I 1293  
  +  $\text{KBr}$  ..... II 453  
  +  $2\text{KCl} \rightleftharpoons \text{MgCl}_2 + 2\text{KBr} (+ \text{H}_2\text{O})$  ..... II 23, 138  
  +  $\text{LiBr}$  ..... II 371  
  +  $\text{LiBr} + \text{H}_2\text{O}$  ..... II 367, 8  
  in  $\text{NH}_3$  ..... II 453  
  +  $\text{NaBr}$  ..... II 453  
  in pyridine ..... II 453  
  +  $\text{RbBr} + \text{H}_2\text{O}$  ..... II 445  
 $\text{MgBr}_2$  acetamide in acetamide ..... II 452  
 $\text{MgBr}_2$  acetanilide in acetanilide ..... II 452  
 $\text{MgBr}_2$  acetic acid in acetic acid ..... II 451  
 $\text{MgBr}_2$  acetic anhydride in acetic anhydride ..... II 452  
 $\text{MgBr}_2$  acetone in acetone ..... II 450  
 $\text{MgBr}_2$  in acetonitrile ..... II 453  
 $\text{MgBr}_2$  alcoholates in alcohols ..... II 448-9  
 $\text{MgBr}_2$  anilines in aniline ..... II 449  
 $\text{MgBr}_2$  benzaldehyde in benzaldehyde ..... II 450  
 $\text{MgBr}_2$  etherates in ethyl ether ..... II 447-8  
 $\text{MgBr}_2$  formic acid in formic acid ..... II 451  
 $\text{MgBr}_2$  methylol in methylol ..... II 451  
 $\text{MgBr}_2$  otha ethylformate in otha ethylformate ..... II 451  
 $\text{MgBr}_2$  phenylhydrazines in phenylhydrazine ..... II 450  
 $\text{MgBr}_2$  urea compounds in urea ..... II 453  
 $\text{MgBr}_2$  urethan compounds in urethan ..... II 453  
 $\text{Mg}(\text{BrO}_3)_2 + \text{H}_2\text{O}$  ..... II 454  
  in  $\text{Mg}(\text{NO}_3)_2$  ..... II 454  
 $\text{MgCO}_3 + \text{CaCO}_3$  in  $\text{H}_2\text{O}$  ..... II 468, 72  
  +  $\text{CaCO}_3 + \text{H}_2\text{O}$  ..... I 545, 6  
  +  $\text{CaCO}_3$  in  $\text{H}_2\text{O}$  ..... I 546  
  +  $\text{CaSO}_4 \rightleftharpoons \text{CaCO}_3 + \text{MgSO}_4$  ..... I 546  
  +  $\text{CaSO}_4 \rightleftharpoons \text{CaCO}_3 + \text{MgSO}_4 (+ \text{H}_2\text{O})$  ..... I 683  
  +  $\text{CaSO}_4 \rightleftharpoons \text{MgSO}_4 + \text{CaCO}_3$  ..... II 473  
  +  $\text{CO}_2 + \text{H}_2\text{O}$  ..... II 470, 1, 2  
  +  $\text{H}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 470  
 $\text{Mg}$  carbonates in  $\text{H}_2\text{O}$  ..... II 468  
  in  $\text{H}_2\text{O} + \text{CO}_2$  ..... II 468, 9  
 $\text{MgCO}_3$  hydrates ..... II 470, 1  
 $\text{MgCO}_3$  in aq.  $\text{KHCO}_3$  ..... II 474  
  in  $\text{KHCO}_3 + \text{Sacrose}$  ..... II 474  
  +  $\text{Na}_2\text{CO}_3 + \text{NaCl} + \text{NaOH} + \text{H}_2\text{O}$  ..... II 477  
  in  $\text{Na}_2\text{CO}_3$  solns ..... II 475-6  
  in aq.  $\text{Na}_2\text{SO}_4$  ..... II 477  
  +  $(\text{NH}_4)_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 475  
 $\text{Mg}$  carbonates in aq. salts ..... II 476  
 $\text{Mg}$  carbonate, basic, in furfural ..... II 477  
 $\text{MgC}_2\text{O}_4$  in  $\text{H}_2\text{C}_2\text{O}_4$  solns ..... II 478  
  in  $\text{H}_2\text{O}$  ..... II 477  
  in aq.  $\text{H}_2\text{SO}_4$  ..... II 478  
  in  $\text{NH}_4\text{Cl}$  solns ..... II 479  
  +  $\text{Na}_2\text{C}_2\text{O}_4 + \text{H}_2\text{O}$  ..... II 478  
  in salt solns ..... II 479  
 $\text{Mg}$  Camphor Carbonate in alcs ..... II 462  
 $\text{Mg}$  Camphorate in Camphoric acid ..... II 462  
 $\text{MgCe}$  nitrate ..... I 772  
 $\text{Mg}$  Chaulmoograte in Organic Solvents ..... II 465  
 $\text{Mg}$  Cinnamate in  $\text{H}_2\text{O}$  ..... II 461  
 $\text{Mg}$  Cinnamate in aq.  $\text{NH}_4\text{Cl} + \text{aq. NH}_3$  ..... II 461  
 $\text{MgCl}_2 + \text{AgCl}$  ..... I 77  
  in alcs ..... II 493  
 $3\text{MgCl}_2 + 2\text{Al} \rightleftharpoons 3\text{Mg} + 2\text{AlCl}_3$  ..... I 177  
 $\text{MgCl}_2 + \text{AlCl}_3$  ..... I 177  
  +  $\text{BaCl}_2$  ..... I 353  
  +  $\text{BaCl}_2 + \text{H}_2\text{O}$  ..... II 487  
  +  $\text{BaCl}_2 + \text{KCl}$  ..... I 353  
  +  $\text{BeCl}_2$  ..... I 406  
  +  $\text{BeCl}_2 + \text{H}_2\text{O}$  ..... II 488  
  +  $\text{Ca} \rightleftharpoons \text{Mg} + \text{CaCl}_2$  ..... I 495  
  +  $\text{CaCl}_2$  ..... I 597  
  +  $\text{CaCl}_2 + \text{H}_2\text{O}$  ..... I 580-4  
  +  $\text{CaCl}_2 + \text{H}_3\text{BO}_3 + \text{H}_2\text{O}$  ..... II 488  
  +  $\text{CaCl}_2 + \text{KCl}$  ..... I 597  
  +  $\text{CaCl}_2 + \text{KCl} + \text{H}_2\text{O}$  ..... II 140  
  +  $\text{CaCl}_2 + \text{KCl} + \text{H}_2\text{O}$  ..... I 584, 5  
  +  $\text{CaCl}_2 + \text{NaCl} + \text{H}_2\text{O}$  ..... I 585, 6  
  +  $\text{CaCl}_2 + \text{NaCl} + \text{H}_2\text{O}$  ..... II 477  
 $\text{Mg}^{++}, \text{Ca}^{++}, \text{Na}^+, \text{Cl}^-, \text{II SO}_4^{--}, \text{HCO}_3^- (+ \text{H}_2\text{O})$  ..... II 477  
  +  $\text{CaCl}_2 + \text{NaCl} + \text{KCl} + \text{H}_2\text{O}$  ..... I 587  
  +  $\text{CaCl}_2 + \text{SrCl}_2 + \text{KCl} + \text{NaCl} + \text{H}_2\text{O}$  ..... I 587  
  +  $\text{CaO} + \text{H}_2\text{O}$  ..... II 481  
  +  $\text{CdCl}_2$  ..... I 728  
  +  $\text{CdCl}_2 + \text{H}_2\text{O}$  ..... I 724  
  +  $2\text{CdCl}_2 \cdot 12\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$  ..... I 724  
  +  $\text{CoCl}_2 + \text{H}_2\text{O}$  ..... I 807  
  +  $\text{CsCl}$  ..... I 885  
  +  $\text{CsCl} + \text{H}_2\text{O}$  ..... I 882  
  + Dioxane +  $\text{H}_2\text{O}$  ..... II 493  
  +  $\text{HCl}$  ..... I 1121  
  in  $\text{HCl}$  solns ..... II 480  
  in  $\text{H}_2\text{O}$  ..... II 480  
  +  $\text{HgCl}_2 + \text{H}_2\text{O}$  ..... I 1211  
  +  $\text{InCl}_3 + \text{H}_2\text{O}$  ..... I 1295  
 $\text{MgCl}_2 + 2\text{KBr} \rightleftharpoons \text{MgBr}_2 + 2\text{KCl} (+ \text{H}_2\text{O})$  ..... II 138  
  +  $2\text{KBr} \rightleftharpoons 2\text{KCl} + \text{MgBr}_2 (+ \text{H}_2\text{O})$  ..... II 23  
  +  $\text{KCl}$  ..... II 169  
  +  $\text{KCl}$  ..... II 494  
  +  $\text{KCl} + \text{H}_2\text{O}$  ..... II 141, 2, 3  
  +  $\text{KCl} + \text{NaCl}$  ..... II 494  
 $\text{Mg}^{++}, \text{K}^+, \text{Na}^+, \text{II Cl}^-, \text{SO}_4^{--}$  ..... II 169  
  +  $\text{H}_2\text{O}$  ..... II 143  
 $\text{MgCl}_2 + 2\text{KHC}_2\text{O}_4 \rightleftharpoons 2\text{KCl} + [\text{Mg}(\text{HCO}_3)_2] (+ \text{H}_2\text{O})$  ..... II 105  
  in aq.  $\text{KMnO}_4$  ..... II 492  
  +  $2\text{KNO}_3 \rightleftharpoons 2\text{KCl} + \text{Mg}(\text{NO}_3)_2 (+ \text{H}_2\text{O})$  ..... II 259, 60  
  +  $\text{K}_2\text{SO}_4 \rightleftharpoons 2\text{KCl} + \text{MgSO}_4 (+ \text{H}_2\text{O})$  ..... II 311  
  +  $\text{K}_2\text{SO}_4 \rightleftharpoons \text{MgSO}_4 + 2\text{KCl}$  ..... II 169, 494  
  +  $\text{K}_2\text{SO}_4 \rightleftharpoons \text{MgSO}_4 + 2\text{KCl} (+ \text{H}_2\text{O})$  ..... II 138, 487  
  +  $\text{LiCl}$  ..... II 405  
  +  $\text{LiCl} + \text{H}_2\text{O}$  ..... II 394, 5  
  +  $\text{Mg}$  ..... II 442  
  +  $\text{MgMoO}_4 + \text{H}_2\text{O}$  ..... II 508  
  +  $\text{Mg}(\text{NO}_3)_2 + \text{H}_2\text{O}$  at various temps ..... II 483  
  +  $\text{MgO} + \text{H}_2\text{O}$  ..... II 481, 2  
  +  $\text{MgSO}_4$  ..... II 494  
  +  $\text{MgSO}_4 + \text{H}_2\text{O}$  ..... II 526  
  +  $\text{MgSO}_4 + \text{H}_2\text{O}$  at various temps ..... II 483-4, 526  
  +  $\text{MgSO}_4 + \text{KCl} + \text{NaCl} + \text{H}_2\text{O}$  in sat.  $\text{NaCl}$  solns ..... II 487  
  +  $\text{MnCl}_2$  ..... II 494  
  +  $\text{NaCl}$  ..... II 494, 1012  
  +  $\text{NaCl} + \text{CaCl}_2 + \text{H}_2\text{O}$  ..... II 490  
  +  $\text{NaCl} + \text{H}_2\text{O}$  ..... II 489-90  
  +  $\text{NaCl} + \text{H}_2\text{O}$  ..... II 989  
 $\text{Mg}^{++}, \text{Na}^+, \text{II Cl}^-, \text{NO}_3^-, \text{SO}_4^{--}$  ..... II 487  
 $\text{MgCl}_2 + \text{NaCl} + \text{KCl}$  ..... II 169  
 $\text{Mg}^{++}, \text{Na}^+, \text{K}^+, \text{II Cl}^-, \text{SO}_4^{--} (+ \text{H}_2\text{O})$  ..... II 138  
 $\text{MgCl}_2 + \text{NaCl} + \text{Na}_2\text{SO}_4 + \text{NaNO}_3 + \text{Mg}(\text{NO}_3)_2 + \text{H}_2\text{O}$  ..... II 491  
  +  $\text{NaCl} + \text{Na}_2\text{SO}_4 + \text{NaNO}_3 + \text{H}_2\text{O}$  ..... II 491  
  +  $2\text{NaNO}_3 \rightleftharpoons \text{Mg}(\text{NO}_3)_2 + \text{NaCl} (+ \text{H}_2\text{O})$  ..... II 483  
  +  $\text{Na}_2\text{SO}_4 \rightleftharpoons \text{MgSO}_4 + 2\text{NaCl}$  ..... II 494  
  +  $\text{Na}_2\text{SO}_4 \rightleftharpoons 2\text{NaCl} + \text{MgSO}_4 (+ \text{H}_2\text{O})$  ..... II 485-7, 533, 985  
  +  $\text{Na}_2\text{S}_2\text{O}_3 \rightleftharpoons \text{MgS}_2\text{O}_3 + 2\text{NaCl} (+ \text{H}_2\text{O})$  ..... II 492  
  +  $\text{Na}_2\text{S}_2\text{O}_3 \rightleftharpoons \text{MgS}_2\text{O}_3 + 2\text{NaCl}$  ..... II 539  
  +  $\text{NbCl}_5$  ..... II 494  
  +  $\text{NH}_4\text{Cl} + \text{H}_2\text{O}$  ..... II 468  
  +  $\text{NH}_4\text{NO}_3 + \text{H}_2\text{O}$  ..... II 489-90  
 $\text{Mg}^{++} + 2\text{NH}_4\text{OH} \rightleftharpoons \text{Mg}(\text{OH})_2 + \text{NH}_4^+$  ..... II 516  
 $\text{MgCl}_2 + \text{Pb} \rightleftharpoons \text{Mg} + \text{PbCl}_2$  ..... II 442  
  +  $\text{PbCl}_2$  ..... II 494  
  +  $\text{RbCl}$  ..... II 494  
  +  $\text{RbCl}$  ..... II 1366  
  +  $\text{RbCl} + \text{KCl} + \text{H}_2\text{O}$  ..... II 143  
  +  $\text{RbCl} + \text{KCl} + \text{H}_2\text{O}$  ..... II 491  
  in various aq. solts ..... II 484  
  +  $\text{SnCl}_2$  ..... II 494  
  in various solvents ..... II 493  
  +  $\text{SrCl}_2 + \text{H}_2\text{O}$  ..... II 491-2  
  +  $\text{SrCl}_2$  ..... II 494  
  +  $\text{TiCl}_4$  ..... II 1553  
  +  $\text{TiCl}_4$  ..... II 494  
  +  $\text{TiCl}_4 + \text{H}_2\text{O}$  ..... II 1572  
  +  $\text{ZnCl}_2$  ..... II 494  
  +  $\text{ZrCl}_4$  ..... II 494

Basic, in H <sub>2</sub> O	II 481-2
Mg(ClO <sub>3</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 494
Mg(ClO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 495
in organic solvents	II 495
MgCrO <sub>4</sub> in aq. sol.	II 498
in H <sub>2</sub> O	II 498
K <sub>2</sub> CrO <sub>4</sub> · 2H <sub>2</sub> O	II 496
+ (NH <sub>4</sub> ) <sub>2</sub> CrO <sub>4</sub> · H <sub>2</sub> O	II 497
MgCr <sub>2</sub> O <sub>7</sub> in H <sub>2</sub> O	II 497
MgCr <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> in H <sub>2</sub> O	I 902
Mg Diethyl in organic solvents	II 455
Mg Dilactates in H <sub>2</sub> O	II 458
Mg 2, 4-Dinitroresylate in H <sub>2</sub> O	II 460
Mg 2, 4 Dinitrophenate in H <sub>2</sub> O	II 460
Mg Diphenyl in organic solvents	II 458
Mg Eruente in aq. sol.	II 465
MgF <sub>2</sub> + AgF + H <sub>2</sub> O	I 91
+ Al <sub>2</sub> O <sub>3</sub> + SiO <sub>2</sub>	II 498
+ BaF <sub>2</sub>	I 360
+ BeF <sub>2</sub>	I 409
+ CaF <sub>2</sub>	I 603
in aq. HCl	II 498
in H <sub>2</sub> O	II 496
+ KF	II 211
+ LiF	II 496
+ LiF	II 414
+ MgO + SiO <sub>2</sub>	II 496
+ NaF	II 496
+ NaF	II 1040
+ NaF + KF	II 211
+ NaF + LiF	II 414
+ RbF	II 496
+ RbF + KF	II 211
+ SiO <sub>2</sub> + KF	II 211
Mg Ferrocyanides in H <sub>2</sub> O	II 467
Mg Formate in H <sub>2</sub> O	II 455
Mg Formate in aq. solns. formic acid	II 455
Mg <sub>3</sub> Gd(NO <sub>3</sub> ) <sub>6</sub> · 24H <sub>2</sub> O	I 1071
Mg <sub>2</sub> GaO <sub>4</sub> in H <sub>2</sub> O and aq. soln.	II 499
+ Mg <sub>2</sub> SiO <sub>4</sub>	II 543
Mg Glucosate in H <sub>2</sub> O	II 458
MgHASO <sub>4</sub> in H <sub>2</sub> O	II 443
Mg(HCO <sub>3</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 105
Mg(HCO <sub>3</sub> ) <sub>2</sub> · 2KCl = MgCl <sub>2</sub> + 2KHCO <sub>3</sub> (+ H <sub>2</sub> O)	II 533
Mg(HCO <sub>3</sub> ) <sub>2</sub> + Na <sub>2</sub> SO <sub>4</sub> = MgSO <sub>4</sub> + 2NaHCO <sub>3</sub> (+ H <sub>2</sub> O)	II 105
Mg Helioleate in H <sub>2</sub> O	II 465
Mg Hexa Antipyrine Fleohorate in H <sub>2</sub> O	II 498
Mg Hexa Antipyrine Perchlorate in H <sub>2</sub> O	II 495
Mg(H <sub>2</sub> NSO <sub>3</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 539
MgHPO <sub>4</sub>	II 521
+ CaHPO <sub>4</sub> + H <sub>2</sub> O	I 653, 4
Mg(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> + Ca(H <sub>2</sub> PCO <sub>4</sub> ) <sub>2</sub> + H <sub>2</sub> O	I 653, 4
MgH <sub>2</sub> P <sub>2</sub> O <sub>6</sub> · 4H <sub>2</sub> O in H <sub>2</sub> O	II 523
Mg hydneacopate in organic solvents	II 465
Mg <sub>12</sub> acetol in acetol	II 503
Mg <sub>12</sub> acetamide in acetamide	II 505
Mg <sub>12</sub> acetic acid in acetic acid	II 503
Mg <sub>12</sub> acetone in acetone	II 503
Mg <sub>12</sub> acetonitrile in acetonitrile	II 505
Mg <sub>12</sub> alcohates in alcohols	II 502
Mg <sub>12</sub> anilino in aniline	II 502
Mg <sub>12</sub> benzaldehyde in benzaldehyde	II 503
Mg <sub>12</sub> + (C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O - CH <sub>3</sub> MgI	II 502
Mg <sub>12</sub> dietherate	II 500, 1, 2
Mg <sub>12</sub> ethyl acetate in ethyl acetate	II 504
Mg <sub>12</sub> formic acid ester in ethyl formate	II 504
Mg <sub>12</sub> · 2H <sub>2</sub> O · 7H <sub>2</sub> O	II 505
Mg <sub>12</sub> in H <sub>2</sub> O	II 500
+ InI <sub>3</sub> + H <sub>2</sub> O	I 1296
Mg <sub>12</sub> isocetyl acetate in isocetyl acetate	II 504
Mg <sub>12</sub> isobutyl acetate in isobutyl acetate	II 504
Mg <sub>12</sub> + KI	II 234, 505
+ KI + ethanol	II 233
Mg <sub>12</sub> methyl acetate in methyl acetate	II 504
Mg <sub>12</sub> + NaI	II 505
in NH <sub>4</sub>	II 505
Mg <sub>12</sub> urethan in urethan	II 505
Mg <sub>12</sub> (IO <sub>3</sub> ) <sub>2</sub> + HIO <sub>3</sub> + H <sub>2</sub> O	II 506
in H <sub>2</sub> O	II 506
+ Mo <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> + H <sub>2</sub> O	II 507
+ NaIO <sub>3</sub> + H <sub>2</sub> O	II 507
Mg <sub>12</sub> propyl acetate in propyl acetate	II 504
MgK <sub>2</sub> (SeO <sub>4</sub> ) <sub>2</sub> + Mg(NH <sub>4</sub> ) <sub>2</sub> (SeO <sub>4</sub> ) <sub>2</sub> + H <sub>2</sub> O	II 541

Mg lactate in methyl alc.	II 457
Mg laurate in organic solvents	II 467
in H <sub>2</sub> O	II 467
Mg lignocerate in aq. alc.	II 465
in H <sub>2</sub> O	II 465
Mg malate in H <sub>2</sub> O	II 457
Mg mandelates + mandelic acids + H <sub>2</sub> O	II 460
Mg mandelate in H <sub>2</sub> O	II 460
Mg methacolate in methyl alc.	II 455
MgMoO <sub>4</sub> in H <sub>2</sub> O	II 508
+ MgCl <sub>2</sub> + H <sub>2</sub> O	II 508
+ MgSO <sub>4</sub> + H <sub>2</sub> O	II 509
+ Na <sub>2</sub> MoO <sub>4</sub> + H <sub>2</sub> O	II 509
+ Na <sub>2</sub> SO <sub>4</sub> = MgSO <sub>4</sub> + Na <sub>2</sub> MoO <sub>4</sub>	II 510
Mg myristate in H <sub>2</sub> O	II 467
in organic solvents	II 467
Mg naphthalene disulfonates in H <sub>2</sub> O	II 463
Mg naphthalene trisulfonate in H <sub>2</sub> O	II 464
Mg naphthalene sulfonates in H <sub>2</sub> O	II 463
in aq. NH <sub>4</sub> Cl + NH <sub>3</sub>	II 463
Mg(NbO <sub>3</sub> ) <sub>2</sub>	II 516
Mg(NH <sub>4</sub> ) <sub>2</sub> (CrO <sub>4</sub> ) <sub>2</sub> + Mg(NH <sub>4</sub> ) <sub>2</sub> SeO <sub>4</sub> + H <sub>2</sub> O	II 497
+ Mg(NH <sub>4</sub> ) <sub>2</sub> (SC <sub>4</sub> ) <sub>2</sub> + H <sub>2</sub> O	II 497
MgNH <sub>4</sub> PO <sub>4</sub> · 6H <sub>2</sub> O in aq. salts	II 522, 3
MgNH <sub>4</sub> PO <sub>4</sub> in MgCl <sub>2</sub> soln.	II 523
in (NH <sub>4</sub> ) <sub>2</sub> HPO <sub>4</sub> soln.	
Mg(NO <sub>3</sub> ) <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> + Cu(NH <sub>4</sub> ) <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> + H <sub>2</sub> O	I 985
Mg(NH <sub>4</sub> ) <sub>2</sub> (SeO <sub>4</sub> ) <sub>2</sub> + MgK <sub>2</sub> (S <sub>2</sub> C <sub>4</sub> ) + H <sub>2</sub> O	II 541
+ Mg(NH <sub>4</sub> ) <sub>2</sub> (CrO <sub>4</sub> ) <sub>2</sub> + H <sub>2</sub> O	II 497
+ Mg(NH <sub>4</sub> ) <sub>2</sub> (SeO <sub>4</sub> ) <sub>2</sub> + H <sub>2</sub> O	II 541
+ Mg(NH <sub>4</sub> ) <sub>2</sub> (SO <sub>4</sub> ) <sub>2</sub> + H <sub>2</sub> O	II 541
+ Mg(NH <sub>4</sub> ) <sub>2</sub> (CrO <sub>4</sub> ) <sub>2</sub> + H <sub>2</sub> O	II 497
Mg 4-nitro benzoate in H <sub>2</sub> O	II 458
Mg(NO <sub>3</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 510
Mg(NO <sub>3</sub> ) <sub>2</sub> elcates	II 515
+ Ca(NO <sub>3</sub> ) <sub>2</sub>	I 629
+ Ca(NO <sub>3</sub> ) <sub>2</sub> + KNO <sub>3</sub>	I 629
+ Ca(NO <sub>3</sub> ) <sub>2</sub> + NaNO <sub>3</sub>	I 629
3Mg(NO <sub>3</sub> ) <sub>2</sub> · 2Ca(NO <sub>3</sub> ) <sub>2</sub> in H <sub>2</sub> O	I 772
Mg(NO <sub>3</sub> ) <sub>2</sub> + H <sub>3</sub> BO <sub>3</sub> + Ca(NO <sub>3</sub> ) <sub>2</sub> + H <sub>2</sub> O	I 624
+ KNO <sub>3</sub> + Ca(NO <sub>3</sub> ) <sub>2</sub> + NaNO <sub>3</sub>	I 629
Mg(NO <sub>3</sub> ) <sub>2</sub> in H <sub>2</sub> O	II 511
Mg(NO <sub>3</sub> ) <sub>2</sub> · 6H <sub>2</sub> O in furfural	II 515
Mg(NO <sub>3</sub> ) <sub>2</sub> in aq. HNO <sub>3</sub>	II 512
+ 2KCl = MgCl <sub>2</sub> + 2KNO <sub>3</sub> (+ H <sub>2</sub> O)	II 259, 60
+ KNO <sub>3</sub>	II 274
+ KNO <sub>3</sub> + H <sub>2</sub> O	II 258, 9
+ K <sub>2</sub> SO <sub>4</sub> = MgSO <sub>4</sub> + K <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub>	II 311
+ K <sub>2</sub> SO <sub>4</sub> = MgSO <sub>4</sub> + K <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> (+ H <sub>2</sub> O)	II 513
+ K <sub>2</sub> SO <sub>4</sub> = MgSO <sub>4</sub> + (KNO <sub>3</sub> ) <sub>2</sub> + (H <sub>2</sub> O)	II 359
+ La(NO <sub>3</sub> ) <sub>3</sub>	II 256
+ La(NO <sub>3</sub> ) <sub>3</sub> + H <sub>2</sub> O	II 355
+ La(NO <sub>3</sub> ) <sub>3</sub> + H <sub>2</sub> O	II 513
+ MgCl <sub>2</sub> + H <sub>2</sub> O at various temps.	II 483
+ MgCl <sub>2</sub> + NaCl + Na <sub>2</sub> SO <sub>4</sub> + NaNO <sub>3</sub> + H <sub>2</sub> O	II 491
+ Mg(O <sub>2</sub> ) <sub>2</sub> + H <sub>2</sub> O	II 507
+ MgSO <sub>4</sub> + H <sub>2</sub> O	II 512, 3
+ Mn(NO <sub>3</sub> ) <sub>2</sub> + H <sub>2</sub> O	II 513
+ 2NaCl = 2NaNO <sub>3</sub> + MgCl <sub>2</sub> (+ H <sub>2</sub> O)	II 483
+ NaNO <sub>3</sub>	II 515
+ NaNO <sub>3</sub> + KNO <sub>3</sub>	II 274
+ NaNO <sub>3</sub> + H <sub>2</sub> O	II 514
+ Na <sub>2</sub> SO <sub>4</sub> = MgSO <sub>4</sub> + 2NaNO <sub>3</sub> (+ H <sub>2</sub> O)	II 533, 1077
3Mg(NO <sub>3</sub> ) <sub>2</sub> · 2H <sub>2</sub> O · 2H <sub>2</sub> O in H <sub>2</sub> O	II 514
in aq. HNO <sub>3</sub>	II 515
in aq. Mg(NO <sub>3</sub> ) <sub>2</sub>	II 515
Mg(NO <sub>3</sub> ) <sub>2</sub> · 2NH <sub>4</sub> NO <sub>3</sub> in H <sub>2</sub> O	II 513
MgO + Al <sub>2</sub> O <sub>3</sub> + SiO <sub>2</sub> + H <sub>2</sub> O	II 442
+ As <sub>2</sub> O <sub>3</sub> + H <sub>2</sub> O	II 442
+ B <sub>2</sub> O <sub>3</sub>	II 444
+ B <sub>2</sub> O <sub>3</sub> + H <sub>2</sub> O	II 443
+ BaO	I 383
+ CO <sub>2</sub> + H <sub>2</sub> O	II 470
5MgO · 4CO <sub>2</sub> · 7H <sub>2</sub> O in H <sub>2</sub> O	II 470
+ CaF <sub>2</sub>	I 603
+ CaO	I 630
+ CaO + Al <sub>2</sub> O <sub>3</sub>	I 630
+ CaO + P <sub>2</sub> O <sub>5</sub> + H <sub>2</sub> O	I 633, 3
+ CaO + SiO <sub>2</sub>	I 630
MgO in chlorides	II 519
in cryolite	II 519
+ HAc + H <sub>2</sub> O	II 458



- +  $\text{H}_2\text{O}$  ..... II 516  
 +  $\text{H}_2\text{O}$  in carnallite ..... II 519  
 +  $\text{K}_2\text{O} + \text{B}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 444  
 +  $\text{MgCl}_2 + \text{H}_2\text{O}$  ..... II 481, 2  
 +  $\text{MgF}_2 + \text{SiO}_2$  ..... II 498  
 +  $\text{Na}_2\text{O} + \text{B}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 444  
 +  $\text{P}_2\text{O}_5$  ..... II 523  
 +  $\text{P}_2\text{O}_5 + \text{H}_2\text{SiF}_6 + \text{H}_2\text{O}$  ..... II 542  
 +  $\text{P}_2\text{O}_5 + \text{H}_2\text{O}$  ..... II 520, 1  
 +  $\text{Ti}_2\text{CrO}_4$  ..... II 1580  
 +  $\text{TiI}_3$  ..... II 1581  
 in sulfates ..... II 519  
 **$2\text{MgO} \cdot \text{SiO}_2 + \text{Ca}_3(\text{PO}_4)_2$**  ..... 1655  
 **$\text{MgO} \cdot \text{SiO}_2 + 3\text{Ca}_3(\text{PO}_4)_2 \cdot \text{CaF}_2$**  ..... 1655  
 **$2\text{MgO} \cdot \text{SiO}_2 + 3\text{Ca}_3(\text{PO}_4)_2 \cdot \text{CaF}_2$**  ..... 1655  
 **$\text{Mg}(\text{OH})_2 + 2\text{Ag}^+ \rightleftharpoons 2\text{AgOH} + \text{Mg}^{2+}$**  ..... 1126  
 in alc. solns ..... II 519  
 +  $\text{CaSO}_4$  in sea water ..... 1682  
 in  $\text{H}_2\text{O}$  ..... II 516, 7  
 +  $\text{H}_2\text{O}_2 + \text{H}_2\text{O}$  ..... II 518, 9  
 +  $\text{MgSO}_4 + \text{H}_2\text{O}$  ..... II 525, 6  
 +  $\text{MgSO}_4 + \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 309  
 +  $2\text{NH}_4^+ \rightleftharpoons \text{Mg}^{2+} + 2\text{NH}_3\text{OH}$  ..... II 516  
 in salt solns ..... II 517, 8  
**Mg oleate** in alc. .... II 466  
 in glycerol ..... II 466  
 in  $\text{H}_2\text{O}$  ..... II 466  
 in aq. salt ..... II 466  
**Mg palmitate** in  $\text{H}_2\text{O}$ , aq. salt ..... II 466-7  
 in organic solvents ..... II 467  
**Mg phthalanthrene sulfonates** in  $\text{H}_2\text{O}$  ..... II 464  
**Mg phthalate** + Li phthalate +  $\text{H}_2\text{O}$  ..... II 380  
 + phthalic acid +  $\text{H}_2\text{O}$  ..... II 459  
**Mg platonic cyanide** in  $\text{H}_2\text{O}$  ..... II 468  
 **$\text{Mg}_3(\text{PO}_4)_2$**  ..... II 521  
 +  $\text{Ca}_3(\text{PO}_4)_2$  ..... II 523  
 **$\text{Mg}_2\text{P}_2\text{O}_7 \cdot 12\text{H}_2\text{O}$**  in  $\text{H}_2\text{O}$  ..... II 523  
**Mg quinolines** in aq. ethanol ..... II 461  
 in  $\text{H}_2\text{O}$  ..... II 461  
 **$\text{MgSO}_3$**  in  $\text{H}_2\text{O}$  ..... II 524  
 **$\text{MgSO}_4 + \text{As}_2\text{SO}_4 + \text{H}_2\text{O}$**  ..... I 137, 8  
 + allyl alc. +  $\text{H}_2\text{O}$  ..... II 536  
 + butyl alc. +  $\text{H}_2\text{O}$  ..... II 536  
 +  $\text{CaCO}_3 \rightleftharpoons \text{CaSO}_4 + \text{MgCO}_3$  ..... I 546, II 473  
 +  $\text{CaCO}_3 \rightleftharpoons \text{CaSO}_4 + \text{MgCO}_3 (+ \text{H}_2\text{O})$  ..... I 683  
 +  $\text{CaSO}_4$  ..... I 687  
 +  $\text{CaSO}_4 + \text{H}_2\text{O}$  ..... II 527  
 +  $\text{CaSO}_4 + \text{K}_2\text{SO}_4$  ..... I 687  
 +  $\text{CaSO}_4 + \text{K}_2\text{SO}_4$  ..... II 326  
 +  $\text{CaSO}_4 + \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 303  
 +  $\text{CaSO}_4 + \text{Na}_2\text{SO}_4$  ..... I 687  
 +  $\text{CaSO}_4 + \text{H}_2\text{O}$  ..... I 755, 6  
 +  $\text{CaSO}_4 + \text{H}_2\text{O}$  ..... I 988, 9  
 in aq. ethanol ..... II 535  
 +  $\text{H}_3\text{BO}_3 + \text{H}_2\text{O}$  ..... II 525  
 in  $\text{H}_2\text{O}$  ..... II 524-5  
 +  $\text{H}_2\text{SO}_4$  ..... II 538  
 in  $\text{H}_2\text{SO}_4$  solns ..... II 525  
 +  $\text{H}_3\text{BO}_3 + \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 309, 10  
 in aq. iso propyl alc. .... II 536  
 +  $\text{KBr}$  ..... II 30  
 +  $2\text{KCl} \rightleftharpoons \text{K}_2\text{SO}_4 + \text{MgCl}_2$  ..... II 169  
 +  $2\text{KCl} \rightleftharpoons \text{K}_2\text{SO}_4 + \text{MgCl}_2 (+ \text{H}_2\text{O})$  ..... II 138  
 +  $\text{KCl} \rightleftharpoons \text{MgCl}_2 + \text{K}_2\text{SO}_4$  ..... II 494  
 +  $2\text{KCl} \rightleftharpoons \text{MgCl}_2 + \text{K}_2\text{SO}_4 (+ \text{H}_2\text{O})$  ..... II 311  
 +  $2\text{KCl} \rightleftharpoons \text{MgCl}_2 + \text{K}_2\text{SO}_4 (+ \text{H}_2\text{SO}_4)$  ..... II 487  
 +  $(\text{KNO}_3)_2 \rightleftharpoons \text{K}_2\text{SO}_4 + \text{Mg}(\text{NO}_3)_2$  ..... II 311  
 +  $(\text{KNO}_3)_2 \rightleftharpoons \text{Mg}(\text{NO}_3)_2 + \text{K}_2\text{SO}_4 (+ \text{H}_2\text{O})$  ..... II 259  
 +  $(\text{KNO}_3)_2 \rightleftharpoons \text{Mg}(\text{NO}_3)_2 + \text{K}_2\text{SO}_4 (+ \text{H}_2\text{O})$  ..... II 513  
 +  $\text{K}_2\text{SO}_4$  ..... II 326, 538  
 +  $\text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 305, 6, 7, 8  
 +  $\text{K}_2\text{SO}_4 + \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 310, 11  
 +  $\text{K}_2\text{SO}_4 + (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 311  
 +  $\text{MgCl}_2$  ..... II 494  
 +  $\text{MgCl}_2 + \text{H}_2\text{O}$  ..... II 526  
 +  $\text{MgCl}_2 + \text{H}_2\text{O}$  at various temps ..... II 483-4, 526  
 +  $\text{MgCl}_2 + \text{KCl} + \text{NaCl} + \text{H}_2\text{O}$  in sat. NaCl solns ..... II 487  
 +  $\text{MgMoO}_4 + \text{H}_2\text{O}$  ..... II 509  
 +  $\text{Mg}(\text{NO}_3)_2 + \text{H}_2\text{O}$  ..... II 512, 3  
 +  $\text{Mg}(\text{OH})_2 + \text{H}_2\text{O}$  ..... II 525, 6  
 +  $\text{Mg}(\text{OH})_2 + \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 309  
 +  $\text{MnSO}_4 + \text{H}_2\text{O}$  ..... II 527-8  
 in aq. methanol ..... II 534  
 +  $(\text{NH}_4)_2\text{SO}_4 + \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 310  
 +  $(\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 528-9  
 +  $\text{NaCl} \quad \text{MgCl}_2 + \text{Na}_2\text{SO}_4$  ..... II 494  
 +  $2\text{NaCl} \rightleftharpoons \text{MgCl}_2 + \text{Na}_2\text{SO}_4 (+ \text{H}_2\text{O})$  ..... II 485, 6, 7, 533, 985  
 +  $2\text{NaHCO}_3 \rightleftharpoons \text{Mg}(\text{HCO}_3)_2 + \text{Na}_2\text{SO}_4 (+ \text{H}_2\text{O})$  ..... II 533  
 +  $\text{Na}_2\text{MoO}_4 \rightleftharpoons \text{Na}_2\text{SO}_4 + \text{MgMoO}_4$  ..... II 510  
 +  $\text{Na}_2(\text{NO}_3)_2 + \text{H}_2\text{O}$  ..... II 1075  
 +  $2\text{NaNO}_3 \rightleftharpoons \text{Mg}(\text{NO}_3)_2 + \text{Na}_2\text{SO}_4 (+ \text{H}_2\text{O})$  ..... II 533, 1077  
 +  $\text{Na}_2\text{SO}_4$  ..... II 538  
 +  $\text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 530, 1, 2  
 +  $\text{Na}_2\text{SO}_4 + \text{K}_2\text{SO}_4$  ..... II 326  
 +  $\text{NiSO}_4 + \text{H}_2\text{O}$  ..... II 533-4  
 + phenol +  $\text{H}_2\text{O}$  ..... II 538  
 + pyridine +  $\text{H}_2\text{O}$  ..... II 536  
 +  $\text{RbCl}$  ..... II 538  
 +  $\text{Rb}_2\text{SO}_4$  ..... II 538  
 +  $\text{Ti}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 534  
 + urea +  $\text{H}_2\text{O}$  ..... II 536, 7  
 + urethane +  $\text{H}_2\text{O}$  ..... II 538  
 in various solvents ..... II 538  
 **$\text{MgS}_2\text{O}_3$**  in  $\text{H}_2\text{O}$  ..... II 539  
 **$\text{MgS}_2\text{O}_3 + 2\text{NaCl} \rightleftharpoons \text{Na}_2\text{S}_2\text{O}_3 + \text{MgCl}_2$**  ..... II 539  
 **$\text{MgS}_2\text{O}_3 + 2\text{NaCl} \rightleftharpoons \text{MgCl}_2 + \text{Na}_2\text{S}_2\text{O}_3 (+ \text{H}_2\text{O})$**  ..... II 492  
 **$\text{MgS}_2\text{O}_8 + \text{BaS}_2\text{O}_8 + \text{H}_2\text{O}$**  ..... I 397  
**Mg salicylate** in alcohol ..... II 459  
 in  $\text{H}_2\text{O}$  ..... II 459  
 **$\text{MgSeO}_3$**  ..... II 540  
 **$\text{MgSeO}_4$**  in  $\text{H}_2\text{O}$  ..... II 540  
 +  $\text{H}_2\text{SeO}_4 + \text{H}_2\text{O}$  ..... II 540  
 +  $\text{Na}_2\text{SeO}_4 + \text{H}_2\text{O}$  ..... II 541  
 +  $\text{K}_2\text{SeO}_4 + \text{H}_2\text{O}$  ..... II 337  
 +  $(\text{NH}_4)_2\text{SeO}_4 + \text{H}_2\text{O}$  ..... II 541  
 **$\text{MgSiF}_6$**  in  $\text{H}_2\text{O}$  ..... II 499  
 in  $\text{H}_3\text{PO}_4$  solns ..... II 542  
 in aq.  $\text{H}_2\text{SiF}_6$  ..... II 499  
 +  $(\text{NH}_4)_2\text{SiF}_6 + \text{H}_2\text{O}$  ..... II 542  
 **$\text{MgSiO}_3$**  ..... II 543  
 +  $\text{CaSiO}_3$  ..... I 693  
 +  $\text{MnSiO}_3$  ..... II 543  
 +  $\text{Na}_2\text{SiO}_3$  ..... II 543  
 **$\text{Mg}_2\text{SiO}_4$**  ..... II 543  
 +  $\text{Ca}_2\text{SiO}_4$  ..... II 543  
 +  $\text{Mg}_2\text{GeO}_4$  ..... II 543  
**Mg stearate** in aq. alc. .... II 467  
 in  $\text{H}_2\text{O}$ , aq. salt ..... II 466-7  
 in organic solvents ..... II 467  
**Mg succinate** in  $\text{H}_2\text{O}$  ..... II 457  
**Mg tartrates** in  $\text{H}_2\text{O}$  ..... II 457  
**Mg uranium carbonate** in  $\text{H}_2\text{O}$  ..... II 477  
**Mg xylel selenates** in  $\text{H}_2\text{O}$  ..... II 464  
**Mirabilite** ..... I 676, 7  
**Mixed isomeric decanes** +  $\text{H}_2$  ..... I 1095  
**Mn + B** ..... I 255  
 + C ..... II 543  
 + Fe + P ..... II 1006  
 +  $\text{FeO} \rightleftharpoons \text{Fe} + \text{MnO}$  ..... I 1006  
 in  $\text{H}_2$  ..... II 543  
 **$2\text{Mn} + \text{SiO}_2 \rightleftharpoons 2\text{MnO} + \text{Si}$**  ..... II 558  
**Mn acetate  $4\text{H}_2\text{O}$**  in furfural ..... II 545  
**Mn acetate  $4\text{H}_2\text{O}$**  in  $\text{H}_2\text{O}$  ..... II 545  
**Mn acetate** in methyl alc. .... II 545  
**Mn amine fluorides** in  $\text{CH}_3\text{COOH}$  ..... II 555  
 in ethyl alc. .... II 555  
**Mn anthracene sulfonates** in  $\text{H}_2\text{O}$  ..... II 547  
 **$\text{Mn}_3(\text{AsO}_4)_2$**  ..... II 544  
**Mn benzene sulfonates** in  $\text{H}_2\text{O}$  ..... II 547  
**Mn benzoates** in  $\text{H}_2\text{O}$  ..... II 546  
 **$\text{MnBO}_3$**  in furfural ..... II 545  
 **$\text{Mn}_3\text{Bi}_2(\text{NO}_3)_{12} \cdot 24\text{H}_2\text{O}$**  in  $\text{HNO}_3$  ..... I 434  
 **$\text{MnBr}_2 + \text{AlBr}_3$**  ..... I 162  
 in  $\text{H}_2\text{O}$  ..... II 545  
 **$\text{MnC}_4\text{H}_2\text{O}_4$**  in  $\text{H}_2\text{O}$  ..... II 546  
 **$\text{Mn}(\text{C}_6\text{H}_{11}\text{O}_7)_2$**  in  $\text{H}_2\text{O}$  ..... II 546  
 **$\text{Mn}(\text{C}_{10}\text{H}_{15}\text{O} \cdot \text{COO})_2$**  in alcs. .... II 550  
 **$\text{Mn}(\text{C}_{14}\text{H}_{14}\text{N}_3\text{SO}_3)_2 \cdot 4\text{H}_2\text{O}$**  in  $\text{H}_2\text{O}$  ..... II 546  
 **$\text{Mn}(\text{C}_{18}\text{H}_{14}\text{O}_4 \cdot 2\text{H}_2\text{O})$**  in  $\text{H}_2\text{O}$  ..... II 546  
 **$\text{MnCO}_3 + \text{CaCl}_2 \rightleftharpoons \text{CaCO}_3 + \text{MnCl}_2 (+ \text{H}_2\text{O})$**  ..... II 549  
 +  $\text{CaCO}_3$  ..... II 549  
 in  $\text{H}_2\text{O}$  ..... II 549  
 **$\text{Mn}_2\text{O}_4$**  in aq.  $\text{H}_2\text{C}_2\text{O}_4$  ..... II 548  
 in aq.  $\text{H}_2\text{SO}_4$  ..... II 548

- $\text{MnC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$  in aq.  $\text{H}_2\text{SO}_4 + \text{H}_2\text{C}_2\text{O}_4$  .. II 548  
 $\text{MnC}_2\text{O}_4$  hydrates in  $\text{H}_2\text{O}$  .. II 548  
 in aq.  $\text{KCl}$  .. II 549  
 in aq.  $\text{K}_2\text{C}_2\text{O}_4$  .. II 549  
 in aq.  $\text{K}_2\text{SC}_4$  .. II 549  
 in aq.  $\text{MnCl}_2$  .. II 549  
 in aq.  $\text{NaCl}$  .. II 549  
 in aq.  $\text{Na}_2\text{C}_2\text{O}_4$  .. II 549  
 in aq.  $\text{Na}_2\text{SO}_4$  .. II 549  
 in aq.  $(\text{NH}_4)_2\text{C}_2\text{O}_4$  .. II 548  
 $[\text{Mn}(\text{COC}(\text{OH})(\text{H}_2\text{N})_2)_6(\text{BF}_4)_3]$  in  $\text{H}_2\text{O}$  .. II 555  
 $\text{Mn}(\text{COC}(\text{OH})(\text{H}_2\text{N})_2)_6(\text{ClO}_4)_2$  in  $\text{H}_2\text{O}$  .. II 553  
 $\text{MnCO}_3$  nitrate .. I 772  
 $\text{MnCl}_3 + \text{AgCl}$  .. I 78  
 +  $\text{AlCl}_3$  .. I 177  
 +  $\text{BaCl}_2$  .. I 353  
 +  $\text{CaCl}_2$  .. I 597  
 +  $\text{CaCO}_3 = \text{MnCO}_3 + \text{CaCl}_2 (+ \text{H}_2\text{C})$  .. II 549  
 +  $\text{CdCl}_2$  .. I 728  
 +  $\text{CdCl}_2 + \text{H}_2\text{C}$  .. I 724  
 +  $\text{CdCl}_2 + \text{NaCl} + \text{H}_2\text{O}$  .. I 724  
 +  $\text{CsCl}$  .. II 553  
 in ethyl ether +  $\text{H}_2\text{O} + \text{HCl}$  .. II 552  
 +  $\text{FeCl}_2$  .. I 1016  
 in  $\text{H}_2\text{O}$  .. II 550  
 in hydrazine .. II 553  
 +  $\text{KCl} + \text{H}_2\text{O}$  .. II 143  
 +  $\text{KCl} + \text{H}_2\text{O}$  .. II 551  
 +  $\text{LiCl}$  .. II 405  
 +  $\text{NH}_4\text{Cl} + \text{H}_2\text{O}$  .. II 551, 2  
 +  $\text{NH}_4\text{Cl} + \text{H}_2\text{O}$  .. II 669  
 +  $\text{PbCl}_2$  .. II 553  
 in pyridine .. II 553  
 +  $\text{RbCl}$  .. II 553  
 +  $\text{RbCl}$  .. II 1366  
 in  $\text{SeOCl}_2$  .. II 553  
 +  $\text{SnCl}_2$  .. II 553  
 +  $\text{TiCl}_4$  .. II 553  
 +  $\text{ZnCl}_2$  .. II 553  
 $\text{Mn}(\text{ClO}_4)_2 \cdot 6\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$  .. II 553  
 in cellosolve .. II 553  
 in furfural .. II 553  
 $\text{MnCl}_2(\text{SO}_4)_2$  in  $\text{H}_2\text{O}$  .. I 902  
 $\text{MnF}_2$  distr. between ether + aq.  $\text{HF}$  .. II 555  
 in aq.  $\text{HF}$  .. II 554  
 in  $\text{H}_2\text{O}$  .. II 554  
 $\text{Mn}_2\text{Fe}(\text{CN})_6$  in  $\text{H}_2\text{O}$  .. II 547  
 $\text{MnH}_2\text{O}_4 \cdot 4\text{H}_2\text{O}$  in  $\text{As}_2\text{O}_5$  .. II 543  
 $\text{MnH}_2(\text{BO}_3)_2$  in aq. salt .. II 545  
 $\text{Mn}(\text{H}_2\text{PO}_3)_2 \cdot \text{H}_2\text{O}$  .. II 561  
 $\text{Mn}$  8-hydroxy quinolate .. II 547  
 $3\text{MnI}_2 \cdot 5\text{H}_2\text{O} \cdot 2\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$  .. II 556  
 $\text{MnI}_2$  in  $\text{NH}_3$  .. II 555  
 $\text{Mn}(\text{IO}_3)_2$  in  $\text{H}_2\text{O}$  .. II 556  
 in  $\text{KIO}_3$  .. II 556  
 in  $\text{Mn}(\text{ClO}_4)_2$  .. II 556  
 in  $\text{NaCl}$  .. II 556  
 $\text{MnKV}_5\text{O}_{14} \cdot 8\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$  .. II 572  
 $\text{Mn}$  2-methyl-8-hydroxy quinolate .. II 547  
 $\text{Mn}_2(\text{Mn}_2\text{O}_7)_3 \cdot 5(\text{NH}_4)_2\text{MnO}_4 \cdot 12\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$  .. II 556  
 $\text{Mn}$  naphthalene sulfonates in  $\text{H}_2\text{O}$  .. II 547  
 $\text{MnNH}_4\text{F}_3$  in  $\text{H}_2\text{O}$  .. II 554  
 $\text{MnH}_4\text{PO}_4 \cdot 7\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$  .. II 561  
 in aq.  $\text{NH}_4\text{Cl}$  .. II 561  
 in  $\text{NH}_3 + \text{H}_2\text{O}$  .. II 561  
 in aq.  $\text{NH}_4\text{NO}_3$  .. II 561  
 $\text{Mn}(\text{NH}_4)_2(\text{SO}_4)_2 + \text{Cu}(\text{NH}_4)_2(\text{SO}_4)_2 + \text{H}_2\text{O}$  .. I 985  
 $\text{Mn}(\text{NO}_3)_2 + \text{HNO}_3 + \text{H}_2\text{O}$  .. II 557  
 in  $\text{H}_2\text{O}$  .. II 556  
 +  $\text{La}(\text{NO}_3)_3 + \text{H}_2\text{O}$  .. II 355  
 +  $\text{Mg}(\text{NO}_3)_2 + \text{H}_2\text{O}$  .. II 513  
 $\text{MnO} + \text{As}_2\text{O}_5 + \text{H}_2\text{O}$  .. II 543, 4  
 +  $\text{CaO}$  .. I 629  
 $\text{Mn}$  distr. between  $\text{Fe} + \text{FeS}$  .. II 572  
 $\text{Mn}^*$  distr. between  $\text{HCl} + \text{ethyl ether} + \text{K}_2\text{HPO}_4, \text{H}_2\text{C}_2\text{O}_4, \text{NaF}$  .. II 572  
 distr. between aq. + organic phases .. II 574  
 +  $\text{Fe} = \text{FeO} + \text{Mn}$  .. I 1006  
 $\text{Mn}$  in  $\text{Hg}$  .. II 572  
 $\text{MnO} + \text{Mn}_3\text{P}_2\text{O}_8$  .. II 561  
 +  $\text{P}_2\text{O}_5 + \text{H}_2\text{O}$  .. II 559, 60  
 $2\text{MnO} + \text{Si} = 2\text{Mn} + \text{SiO}_2$  .. II 558  
 $\text{MnO} + \text{SiO}_2$  .. II 558  
 $\text{Mn}(\text{OH})_2$  in  $\text{HCl}$  solns. .. II 558  
 in  $\text{H}_2\text{O}$  .. II 557  
 in  $\text{NaOH}$  solns. .. II 558  
 in organic solts. .. II 558  
 $\text{Mn}_3\text{P}_2\text{O}_8 + \text{MnO}$  .. II 561  
 $\text{Mn}$  8-quinoline-5-sulfonate .. II 547  
 $\text{MnS} + \text{CdS} + \text{ZnS}$  .. I 747  
 +  $\text{CdS} + \text{ZnS} + \text{MnS}$  .. I 747  
 +  $\text{Cu}_2\text{O}$  .. I 959  
 in  $\text{H}_2\text{SO}_4 + \text{H}_2\text{S}$  .. II 561  
 $\text{MnSO}_4 + \text{Al}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$  .. I 1213  
 +  $\text{BeSO}_4 + \text{H}_2\text{O}$  .. I 1423  
 +  $\text{CdSO}_4 + \text{H}_2\text{O}$  .. I 754, 5  
 +  $\text{CuSO}_4 + \text{H}_2\text{O}$  .. I 989, 90  
 +  $\text{FeSO}_4 + \text{H}_2\text{O}$  .. I 1054  
 in  $\text{D}_2\text{O}$  .. II 563  
 in aq. ethyl alc. .. II 569, 70  
 in ethyl + methyl alics. .. II 571  
 in glycol .. II 571  
 in  $\text{H}_2\text{O}$  .. II 562, 3  
 +  $\text{H}_2\text{SO}_4 + \text{H}_2\text{O}$  .. II 563, 4  
 in hydrazine .. II 571  
 +  $\text{K}_2\text{SO}_4$  .. II 571  
 +  $\text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  .. II 312  
 +  $\text{Li}_2\text{SO}_4$  .. II 439  
 +  $\text{MgSO}_4 + \text{H}_2\text{O}$  .. II 527-8  
 +  $\text{Na}_2\text{SO}_4$  .. II 571  
 +  $\text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  .. II 565, 6, 7  
 +  $(\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  .. II 564, 5  
 in propyl alc. .. II 570  
 +  $\text{RbSO}_4 + \text{H}_2\text{O}$  .. II 567  
 +  $\text{Th}(\text{SO}_4)_2 + \text{H}_2\text{O}$  .. II 568  
 +  $\text{Ti}_2\text{SO}_4 + \text{H}_2\text{O}$  .. II 568  
 + urethan +  $\text{H}_2\text{O}$  .. II 571  
 +  $\text{ZnSO}_4 + \text{H}_2\text{O}$  .. II 569  
 $\text{MnSeO}_3$  .. II 571  
 $\text{MnSeO}_4$  in  $\text{H}_2\text{O}$  .. II 571  
 $\text{MnSiF}_6 \cdot 6\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$  .. II 555  
 $\text{MnSiO}_3 + \text{BaSiO}_3$  .. I 400  
 +  $\text{CaSiO}_3$  .. I 693  
 +  $\text{MgSiO}_3$  .. II 543  
 $\text{MnCl}_6$  complexes distr. between  $\text{HCl} + \text{alcs.}$  .. II 572  
 + ethers .. II 572  
 +  $\text{HF}$  .. II 572  
 $\text{MnI}_6 + \text{HCl}$  .. II 572  
 $\text{MnO}_3 + \text{CaF}$  .. I 889  
 +  $\text{Ca}_2\text{MnO}_4$  .. I 898  
 in  $\text{HClO}_4$  solns. .. II 573  
 in  $\text{HCl}$  solns. .. II 574  
 in  $\text{H}_2\text{O}$  .. II 573  
 $\text{MnO}_3 \cdot 2\text{H}_2\text{O}$  in aq. ammonium salts .. II 574  
 $\text{MnO}_3 + \text{KF}$  .. II 211  
 in  $\text{KF}$  .. II 574  
 +  $\text{K}_2\text{MnO}_4$  .. II 246  
 $12\text{MnO}_3 \cdot 3\text{K}_2\text{O} \cdot \text{Cr}_2\text{O}_3 \cdot 20\text{H}_2\text{O}$  .. II 246  
 $11\text{MnO}_3 \cdot \text{K}_3\text{PO}_4 \cdot 19\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$  .. II 246  
 $\text{MnO}_3 + \text{LiF}$  .. II 414  
 +  $\text{Li}_2\text{MnO}_4$  .. II 419  
 +  $\text{NaF}$  .. II 1040  
 +  $\text{Na}_2\text{MnO}_4$  .. II 1065  
 +  $\text{Na}_2\text{MnO}_4$  .. II 574  
 +  $\text{Na}_2\text{O} + \text{H}_2\text{O}$  .. II 1060, 1  
 +  $\text{NH}_3 + \text{H}_2\text{O}$  .. II 705, 6  
 +  $\text{PbO}$  .. II 1313  
 +  $\text{RbF}$  .. II 1370  
 +  $\text{V}_2\text{O}_5$  .. II 574  
 +  $\text{WO}_3$  .. II 574  
 $\text{Mn}$  oxine .. II 572  
 $\text{Mn}$  sulfonates +  $\text{Pb}$  naphthalene .. II 1270  
 $\text{Mn}$  in acetamide .. II 581  
 in acetate solns. .. II 577  
 in acetone .. II 585  
 in alanine .. II 581  
 +  $\text{A}$  .. II 588  
 in arabinose .. II 581  
 in aq. salts .. II 577, 8  
 in azobacter cells .. II 583  
 in benzene .. II 585  
 in benzene +  $\text{H}_2$  .. II 585  
 + benzene .. II 588  
 in butane .. II 587

- in blood ..... II 562  
in whole blood ..... II 581, 2  
in  $\text{CCl}_4$  ..... II 584, 5  
+  $\text{CO}_2$  (f.p.), (l.v.) ..... 1493  
in aq. chloral hydrates ..... II 580  
in chlorobenzene ..... II 585  
in edible oils ..... II 586  
in ethanol ..... II 583, 4  
in aq. ethanol ..... II 579  
in erythritol ..... II 585  
in ethyl ether ..... II 588  
in ethylene ..... II 588  
+ Fe ..... I 1006  
in glucose ..... II 581  
in aq. glycerol ..... II 580  
in glyccol ..... II 581  
in liq.  $\text{H}_2$  ..... II 588  
+  $\text{H}_2$  ..... I 1095  
+  $\text{H}_2$  in liq.  $\text{CO}_2$  ..... I 1095  
+  $\text{H}_2$  in  $\text{H}_2\text{O}$  ..... I 1078  
+  $\text{H}_2$  + methane ..... I 1095  
+  $\text{H}_2$  +  $\text{NH}_3$  ..... I 1094, 5  
+  $\text{H}_2$  in liq.  $\text{NH}_3$  ..... I 1094  
+  $\text{H}_2$  +  $\text{NH}_3$  (gas) +  $\text{NH}_3$  (liq.) ..... II 589  
in  $\text{H}_2\text{O}$  ..... II 575, 6, 81, 82  
in  $\text{H}_2\text{O}$  and aq. blood lipoids ..... II 583  
in aq.  $\text{H}_2\text{SO}_4$  ..... II 577  
in isobutyric acid soln. .... II 579  
in isopropyl alcohol ..... II 584  
in levulose ..... II 581  
+ methane ..... II 588  
in liq. methane ..... II 588  
+ methane in liq.  $\text{NH}_3$  ..... II 589  
in methanol ..... II 583  
in methanol soln. of KI ..... II 584  
in methanol soln. of urea ..... II 584  
in methyl acetate ..... II 585  
+  $\text{NH}_3$  ..... II 589  
in liq.  $\text{NH}_3$  ..... II 589  
+  $\text{NH}_3$  + methane ..... II 590  
in  $\text{O}_2$  ..... II 582  
in organic dyes ..... II 583  
in organic solvents ..... II 585, 6  
in ox blood and ox serum ..... II 582  
in petroleum oils ..... II 587  
in plasma, blood, etc. .... II 582  
in polystyrene ..... II 587  
in liq. propane ..... II 588  
in aq. propionic acid ..... II 579  
in rubber ..... II 588  
+  $\text{SO}_2$  ..... II 589  
in liq.  $\text{SO}_2$  ..... II 589  
in sea water ..... II 578  
in serum, plasma, haemoglobin solns. .... II 582  
in aq. cane sugar ..... II 581  
+ Ti ..... II 1552  
in urea ..... II 581  
in urea solns. .... II 579  
 $\text{N}(\text{CH}_3)_2\text{H}_2\text{Cl}$  in chloroform ..... II 682  
in  $\text{H}_2\text{O}$  ..... II 682  
 $\text{N}(\text{CH}_3)_2\text{Cl}$  in  $\text{CH}_3\text{CN}$  ..... II 682  
in ethylene dichloride + salts ..... II 682, 3  
 $\text{N}(\text{CH}_3)_2\text{N}_3$  in various solns ..... II 708  
 $\text{N}(\text{C}_2\text{H}_5)_2\text{Cl}$  in acetone ..... II 683  
in acetonitrile ..... II 683  
in alcs. .... II 683  
in chloroform ..... II 683  
in  $\text{H}_2\text{O}$  ..... II 683  
 $\text{NH}_2\text{OH}$  in various solvents ..... II 789  
 $\text{NH}_2\text{OH}\cdot\text{HCl}$  in alcs. .... II 790  
+  $\text{H}_2\text{O}$  ..... II 789  
 $\text{NH}_3$  in  $\text{AgNO}_3$  ..... II 596  
+  $\text{AlBr}_3$  ..... I 162  
+ A ..... II 603  
+  $\text{As}_2\text{O}_3$  +  $\text{H}_2\text{O}$  ..... II 604  
+ acetamide ..... II 603  
+ acetic acid ..... II 620, 1  
+ acetone ..... II 1420  
+  $\text{B}_2\text{O}_3$  +  $\text{H}_2\text{O}$  ..... II 605, 6, 7  
+ biuret f.p., soly., etc. .... II 603  
+ butyl alc. .... II 603  
+ iso butyl alc. .... II 603  
+ sec butyl alc. .... II 603  
+ ter butyl alc. .... II 603  
in  $\text{CCl}_4$  ..... II 601  
in  $\text{CHCl}_3$  ..... II 599, 600  
+  $(\text{CN})_2\text{H}_2$  f.p., soly., etc. .... II 640  
+  $\text{CO}_2$  +  $\text{H}_2\text{O}$  ..... II 638, 9, 40, 49  
+  $\text{CS}(\text{NH}_2)_2$  ..... II 603  
in  $\text{Ca}(\text{NO}_3)_2$  ..... II 596  
+ Ca ..... 1495  
+ chloroform ..... II 1420  
in cyclohexanol ..... II 602  
in dimethylformamide ..... II 603  
distr. betwn.  $\text{CCl}_4$  + air ..... II 601  
distr. betwn.  $\text{CHCl}_3$  +  $\text{NH}_4\text{Cl}$  +  $\text{MgCl}_2$  ..... II 601  
distr. betwn.  $\text{H}_2\text{O}$  and amyl alc. .... II 599  
distr. betwn.  $\text{H}_2\text{O}$  and  $\text{CHCl}_3$  ..... II 600, 1  
distr. betwn. toluene and  $\text{AgNH}_3\text{OH}$  ..... II 602  
distr. betwn. toluene and aq.  $\text{NH}_3\text{Cl}$  ..... II 602  
distr. betwn. toluene and air ..... II 602  
+ ether (vap.) ..... II 1420  
+ ethyl alc. .... II 603  
in ethyl alc., absolute ..... II 599  
in aq. ethyl alc. .... II 598  
in ethyl ether ..... II 602  
+  $\text{H}_2\text{O}$  ..... II 590, 1, 2, 3, 4  
+  $\text{H}_2$  +  $\text{N}_2$  ..... I 1094, 5  
+ HF ..... I 1124  
+  $\text{H}_2\text{O}_2$  ..... I 1148  
+  $\text{H}_2\text{O}_2$  ..... II 595  
+  $\text{H}_2\text{NCO}_2\text{NH}_2$  ..... II 603  
+  $\text{H}_3\text{PO}_4$  +  $\text{H}_2\text{O}$  ..... II 731, 2, 3, 4, 5  
+  $\text{H}_2\text{S}$  ..... II 603  
+  $\text{H}_2\text{S}$  ..... II 746  
+ hydroxy benzene ..... II 603  
in hydroxylamine ..... II 603  
+ K ..... II 603  
 $\text{NH}_3$  (liq.) + K + Kf ..... II 1  
 $\text{NH}_3$  +  $\text{K}_2\text{CO}_3$  +  $\text{H}_2\text{O}$  ..... II 597  
+ KCl ..... II 167  
+ KCl +  $\text{KNO}_3$  +  $\text{H}_2\text{O}$  ..... II 129  
+  $\text{K}_2\text{O}$  +  $\text{P}_2\text{O}_5$  +  $\text{H}_2\text{O}$  ..... II 739  
in KOH ..... II 596  
+ KOH +  $\text{H}_2\text{O}$  ..... II 276  
 $3\text{NH}_3$  +  $\text{LaCl}_3 \rightleftharpoons 3\text{NH}_4\text{Cl} + \text{La}(\text{OH})_3$  (+  $3\text{H}_2\text{O}$ ) ..... II 349  
 $\text{NH}_3$  + Li ..... II 603  
+ LiCl +  $\text{H}_2\text{O}$  ..... II 392  
+  $\text{LiNO}_3$  ..... II 427  
+ methyl alc. .... II 603, 1420  
in methyl alc., absolute ..... II 598  
+ methyl ether ..... II 603  
+  $\text{MoO}_3$  +  $\text{H}_2\text{O}$  ..... II 705, 6  
+  $\text{N}_2$  ..... II 589  
+  $\text{N}_2$  + methane ..... II 590  
 $\text{NH}_3$  (gas) +  $\text{NH}_3$  (liq.) +  $\text{N}_2$  +  $\text{H}_2$  ..... II 589  
 $\text{NH}_3$  +  $\text{NH}_4\text{Br}$  ..... II 603  
+  $\text{NH}_4\text{CNS}$  ..... II 603  
+  $(\text{NH}_4)_2\text{CO}_2$  ..... II 603  
+  $\text{NH}_4\text{Cl}$  ..... II 603  
+  $\text{NH}_4\text{Cl}$  + hydrazine ..... II 681  
 $\text{NH}_3$  liq +  $\text{NH}_4\text{Cl}$  +  $\text{NH}_4\text{NO}_3$  ..... II 679, 80  
+  $\text{NH}_4\text{ClO}_4$  ..... II 603  
+  $\text{N}_2\text{H}_5\text{N}_3$  ..... II 785  
+  $\text{N}_2\text{H}_5\text{N}_3$  +  $\text{N}_2\text{H}_4$  ..... II 785  
+  $\text{NH}_4\text{I}$  ..... II 603  
+  $\text{NH}_4\text{NO}_3$  ..... II 603  
+  $\text{NH}_4\text{NO}_3$  +  $\text{NH}_4\text{CNS}$  +  $\text{H}_2\text{O}$  ..... II 712  
+  $\text{NH}_4\text{NO}_3$  +  $\text{NH}_4\text{Cl}$  ..... II 660, 1, 2  
 $\text{NH}_3$  liq +  $\text{NH}_4\text{NO}_3$  +  $\text{NaNO}_3$  ..... II 727  
 $\text{NH}_3$  +  $\text{NH}_4\text{SCN}$  ..... II 638  
+  $(\text{NH}_4\text{SO}_3)\text{NH}$  +  $\text{H}_2\text{O}$  ..... II 779  
+  $(\text{NH}_4)_2\text{SO}_4$  +  $\text{NH}_4\text{HCO}_3$  +  $\text{H}_2\text{O}$  ..... II 645  
+  $(\text{NH}_4)_2\text{SO}_4$  + urea +  $\text{H}_2\text{O}$  ..... II 650  
+  $(\text{NH}_4)_2\text{SO}_4\cdot\text{CdSO}_4$  +  $\text{H}_2\text{O}$  ..... II 759  
in nitrobenze ..... II 603  
+ Na ..... II 603  
+ Na + NaI ..... II 805  
+ NaBr +  $\text{H}_2\text{O}$  ..... II 833  
 $\text{NH}_3$  (liq) + NaBr + NaCl ..... II 846  
+ NaCN + NaCl ..... II 91  
 $\text{NH}_3$  + NaCl +  $\text{H}_2\text{O}$  ..... II 967  
 $\text{NH}_3$  (liq) + NaCl +  $\text{NaNO}_3$  ..... II 1010  
 $\text{NH}_3$  in aq. NaOH ..... II 596  
+ NaOH +  $\text{H}_2\text{O}$  ..... II 1085

- $\cdot \text{Na}_2\text{SO}_4 + (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  II 762  
 $3\text{NH}_3 + \text{NaCl}_3 \rightleftharpoons 3\text{NH}_4\text{Cl} + \text{Nd}(\text{CH}_3)_3 (+ 3\text{H}_2\text{O})$  II 1184  
**NH<sub>3</sub>** in organic solvents II 602  
   • organic vapors I 1121  
   •  $\text{P}_2\text{O}_5 + \text{SO}_3 + \text{H}_2\text{O}$  II 738  
   in propyl alcs. II 599  
   • propyl alc. II 603  
   • iso propyl alc. II 603  
   in rubber II 603  
   • S II 603  
   in aq. salt II 595, 6  
**NH<sub>3</sub> (aq)** • salts, vapor pressure II 597, 8  
**NH<sub>3</sub> + SO<sub>2</sub> + H<sub>2</sub>O** II 748  
   •  $\text{SO}_3 + \text{H}_2\text{C}$  II 758  
   • urea +  $\text{CO}_2$  I 484  
   • urea f.p., soly, etc. II 640  
   • urea +  $\text{H}_2\text{C}$  f.p., soly, etc. II 640  
   aq. vapor pressure II 594, 5  
   •  $\text{ZnSO}_4 + \text{H}_2\text{C}$  II 1686  
**(NH<sub>4</sub>)<sub>2</sub>Cr(SO<sub>4</sub>)<sub>2</sub> + (NH<sub>4</sub>)<sub>2</sub>Cr(SO<sub>4</sub>)<sub>2</sub> + H<sub>2</sub>O** I 873  
**NH<sub>4</sub> acetate** in acetic acid solns II 620  
   • acetic acid II 621  
   in acetone II 621  
   • Cu acetate + acetic acid I 912  
   in methyl alc. II 621  
   in liq. NH<sub>3</sub> II 621  
   • Ni acetate + acetic acid II 621  
   in liq. SO<sub>2</sub> II 621  
   • Zn acetate + acetic acid II 1649  
**(NH<sub>4</sub>)<sub>2</sub>AlF<sub>6</sub> + H<sub>2</sub>O** I 181  
**NH<sub>4</sub>Al(SO<sub>4</sub>)<sub>2</sub> in H<sub>2</sub>O** I 223, 4  
   •  $\text{KAl}(\text{SO}_4)_2 + \text{H}_2\text{O}$  I 225  
   •  $\text{NaAl}(\text{SO}_4)_2 + \text{H}_2\text{O}$  I 226  
**NH<sub>4</sub>Al(SO<sub>4</sub>)<sub>2</sub> + NH<sub>4</sub>Fe(SO<sub>4</sub>)<sub>2</sub> + H<sub>2</sub>O** I 226  
   in aq. (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>, Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> I 219, 220  
   •  $\text{TiAl}(\text{SO}_4)_2 + \text{H}_2\text{O}$  I 224  
**NH<sub>4</sub> antimonyano sulfamates in H<sub>2</sub>O** II 632  
**NH<sub>4</sub> arsenates in aq. As<sub>2</sub>O<sub>3</sub>** I 236  
**NH<sub>4</sub>BF<sub>4</sub> in acetone** II 695  
   in benzene II 695  
   in chloroform II 695  
   in ethanol II 495  
   in H<sub>2</sub>O II 605, 95  
**(NH<sub>4</sub>)<sub>2</sub>B<sub>4</sub>O<sub>7</sub> in H<sub>2</sub>O** II 607, 9  
   •  $\text{Na}_2\text{B}_4\text{O}_7 + \text{H}_2\text{O}$  II 609  
   •  $2\text{NaCl} \rightleftharpoons 2\text{NH}_4\text{Cl} + \text{Na}_2\text{B}_4\text{O}_7$  II 611, 2  
   • (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O II 608  
   •  $\text{Na}_2\text{SO}_4 \rightleftharpoons \text{Na}_2\text{B}_4\text{O}_7 + (\text{NH}_4)_2\text{SO}_4$  II 609, 10, 11  
   •  $\text{Na}_2\text{SO}_4 \rightleftharpoons \text{Na}_2\text{B}_4\text{O}_7 + (\text{NH}_4)_2\text{SO}_4 (+ \text{H}_2\text{O})$  II 628  
**(NH<sub>4</sub>)<sub>2</sub>BF<sub>4</sub> + NH<sub>4</sub>MnF<sub>3</sub> + H<sub>2</sub>O** II 695  
**(NH<sub>4</sub>)<sub>2</sub>BF<sub>4</sub> + NH<sub>4</sub>NaF<sub>3</sub> + H<sub>2</sub>O in NH<sub>4</sub>F<sub>2</sub>, BeF<sub>2</sub>, MnF<sub>2</sub>** II 695  
**NH<sub>4</sub> benzoate in ethanol solns.** II 627  
   in glycerol II 627  
   in H<sub>2</sub>O II 627  
   in methyl alc. II 627  
**NH<sub>4</sub>Br + AlBr<sub>3</sub>** I 162  
   in alcs. II 615, 6  
   •  $\text{As}_2\text{O}_3 + \text{H}_2\text{O}$  I 236  
   • CdBr<sub>2</sub> in H<sub>2</sub>O I 700  
**4NH<sub>4</sub>Br + CdBr<sub>2</sub> in H<sub>2</sub>O** I 700, 1  
**NH<sub>4</sub>Br + CaBr<sub>2</sub> + H<sub>2</sub>O** I 790, 1  
   in ethyl ether II 616  
   • FeBr<sub>2</sub> + H<sub>2</sub>O I 1008  
   in glycerol II 616  
   in aq. HBr solns II 613  
   in H<sub>2</sub>O II 612  
   • HgBr<sub>2</sub> II 1189  
   • HgBr + aq. NH<sub>3</sub> I 1181  
   • KBr + H<sub>2</sub>O II 21  
   in hydrazine II 617  
   •  $\text{KCl} \rightleftharpoons \text{KBr} + \text{NH}_4\text{Cl}$  II 23  
   • NH<sub>3</sub> II 603  
   in liq. NH<sub>3</sub> II 616  
   • NH<sub>4</sub>Cl II 682  
   • NH<sub>4</sub>Cl + H<sub>2</sub>O II 613  
   • PbBr<sub>2</sub> + H<sub>2</sub>O II 613  
**NH<sub>4</sub>Br, propyl benzyl methyl phenyl distr. betwn H<sub>2</sub>O + CHCl<sub>3</sub>** II 617  
**NH<sub>4</sub>Br in liq. SO<sub>2</sub>** II 617  
**(NH<sub>4</sub>)<sub>2</sub>CH<sub>2</sub>O<sub>2</sub> in H<sub>2</sub>O** II 619  
**(NH<sub>4</sub>)<sub>2</sub>C<sub>2</sub>H<sub>4</sub>O<sub>6</sub> in H<sub>2</sub>O** II 622, 3  
**NH<sub>4</sub>CNS + NH<sub>3</sub>** II 603  
   •  $\text{NH}_4\text{NO}_3 + \text{NH}_3 + \text{H}_2\text{O}$  II 712  
**(NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub> + MgCO<sub>3</sub> + H<sub>2</sub>O** II 475  
   • NH<sub>3</sub> II 603  
   in NH<sub>3</sub> solns II 647  
   •  $\text{NH}_4\text{Cl} + \text{H}_2\text{O}$  II 648  
   •  $\text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$  II 648  
   •  $2\text{NaCl} \rightleftharpoons \text{NH}_4\text{Cl} + \text{Na}_2\text{CO}_3$  II 648  
   in organic solvents II 649  
**(NH<sub>4</sub>)<sub>2</sub>C<sub>2</sub>O<sub>4</sub> in aq. acetone** II 653  
   in formic acid II 651  
   in H<sub>2</sub>O II 650  
   in anh. hydrazine II 650  
   •  $\text{K}_2\text{C}_2\text{O}_4 + \text{H}_2\text{O}$  II 113  
   •  $\text{Li}_2\text{C}_2\text{O}_4 + \text{H}_2\text{O}$  II 387  
   • NH<sub>4</sub> salts II 652  
   •  $\text{Na}_2\text{C}_2\text{O}_4 + \text{H}_2\text{O}$  II 652  
   • oxalates II 652  
   in aq. oxalic acid II 651  
   •  $\text{Th}(\text{C}_2\text{O}_4)_2 + \text{H}_2\text{O}$  II 653  
   •  $\text{UO}_2\text{C}_2\text{O}_4 + \text{H}_2\text{O}$  II 1605  
   •  $\text{ZrC}_2\text{O}_4 + \text{H}_2\text{O}$  II 653  
**NH<sub>4</sub>CO<sub>2</sub>NH<sub>2</sub> in H<sub>2</sub>O** II 649  
   • (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> + NH<sub>3</sub> + H<sub>2</sub>O II 650  
   • urea f.p., soly, etc. II 640  
   • urea + NH<sub>3</sub> f.p., soly, etc. II 640  
**2(NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub> + UO<sub>2</sub>CO<sub>3</sub> in H<sub>2</sub>O** II 649  
**(NH<sub>4</sub>)<sub>2</sub>CoFe(CO)<sub>6</sub> in aq. C<sub>2</sub>H<sub>5</sub>OH** I 536  
   in H<sub>2</sub>O I 535  
**NH<sub>4</sub>Co mecenate in aq. NH<sub>3</sub>** II 631  
**(NH<sub>4</sub>)<sub>2</sub>CalBr<sub>3</sub> in alc.** II 613  
   •  $\frac{1}{2}\text{H}_2\text{O}$  in ether II 613  
   •  $\frac{1}{2}\text{H}_2\text{O}$  in H<sub>2</sub>O II 613  
**NH<sub>4</sub> acid chlorosuccinate + H<sub>2</sub>O + NH<sub>4</sub> acid malate** II 623  
   • H<sub>2</sub>O + NH<sub>4</sub> acid tartrate II 623  
**NH<sub>4</sub> chloro succinates in H<sub>2</sub>O** II 625  
**NH<sub>4</sub> chlorophenanthrene sulfonate in H<sub>2</sub>O** II 631  
**NH<sub>4</sub> neutral chlor succinate + H<sub>2</sub>O + NH<sub>4</sub> acid tartrate** II 623  
**NH<sub>4</sub> citrates in aq. citric acid solns** II 678  
**NH<sub>4</sub>Cl in acetic acid** II 677  
   in aq. acetone II 677, 8  
   in alcs. II 677, 8  
   • AgCl II 682  
   • AgCl II 177  
   • AlCl<sub>3</sub> I 177  
   •  $\text{As}_2\text{O}_3 + \text{H}_2\text{O}$  II 655  
   •  $\text{BaCl}_2 + \text{H}_2\text{O}$  I 329, 348  
   •  $\text{BaCl}_2 + \text{CuCl}_2 + \text{H}_2\text{O}$  I 345  
**2NH<sub>4</sub>Cl + Ba(NO<sub>3</sub>)<sub>2</sub>  $\rightleftharpoons$  BaCl<sub>2</sub> + 2NH<sub>4</sub>NO<sub>3</sub> in H<sub>2</sub>O** I 348  
**NH<sub>4</sub>Cl + BeCl<sub>2</sub> + H<sub>2</sub>O** I 405  
   • butyl alc. + H<sub>2</sub>O II 675, 6  
   •  $\text{Ca}(\text{H}_2\text{PO}_4)_2 + \text{NH}_4\text{H}_2\text{PO}_4$  in H<sub>2</sub>O I 655  
   • CdCl<sub>2</sub> II 682  
   • CdCl<sub>2</sub> + H<sub>2</sub>O II 669  
   • CdCl<sub>2</sub> + H<sub>2</sub>O I 716-18  
   • CdCl<sub>2</sub> in H<sub>2</sub>O I 717  
**4NH<sub>4</sub>Cl + CdCl<sub>2</sub> in H<sub>2</sub>O** I 717  
**NH<sub>4</sub>Cl + CdCl<sub>2</sub> + H<sub>2</sub>O** II 669  
   • CdCl<sub>2</sub> + 4NH<sub>4</sub>Cl + H<sub>2</sub>O II 718  
   • CoCl<sub>2</sub> + H<sub>2</sub>O II 669  
   • CoCl<sub>2</sub> + H<sub>2</sub>O I 807-10  
   • CrCl<sub>3</sub> + H<sub>2</sub>O II 669  
   • CuCl II 682  
   • CuCl + H<sub>2</sub>O I 929  
   • CuCl<sub>2</sub> + H<sub>2</sub>O II 669  
   • CuCl<sub>2</sub> + H<sub>2</sub>O I 942, 3, 948  
   • CuCl<sub>2</sub> in C<sub>2</sub>H<sub>5</sub>OH I 948  
**2NH<sub>4</sub>Cl + CuCl<sub>2</sub> in H<sub>2</sub>O** I 943  
**NH<sub>4</sub>Cl + CuCl + HCl + H<sub>2</sub>O** I 929  
   • CuCl<sub>2</sub> + HCl + H<sub>2</sub>O I 943  
   • CuSO<sub>4</sub> + CuCl<sub>2</sub> + (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> I 974  
   • dioxane + H<sub>2</sub>O II 676  
   in aq. ethanol II 675  
   in ethyl ether + H<sub>2</sub>O + HCl II 677  
   in ethyl urethan II 678  
   • FeCl<sub>3</sub> + H<sub>2</sub>O I 1015, 6  
   • FeCl<sub>3</sub> II 682  
   • FeCl<sub>3</sub> + H<sub>2</sub>O II 669  
   • FeCl<sub>3</sub> + H<sub>2</sub>O I 1023-5  
   in glycerol II 677  
   in aq. glycerol II 677  
   in HCl solns II 655  
**2NH<sub>4</sub>Cl + H<sub>2</sub>SO<sub>4</sub>  $\rightleftharpoons$  (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> + 2HCl** II 655

- $+ \text{H}_2\text{SO}_4 \rightleftharpoons (\text{NH}_4)_2\text{SO}_4 + 2\text{HCl} (+ \text{H}_2\text{O})$  .. II 664  
 $\text{NH}_4^+, \text{H}^+ \parallel \text{PO}_4^{3-}, \text{NO}_3^- + \text{H}_2\text{O}$  .. II 738  
 $\text{NH}_4^+, \text{H}^+, \text{Co}^{3+} \parallel \text{PO}_4^{3-}, \text{NO}_3^- + \text{H}_2\text{O}$  .. II 738  
 $\text{NH}_4\text{Cl}$  in  $\text{H}_2\text{O}$  .. II 654  
 in  $\text{H}_2\text{O} + \text{CO}_2$  .. II 655  
 $+ \text{HgCl}_2$  .. II 682  
 $+ \text{HgCl}_2$  .. II 682  
 $+ \text{HgCl}_2$  .. II 1229  
 $+ \text{HgCl}_2 + \text{H}_2\text{O}$  .. II 1210  
 $+ \text{hydrazine}$  .. II 680, 1  
 $+ \text{KBr} \rightleftharpoons \text{KCl} + \text{NH}_4\text{Br}$  .. II 23  
 $+ \text{KCl}$  .. II 169  
 $+ \text{KCl} + \text{H}_2\text{O}$  .. II 143, 4, 5, 6  
 $\text{NH}_4^+, \text{K}^+ \parallel \text{Cl}^-, \text{NO}_3^-, \text{H}_2\text{PO}_4^-$  .. II 169  
 $\text{NH}_4^+, \text{K}^+ \parallel \text{Cl}^-, \text{H}_2\text{PO}_4^- + \text{H}_2\text{O}$  .. II 287  
 $\text{NH}_4^+, \text{K}^+, \text{Na}^+ \parallel \text{Cl}^-, \text{NO}_3^- + \text{H}_2\text{O}$  .. II 132  
 $\text{NH}_4^+, \text{K}^+, \text{Na}^+ \parallel \text{Cl}^-, \text{HCO}_3^- + \text{H}_2\text{O}$  .. II 105  
 $\text{NH}_4^+, \text{K}^+, \text{Na}^+ \parallel \text{Cl}^-, \text{NO}_3^-, \text{SO}_4^{2-} + \text{H}_2\text{O}$  .. II 146  
 $+ \text{KCl} + \text{HgCl}_2 + \text{H}_2\text{O}$  .. II 1209  
 $[\text{NH}_4^+, \text{K}^+ \parallel \text{Cl}^-, \text{SO}_4^{2-}]$  .. II 194  
 $\text{NH}_4\text{Cl}$  in aq  $\text{K}_2\text{Cr}_2\text{O}_7$  .. II 673  
 $+ \text{KH}_2\text{PO}_4 \rightleftharpoons \text{KCl} + \text{NH}_4\text{H}_2\text{PO}_4 (+ \text{H}_2\text{O})$  .. II 132, 46  
 $+ \text{KH}_2\text{PO}_4 \rightleftharpoons \text{NH}_4\text{H}_2\text{PO}_4 + \text{KCl}$  .. II 169  
 in aq  $\text{KMnO}_4$  .. II 673  
 $+ \text{KNO}_3 \rightleftharpoons \text{KCl} + \text{NH}_4\text{NO}_3$  .. II 261  
 $+ \text{KNO}_3 \rightleftharpoons \text{NH}_4\text{NO}_3 + \text{KCl}$  .. II 169  
 $+ \text{KNO}_3 \rightleftharpoons \text{NH}_4\text{NO}_3 + \text{KCl} (+ \text{H}_2\text{O})$  .. II 131, 46  
 $+ \text{K}_2\text{SO}_4 \rightleftharpoons 2\text{KCl} + (\text{NH}_4)_2\text{SO}_4 (+ \text{H}_2\text{O})$  .. II 135, 6  
 $3\text{NH}_4\text{Cl} + \text{La}(\text{OH})_3 \rightleftharpoons \text{LaCl}_3 + 3\text{NH}_3 (+ 3\text{H}_2\text{O})$  .. II 349  
 $\text{NH}_4\text{Cl} + \text{LiCl}$  .. II 682  
 in methanol .. II 677  
 in aq methanol .. II 678  
 $+ \text{MgCl}_2 + \text{H}_2\text{O}$  .. II 488  
 $\text{MgCl}_2 \cdot 6\text{H}_2\text{O} + \text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O} + \text{H}_2\text{O}$  .. II 146  
 $+ \text{MnCl}_2$  .. II 551, 2  
 $+ \text{MnCl}_2 + \text{H}_2\text{O}$  .. II 551, 2, 669  
 $+ \text{NH}_3$  .. II 603  
 in aq  $\text{NH}_3$  .. II 656  
 in  $\text{NH}_3$  liq. .. II 678, 9  
 $+ \text{NH}_3 + \text{hydrazine}$  .. II 681  
 $+ \text{NH}_4\text{Br}$  .. II 682  
 $+ \text{NH}_4\text{Br} + \text{H}_2\text{O}$  .. II 613  
 $+ (\text{NH}_4)_2\text{CO}_3 + \text{H}_2\text{O}$  .. II 648  
 $+ (\text{NH}_4)_2\text{Cr}_2\text{O}_7 + \text{H}_2\text{O}$  .. II 657  
 $+ \text{NH}_4\text{F} + \text{H}_2\text{O}$  .. II 657  
 $+ \text{NH}_4\text{F} + (\text{NH}_4)_2\text{SiF}_6 + \text{H}_2\text{O}$  .. II 658  
 $+ (\text{NH}_4)_4\text{Fe}(\text{CN})_6 + \text{H}_2\text{O}$  .. II 634  
 in aq  $\text{NH}_4\text{HCO}_3 + \text{CO}_2$  .. II 656  
 $+ \text{NH}_4\text{HCO}_3 + \text{H}_2\text{O}$  .. II 642  
 $+ \text{NH}_4\text{HF}_2 + \text{H}_2\text{O}$  .. II 658  
 $+ \text{NH}_4\text{H}_2\text{PO}_4 + \text{H}_2\text{O}$  .. II 662, 3  
 $+ \text{NH}_4\text{H}_2\text{PO}_4 + \text{NH}_4\text{NO}_3$  .. II 682  
 $+ \text{NH}_4\text{I} + \text{H}_2\text{O}$  .. II 658  
 $+ \text{NH}_4\text{NO}_3$  .. II 682  
 $+ \text{NH}_4\text{NO}_3 + \text{H}_2\text{O}$  .. II 659, 60  
 $+ \text{NH}_4\text{NO}_3 + \text{NH}_3$  .. II 660, 1, 2  
 $+ \text{NH}_4\text{NO}_3 + \text{NH}_3$  liq. .. II 679, 80  
 $+ \text{NH}_4\text{NO}_3 + \text{NaNO}_3$  .. II 682  
 $+ (\text{NH}_4)_2\text{SO}_3 + \text{H}_2\text{O}$  .. II 664, 5  
 $+ (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  .. II 665, 6  
 $+ \text{NH}_4\text{SO}_3\text{NH}_2 + \text{H}_2\text{O}$  .. II 666, 7  
 $+ (\text{NH}_4)_2\text{SiF}_6 + \text{H}_2\text{O}$  .. II 657  
 $+ \text{NH}_4$  succinate  $+ \text{H}_2\text{O}$  .. II 634  
 $+ \text{NH}_4\text{VO}_3 + \text{H}_2\text{O}$  .. II 783  
 $2\text{NH}_4\text{Cl} + \text{Na}_2\text{B}_4\text{O}_7 \rightleftharpoons (\text{NH}_4)_2\text{B}_4\text{O}_7 + 2\text{NaCl}$  .. II 611, 2  
 $+ \text{Na}_2\text{CO}_3 \rightleftharpoons \text{NH}_4\text{Cl} + 2\text{NaCl}$  .. II 648  
 $\text{NH}_4\text{Cl} + \text{NaCl} + \text{H}_2\text{O}$  .. II 667  
 in aq  $\text{NaCl} + \text{CO}_2$  .. II 668  
 $+ \text{NaCl} + \text{NaNO}_3$  .. II 682  
 $+ \text{Na}_2\text{Cr}_2\text{O}_7 + \text{H}_2\text{O}$  .. II 1028  
 $2\text{NH}_4\text{Cl} + \text{Na}_2\text{Cr}_2\text{O}_7 \rightleftharpoons (\text{NH}_4)_2\text{Cr}_2\text{O}_7 + 2\text{NaCl} (+ \text{H}_2\text{O})$  .. II 972  
 $\text{HH}_4\text{Cl} + \text{NaHCO}_3 \rightleftharpoons \text{NH}_4\text{HCO}_3 + \text{NaCl}$  .. II 642, 3, 4  
 $\text{NH}_4^+, \text{Na}^+ \parallel \text{HCO}_3^-, \text{OH}^-, \text{SO}_4^{2-} + \text{H}_2\text{O}$  .. II 647  
 $2\text{NH}_4\text{Cl} + \text{Na}_2\text{HPO}_4 \rightleftharpoons (\text{NH}_4)_2\text{HPO}_4 + 2\text{NaCl} (+ \text{H}_2\text{O})$  .. II 663  
 $\text{NH}_4\text{Cl} + \text{NaNO}_3 \rightleftharpoons \text{NH}_4\text{NO}_3 + \text{NaCl} (\text{H}_2\text{O}), (\text{NH}_3)$  .. II 662  
 $2\text{NH}_4\text{Cl} + \text{Na}_2\text{SO}_3 \rightleftharpoons 2\text{NaCl} + (\text{NH}_4)_2\text{SO}_3 (+ \text{H}_2\text{O})$  .. II 751, 2  
 $+ \text{Na}_2\text{SO}_4 \rightleftharpoons (\text{NH}_4)_2\text{SO}_4 + 2\text{NaCl} (+ \text{H}_2\text{O})$  .. II 666  
 $\text{NH}_4\text{Cl} + \text{NaHSO}_3 \rightleftharpoons \text{NH}_4\text{HSO}_3 + \text{NaCl} (+ \text{H}_2\text{O})$  .. II 754  
 $+ \text{NiCl}_2 + \text{H}_2\text{O}$  .. II 668, 9, 1209  
 $+ \text{NiCl}_2 + \text{H}_2\text{O}$  distr. .. II 669  
 $3\text{NH}_4\text{Cl} + \text{Nd}(\text{OH})_3 \rightleftharpoons \text{NdCl}_3 + 3\text{NH}_3 (+ \text{H}_2\text{O})$  .. II 1187  
 $\text{NH}_4\text{Cl} + \text{PbCl}_2 + \text{H}_2\text{O}$  .. II 669, 70  
 in aq. propanol .. II 675  
 in liq.  $\text{SO}_2$  .. II 682  
 $+ \text{SbCl}_3$  .. II 682  
 $+ \text{urethan} + \text{H}_2\text{O}$  .. II 676  
 $+ \text{ZnCl}_2$  .. II 682  
 $+ \text{ZnCl}_2 + \text{H}_2\text{O}$  .. II 673  
 $+ \text{ZnCl}_2 + \text{LiCl} + \text{CH}_3\text{NH}_3\text{Cl} + \text{H}_2\text{O}$  .. II 673  
 $\text{NH}_4\text{ClO}_4$  in  $\text{H}_2\text{O}$  .. II 684, 8  
 $+ \text{Al}(\text{ClO}_4)_3 + \text{H}_2\text{O}$  .. II 1178  
 $+ \text{Cu}(\text{ClO}_4)_2 + \text{H}_2\text{O}$  .. II 1949  
 $+ \text{KClO}_4 + \text{H}_2\text{O}$  .. II 182  
 $+ \text{KNO}_3 \rightleftharpoons \text{NH}_4\text{NO}_3 + \text{KClO}_4$  .. II 181  
 in methyl alc. + ethyl acetate .. II 688  
 $+ \text{NH}_3$  .. II 603  
 in aq.  $\text{NH}_3$  .. II 685  
 in liq.  $\text{NH}_3$  .. II 688  
 $+ \text{NH}_3\text{NO}_3 + \text{H}_2\text{O}$  .. II 685  
 $+ (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  .. II 687  
 $+ \text{NaClO}_4 + \text{H}_2\text{O}$  .. II 685, 6  
 $+ \text{NaNO}_3 \rightleftharpoons \text{NH}_4\text{NO}_3 + \text{NaClO}_4 (\text{H}_2\text{O})$  .. II 686, 7  
 $2\text{NH}_4\text{ClO}_4 + \text{Na}_2\text{SO}_4 \rightleftharpoons (\text{NH}_4)_2\text{SO}_4 + 2\text{NaClO}_4 (+ \text{H}_2\text{O})$  .. II 687  
 $\text{NH}_4\text{ClO}_4 + \text{Na}_2\text{SO}_4 + \text{NaClO}_4 + (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  .. II 758  
 in org. solvents .. II 688  
 $\text{NH}_4$  perchlorates, quaternary in  $\text{H}_2\text{O}$  .. II 689  
 $\text{HH}_4\text{Co}$  melanate in  $\text{H}_2\text{O}$  .. I 793  
 $(\text{NH}_4)_2\text{Co}(\text{SO}_4)_2$  in  $\text{H}_2\text{O}$  .. I 850  
 $+ (\text{NH}_4)_2\text{Cu}(\text{SO}_4)_2 + \text{H}_2\text{O}$  .. I 983, 4  
 $+ (\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 + \text{H}_2\text{O}$  .. I 852  
 $(\text{NH}_4)_2\text{Co}_2$  in  $\text{H}_2\text{O}$  .. II 689  
 $+ \text{H}_2\text{CrO}_4 + \text{H}_2\text{O}$  .. II 690  
 $+ \text{K}_2\text{CrO}_4 + \text{H}_2\text{O}$  .. II 194  
 $+ \text{K}_2\text{SO}_4 \rightleftharpoons \text{K}_2\text{CrO}_4 + (\text{NH}_4)_2\text{SO}_4$  .. II 315  
 $3(\text{NH}_4)_2\text{Co}_2 \cdot \text{La}(\text{C}_2\text{O}_4)_3 \cdot 5\text{H}_2\text{O}$  .. II 691  
 $(\text{NH}_4)_2\text{CrO}_4 + \text{MgCrO}_4$  .. II 496  
 in aq.  $\text{NH}_3$  .. II 690  
 $+ (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  .. II 690, 1  
 $(\text{NH}_4)_2\text{Cr}(\text{SO}_4)_2$  in  $\text{H}_2\text{O}$  .. I 872  
 $+ \text{KCr}(\text{SO}_4)_2 + \text{H}_2\text{O}$  .. II 304  
 $+ (\text{NH}_4)_2\text{Al}(\text{SO}_4)_2 + \text{H}_2\text{O}$  .. I 873  
 $+ (\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 + \text{H}_2\text{O}$  .. I 872  
 $(\text{NH}_4)_2\text{Cu}(\text{SO}_4)_2$  in  $\text{H}_2\text{O}$  .. I 983  
 $+ \text{K}_2\text{Cu}(\text{SO}_4)_2 + \text{H}_2\text{O}$  .. I 979, 80  
 $+ (\text{NH}_4)_2\text{Co}(\text{SO}_4)_2 + \text{H}_2\text{O}$  .. I 983, 4  
 $+ (\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 + \text{H}_2\text{O}$  .. I 984  
 $+ (\text{NH}_4)_2\text{Mg}(\text{SO}_4)_2 + \text{H}_2\text{O}$  .. I 985  
 $+ (\text{NH}_4)_2\text{Mn}(\text{SO}_4)_2 + \text{H}_2\text{O}$  .. I 985  
 $+ (\text{NH}_4)_2\text{Ni}(\text{SO}_4)_2 + \text{H}_2\text{O}$  .. I 985-7  
 $+ (\text{NH}_4)_2\text{Zn}(\text{SO}_4)_2 + \text{H}_2\text{O}$  .. I 987, 8  
 $+ \text{Ti}_2\text{Cu}(\text{SO}_4)_2 + \text{H}_2\text{O}$  .. I 993  
 $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$  in  $\text{H}_2\text{O}$  .. II 691  
 $+ \text{NH}_4\text{Cl} + \text{H}_2\text{O}$  .. II 657  
 $+ (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  .. II 692  
 $+ 2\text{NaCl} \rightleftharpoons \text{Na}_2\text{Cr}_2\text{O}_7 + 2\text{NH}_4\text{Cl} (+ \text{H}_2\text{O})$  .. II 972  
 $+ \text{Na}_2\text{Cr}_2\text{O}_7 + \text{H}_2\text{O}$  .. II 692, 3  
 $+ \text{Na}_2\text{Cr}_2\text{O}_7 + \text{H}_2\text{O}$  .. II 1028  
 $\text{NH}_4$  2,5 dichlorobenzene sulfonate in  $\text{H}_2\text{O}$ , alics. .. II 628  
 $\text{NH}_4$  di-iodobenzene sulfonate in  $\text{H}_2\text{O}$  .. II 630  
 $\text{NH}_4$  2,4 dinitro benzoate in  $\text{H}_2\text{O}$ , alics. .. II 628  
 $\text{NH}_4$  dinitro crasylate .. II 630  
 $\text{NH}_4$  dinitro phenate .. II 630  
 $\text{NH}_4$  dinitrosalicylate in alics. .. II 630  
 $\text{NH}_4\text{F} + \text{AlF}_3 + \text{H}_2\text{O}$  .. II 1181  
 $+ \text{BeF}_2 + \text{H}_2\text{O}$  .. I 407  
 $2\text{NH}_4\text{F} + \text{BeF}_2$  in  $\text{H}_2\text{O}$  .. I 408, 9  
 $\text{NH}_4\text{F} + \text{CdF}_2 + \text{H}_2\text{O}$  .. I 731  
 $+ \text{CoF}_2 + \text{H}_2\text{O}$  .. I 821  
 $+ \text{CuF}_2 + \text{H}_2\text{O}$  .. I 951  
 $+ \text{ethanol} + \text{H}_2\text{O}$  .. II 494  
 $+ \text{HF}$  .. II 693  
 in  $\text{H}_2\text{O}$  .. II 693  
 $+ \text{Ice}$  .. II 693  
 $+ \text{KF} + \text{H}_2\text{O}$  .. II 204  
 $+ \text{NH}_4\text{Cl} + \text{H}_2\text{O}$  .. II 657  
 $+ (\text{NH}_4)_2\text{SiF}_6 + \text{H}_2\text{O}$  .. II 697  
 $+ (\text{NH}_4)_2\text{SiF}_6 + \text{NH}_4\text{Cl} + \text{H}_2\text{O}$  .. II 658  
 $+ \text{NaF} + \text{H}_2\text{O}$  .. II 1035  
 $+ \text{NiF}_2$  .. II 1213  
 $(\text{NH}_4)_2\text{Fe}(\text{CN})_6 + \text{NH}_4\text{Cl} + \text{H}_2\text{O}$  .. II 634  
 $(\text{NH}_4)_2\text{Fe}(\text{C}_2\text{O}_4)_2$  in methyl alc. .. II 654  
 $(\text{NH}_4)_2\text{Fe}(\text{C}_2\text{O}_4)_3$  in methyl alc. .. II 654  
 $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2$  in  $\text{H}_2\text{O}$  .. I 1055  
 $\text{NH}_4\text{Fe}(\text{SO}_4)_2 + \text{KAl}(\text{SO}_4)_2 + \text{H}_2\text{O}$  .. I 225

- $\bullet$   $\text{NH}_4\text{Al}(\text{SO}_4)_2 \bullet \text{H}_2\text{O}$  ..... 1 226  
 $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \bullet (\text{NH}_4)_2\text{Co}(\text{SO}_4)_2 \bullet \text{H}_2\text{O}$  ..... 1 852  
 $\bullet$   $(\text{NH}_4)_2\text{Cr}(\text{SO}_4)_2 \bullet \text{H}_2\text{O}$  ..... 1 872  
 $\bullet$   $(\text{NH}_4)_2\text{Cu}(\text{SO}_4)_2 \bullet \text{H}_2\text{O}$  ..... 1 984  
 $\bullet$   $(\text{NH}_4)_2\text{Ni}(\text{SO}_4)_2 \bullet \text{H}_2\text{O}$  ..... 1 1055, 6  
 $\text{NH}_4\text{F} \bullet (\text{SO}_4)_2 \bullet (\text{NH}_4)_2\text{Zn}(\text{SO}_4)_2 \bullet \text{H}_2\text{O}$  ..... II 768  
 $\bullet$   $(\text{NH}_4)_2\text{Zn}(\text{SC}_4)_2 \bullet \text{H}_2\text{O}$  ..... 1 1056  
 $\text{NH}_4$  formate  $\bullet$  formic acid f.p. .... II 619  
in formic acid solns. .... II 619  
in  $\text{H}_2\text{O}$  ..... II 619  
 $\text{NH}_4\text{Gd EDTA}$  in  $\text{H}_2\text{O}$  ..... 1 1069  
 $\text{NH}_4[\text{Gd EDTA}] \bullet \text{NH}_4\text{LY-EDTA} \bullet \text{H}_2\text{C}$  ..... II 622  
 $\text{NH}_4\text{Gd}(\text{SO}_4)_2 \bullet 12\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$ , aq. alc. .... 1 1068  
 $\text{NH}_4$  gluconate in  $\text{H}_2\text{O}$  ..... II 631  
 $\text{NH}_4\text{H}_2\text{AsO}_4$  in  $\text{H}_2\text{O}$  ..... II 604  
 $\text{NH}_4\text{HC}_4\text{H}_4\text{O}_6$  in  $\text{H}_2\text{O}$  ..... II 623  
 $\text{NH}_4\text{HCO}_3 \bullet$  biuret f.p. soly, etc. .... II 640  
 $\bullet$  biuret  $\bullet$   $\text{CO}(\text{NH}_2)_2$  f.p., soly, etc. .... II 640  
in  $\text{CCl}_4$  solns. .... II 647  
in  $\text{H}_2\text{O}$  ..... II 641  
 $\bullet$   $\text{H}_2\text{C} \bullet \text{CO}_2$  ..... II 641  
in  $\text{NH}_3$  solns. .... II 641  
 $\bullet$   $\text{NH}_4\text{Cl} \bullet \text{H}_2\text{O}$  ..... II 642  
in aq.  $\text{NH}_4\text{NO}_3$  ..... II 644  
 $\bullet$   $(\text{NH}_4)_2\text{SC}_4 \bullet \text{H}_2\text{O}$  ..... II 644, 5  
 $\bullet$   $(\text{NH}_4)_2\text{SO}_4 \bullet \text{NH}_3 \bullet \text{H}_2\text{O}$  ..... II 645  
 $\bullet$   $\text{NaCl} = \text{NH}_4\text{Cl} \bullet \text{NaHCO}_3$  ..... II 642, 3, 4  
 $\bullet$   $\text{NaHCCO}_3 \bullet \text{H}_2\text{C}$  ..... II 646, 7  
 $2\text{NH}_4\text{HCO}_3 \bullet \text{Na}_2\text{SC}_4 = (\text{NH}_4)_2\text{SC}_4 + 2\text{NaHCO}_3$  ..... II 545, 6  
 $\text{NH}_4\text{HCO}_3 \bullet$  urea f.p., soly, etc. .... II 640  
 $\text{NH}_4\text{HF}_2 \bullet$  ethanol  $\bullet \text{H}_2\text{C}$  ..... II 695  
in  $\text{H}_2\text{O}$  ..... II 694  
 $\bullet$   $\text{NH}_4\text{Cl} \bullet \text{H}_2\text{O}$  ..... II 658  
 $\text{NH}_4\text{H}_2\text{PO}_4 \bullet \text{Cs}(\text{H}_2\text{PO}_4)_2 \bullet \text{NH}_4\text{Cl}$  in  $\text{H}_2\text{O}$  ..... 1 655  
in  $\text{H}_2\text{O}$  ..... II 728, 729  
 $\bullet$   $\text{H}_3\text{PO}_4 \bullet \text{H}_2\text{O}$  ..... II 737  
 $\bullet$   $\text{KCl} \bullet \text{H}_2\text{O}$  ..... II 739  
 $\bullet$   $\text{KCl} = \text{KH}_2\text{PO}_4 \bullet \text{NH}_4\text{Cl} \bullet (\text{H}_2\text{O})$  ..... II 132, 46  
 $\bullet$   $\text{KH}_2\text{PO}_4 \bullet \text{H}_2\text{O}$  ..... II 287, 8, 9  
 $\bullet$   $\text{KH}_2\text{PO}_4 \bullet \text{H}_2\text{C}$  ..... II 739  
 $\bullet$   $\text{KNO}_3 \bullet \text{KCl} \bullet \text{H}_2\text{O}$  ..... II 132  
 $\bullet$   $\text{KNO}_3 = \text{NH}_4\text{NO}_3 \bullet \text{KH}_2\text{PO}_4$  ..... II 256  
 $\bullet$   $\text{KNO}_3 = \text{NH}_4\text{NO}_3 \bullet \text{KH}_2\text{PO}_4 \bullet \text{H}_2\text{C}$  ..... II 289  
 $\bullet$   $\text{K}_3\text{PO}_4 \bullet \text{H}_2\text{O}$  ..... II 288  
 $\bullet$   $\text{NH}_4\text{Cl} \bullet \text{H}_2\text{O}$  ..... II 662, 3  
 $\bullet$   $\text{NH}_4\text{NO}_3 \bullet \text{H}_2\text{O}$  ..... II 737, 8  
 $\bullet$   $\text{NH}_4\text{NO}_3 \bullet \text{NH}_4\text{Cl}$  ..... II 682  
 $\bullet$   $(\text{NH}_4)_2\text{HPO}_4$  ..... II 745  
 $\bullet$   $(\text{NH}_4)_2\text{SO}_4 \bullet \text{H}_2\text{O}$  ..... II 736, 7  
 $\bullet$   $(\text{NH}_4)_2\text{SO}_4 \bullet \text{H}_3\text{PO}_4 \bullet \text{H}_2\text{C}$  ..... II 737  
 $\bullet$   $\text{Na}_2\text{H}_2\text{PO}_4 \bullet \text{H}_2\text{O}$  ..... II 739, 40, 1  
 $\bullet$   $\text{NaNO}_3 = \text{NH}_4\text{NO}_3 \bullet \text{NaH}_2\text{PO}_4 \bullet (\text{H}_2\text{O})$  ..... II 741, 2, 3  
 $\bullet$   $\text{TiH}_2\text{PO}_4 \bullet \text{H}_2\text{O}$  ..... II 743  
 $\bullet$  urea  $\bullet \text{H}_2\text{O}$  ..... II 744, 5  
 $(\text{NH}_4)_2\text{HPO}_4 \bullet$  allyl alc.  $\bullet \text{H}_2\text{O}$  ..... II 744  
 $\bullet$  butyl alc.  $\bullet \text{H}_2\text{O}$  ..... II 744  
 $\bullet \text{H}_2\text{O}$  ..... II 730  
 $\bullet$  iso propyl alc.  $\bullet \text{H}_2\text{O}$  ..... II 744  
 $\bullet \text{NH}_4\text{H}_2\text{PO}_4$  ..... II 745  
 $\bullet$   $(\text{NH}_4)_2\text{SO}_4 \bullet \text{H}_2\text{O}$  ..... II 738  
 $\bullet$   $2\text{NaCl} = 2\text{NH}_4\text{Cl} \bullet \text{Na}_2\text{HPO}_4 \bullet (\text{H}_2\text{O})$  ..... II 663  
 $\text{NH}_4\text{HS}$  ..... II 746  
 $\text{NH}_4\text{HSO}_3$  in  $\text{H}_2\text{O}$  ..... II 753  
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 $2\text{NH}_4\text{I} \bullet \text{CdCl}_2$  in  $\text{H}_2\text{O}$ , alc. ether ..... 1 736  
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 $\bullet$  aniline nitrate ..... II 728  
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 $\text{NH}_4\text{HO}_2 \bullet \text{Ba}(\text{NO}_3)_2$  ..... II 728  
 $\bullet$   $\text{Ba}(\text{NO}_3)_2 \bullet \text{AgNO}_3 \bullet \text{H}_2\text{O}$  ..... 1 374  
 $\bullet$   $\text{Ba}(\text{NO}_3)_2 \bullet \text{H}_2\text{O}$  ..... 1 374  
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 $\bullet$   $\text{Ca}(\text{NO}_3)_2 \bullet \text{HNO}_3$  ..... 1 624  
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 $\bullet$   $\text{Ce}(\text{NO}_3)_4$  in  $\text{H}_2\text{O}$  ..... 1 771  
 $\text{NH}_4\text{HO}_3 \bullet$  cholesterol ..... II 728  
 $\bullet$   $\text{Cu}(\text{NO}_3)_2 \bullet \text{H}_2\text{O}$  ..... 1 957  
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- $\text{NH}_4\text{NO}_3$  in aq. ethanol. . . . . II 721, 2  
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 + guanidine nitrate. . . . . II 728  
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 +  $\text{HNO}_3$ . . . . . I 1131  
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 2 $\text{HNO}_3$  in  $\text{H}_2\text{O}$ . . . . . II 710, 11  
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 +  $\text{KCl} \rightleftharpoons \text{NH}_4\text{Cl} + \text{KNO}_3$ . . . . . II 261  
 +  $\text{KClO}_4 \rightleftharpoons \text{KNO}_3 + \text{NH}_4\text{ClO}_4$ . . . . . II 181  
 +  $\text{KH}_2\text{PO}_4 \rightleftharpoons \text{KNO}_3 + \text{NH}_4\text{H}_2\text{PO}_4 + \text{H}_2\text{O}$ . . . . . II 289  
 +  $\text{KH}_2\text{PO}_4 \rightleftharpoons \text{NH}_4\text{H}_2\text{PO}_4 + \text{KNO}_3$ . . . . . II 256  
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 +  $\text{K}_2\text{SO}_4$ . . . . . II 325  
 2 $\text{NH}_4\text{NO}_3 + \text{K}_2\text{SO}_4 \rightleftharpoons 2\text{KNO}_3 + (\text{NH}_4)_2\text{SO}_4 + (\text{H}_2\text{O})$ . . . . . II 315  
 +  $\text{K}_2\text{SO}_4 \rightleftharpoons (\text{NH}_4)_2\text{SO}_4 + 2\text{KNO}_3$ . . . . . II 261  
 +  $\text{La}(\text{NO}_3)_3 + \text{H}_2\text{O}$ . . . . . II 714  
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 +  $\text{LiNO}_3$ . . . . . II 427, 727  
 +  $\text{LiNO}_3 + \text{H}_2\text{O}$ . . . . . II 423  
 +  $\text{LiNO}_3 + \text{guanidine nitrate}$ . . . . . II 728  
 +  $\text{LiNO}_3 + \text{NaNO}_3$ . . . . . II 727  
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 + methylalcohol hydrochloride. . . . . II 728  
 +  $\text{MgCl}_2 + \text{H}_2\text{O}$ . . . . . II 489-90  
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 +  $\text{NH}_3$ . . . . . II 603  
 in aq.  $\text{NH}_3$  solns. . . . . II 711, 12  
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 +  $\text{NH}_4\text{Cl} + \text{NH}_3$ . . . . . II 660, 1, 2  
 +  $\text{NH}_4\text{Cl} + \text{NH}_3$  liq. . . . . II 679, 80  
 +  $\text{NH}_4\text{Cl} + \text{NaNO}_3$ . . . . . II 682  
 +  $\text{NH}_4\text{ClO}_4 + \text{H}_2\text{O}$ . . . . . II 685  
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 +  $\text{N}_2\text{H}_4\text{HNO}_3$ . . . . . II 786  
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 +  $\text{NH}_4\text{H}_2\text{PO}_4 + \text{NH}_4\text{Cl}$ . . . . . II 602  
 +  $\text{NH}_4\text{HSO}_4 + \text{H}_2\text{O}$ . . . . . II 714  
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 +  $(\text{NH}_4)_2\text{SO}_4$ . . . . . II 727  
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 +  $\text{NaCl}$ . . . . . II 727  
 +  $\text{NaCl} \rightleftharpoons \text{NH}_4\text{Cl} + \text{NaNO}_3 (\text{H}_2\text{O}), (\text{NH}_3)$ . . . . . II 662  
 +  $\text{NaH}_2\text{PO}_4 \rightleftharpoons \text{NH}_4\text{H}_2\text{PO}_4 + \text{NaNO}_3 + (\text{H}_2\text{O})$ . . . . . II 741, 2, 3  
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 +  $\text{NaCl} + \text{NaNO}_3$ . . . . . II 727  
 +  $\text{NaNO}_3$ . . . . . II 727  
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 +  $\text{NaNO}_3 + \text{Cd}(\text{NO}_3)_2$ . . . . . I 744  
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 +  $\text{NaNO}_3 + \text{urea}$ . . . . . II 728  
 +  $\text{NaNO}_3 + \text{urea nitrate}$ . . . . . II 728  
 +  $\text{Na}_2\text{SO}_4$ . . . . . II 727  
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 + o-phenylenediamine. . . . . II 728  
 + p-phenylenediamine. . . . . II 728  
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 + trinitrotoluene. . . . . II 728  
 +  $\text{UO}_2(\text{NO}_3)_2 + \text{H}_2\text{O}$ . . . . . II 718  
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 $(\text{NH}_4)\text{NaSO}_4 + (\text{NH}_4)_2\text{SO}_4$ . . . . . II 609  
 $(\text{NH}_4)_2\text{Ni}(\text{SO}_4)_2$  in  $\text{H}_2\text{O}$ . . . . . II 763  
 +  $(\text{NH}_4)_2\text{Cu}(\text{SO}_4)_2 + \text{H}_2\text{O}$ . . . . . I 985-7  
 +  $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 + \text{H}_2\text{O}$ . . . . . I 1055, 6  
 +  $(\text{NH}_4)_2\text{Zn}(\text{SO}_4)_2 + \text{H}_2\text{O}$ . . . . . II 763  
 $\text{NH}_4$  4 nitrochlorobenzene-*w*-sulfonate in  $\text{H}_2\text{O}$ , alcs. . . . . II 628  
 $\text{NH}_4$  nitrophenylacetate in  $\text{H}_2\text{O}$ , alcs. . . . . II 628  
 $\text{NH}_4$  nitrosalicylate in  $\text{H}_2\text{O}$ . . . . . II 630  
 2 $\text{NH}_4\text{OH} + \text{Mg}^{++} \rightleftharpoons \text{Mg}(\text{OH})_2 + 2\text{NH}_4^+$ . . . . . II 516  
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 14 $\text{MoO}_3 \cdot 4\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$ . . . . . II 707  
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 $\text{NH}_4^+ + \text{Mg}(\text{OH})_2 \rightleftharpoons \text{Mg}^{++} + 2\text{NH}_4\text{OH}$ . . . . . II 516  
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 $\text{NH}_4\text{ReO}_4$  extraction with pyridine. . . . . II 745  
 $\text{NH}_4\text{ReO}_4$  in  $\text{H}_2\text{O}$ . . . . . II 745  
 $\text{NH}_4\text{ReO}_4\text{S}$  in  $\text{H}_2\text{O}$ . . . . . II 746  
 $(\text{NH}_4)_2\text{S}$ . . . . . II 746  
 in liq.  $\text{NH}_3$ . . . . . II 746  
 $\text{NH}_4\text{SCN}$  in acetonitrile. . . . . II 637  
 in alcs. . . . . II 637  
 +  $\text{Ba}(\text{SCN})_2 + \text{H}_2\text{O}$ . . . . . I 326  
 +  $\text{Ca}(\text{SCN})_2 + \text{H}_2\text{O}$ . . . . . I 533, 4  
 + ethyl ether +  $\text{H}_2\text{O}$ . . . . . II 637  
 in  $\text{H}_2\text{O}$ . . . . . II 634, 5  
 +  $\text{H}_2\text{O}$  f.p. . . . . II 634  
 +  $\text{KSCN}$ . . . . . II 80  
 +  $\text{KSCN}$  f.p. . . . . II 638  
 +  $\text{KSCN} + \text{H}_2\text{O}$ . . . . . II 77, 8  
 in aq.  $\text{NH}_3$ . . . . . II 635, 6  
 in liq.  $\text{NH}_3$ . . . . . II 637  
 +  $\text{NH}_3$  f.p. . . . . II 638  
 +  $\text{NH}_4\text{NO}_3$  f.p. . . . . II 638  
 +  $\text{NH}_4\text{NO}_3 + \text{H}_2\text{O}$ . . . . . II 635, 6  
 + phenol +  $\text{H}_2\text{O}$ . . . . . II 637  
 in liq.  $\text{SO}_2$ . . . . . II 637  
 + thiocarbamide f.p. . . . . II 638  
 + thiourea +  $\text{H}_2\text{O}$ . . . . . II 637  
 $(\text{NH}_4)_2\text{SO}_3$  + acetone +  $\text{H}_2\text{O}$ . . . . . II 773  
 +  $\text{Ag}_2\text{SO}_4 + \text{H}_2\text{O}$ . . . . . I 138, 9  
 + allyl alc. +  $\text{H}_2\text{O}$ . . . . . II 772  
 +  $\text{Al}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$ . . . . . I 219, 220  
 +  $\text{BaSO}_4 + \text{H}_2\text{O}$ . . . . . I 417, 8  
 +  $\text{Bi}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$ . . . . . I 439  
 in  $\text{H}_2\text{O}$ . . . . . II 747  
 +  $\text{NH}_4\text{Cl} + \text{H}_2\text{O}$ . . . . . II 664, 5  
 +  $\text{NH}_4\text{HSO}_3 + \text{H}_2\text{O}$ . . . . . II 748, 9  
 +  $\text{NH}_4\text{HSO}_4 + (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$ . . . . . II 751

- +  $(\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 749, 50, 1  
 +  $(\text{NH}_4)_2\text{S}_2\text{O}_5 + \text{H}_2\text{O}$  ..... II 755  
 +  $2\text{NaCl} \rightleftharpoons 2\text{NH}_4\text{Cl} + \text{Na}_2\text{SO}_3 + (\text{H}_2\text{O})$  ..... II 751, 2  
 +  $\text{Na}_2\text{SC}_3 + \text{H}_2\text{O}$  ..... II 752  
 **$(\text{NH}_4)_2\text{SO}_4$**  + butyl alc. +  $\text{H}_2\text{O}$  ..... II 777  
 +  $\text{CaSO}_4 + \text{H}_2\text{O}$  ..... I 674, 5  
 + caprolactum +  $\text{H}_2\text{O}$  ..... II 773, 4  
 +  $\text{Cd}(\text{OH})_2 \rightleftharpoons \text{CdSC}_4 + 2\text{NH}_4\text{OH}$  in  $\text{H}_2\text{O}$  ..... I 758  
 +  $\text{CdSO}_4 + \text{H}_2\text{O}$  ..... I 756, 7  
 +  $\text{CSO}_4 + \text{NH}_3 + \text{H}_2\text{O}$  ..... II 759  
 +  $\text{Ce}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$  ..... I 778-80  
 +  $\text{Ce}_2(\text{SO}_4)_3 \cdot 8\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$  ..... I 780  
 +  $\text{Co}(\text{SO}_4)_2 + \text{H}_2\text{O}$  ..... I 850  
 +  $\text{Cs}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... I 901  
 +  $\text{CuSO}_4 + \text{CuCl}_2 + \text{NH}_4\text{Cl} + \text{H}_2\text{O}$  ..... I 974  
 +  $\text{CuSO}_4 + \text{H}_2\text{O}$  ..... I 982  
 +  $\text{CuSO}_4 + \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... I 983  
 in aq. ethanol ..... II 769, 70, 1  
 +  $\text{FeSO}_4 + \text{H}_2\text{O}$  ..... I 1055  
 +  $\text{FeSO}_4 \cdot 6\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$  ..... I 1055  
 +  $\text{Fe}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$  ..... I 1064  
 +  $\text{Fe}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$  ..... I 1064  
 +  $\text{Fe}_2(\text{SO}_4)_3 + \text{H}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... I 1065  
 +  $\text{FeSO}_4 + \text{Li}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... I 1054  
 in formic acid ..... II 774  
 +  $2\text{HCl} \rightleftharpoons 2\text{NH}_4\text{Cl} + \text{SO}_4$  ..... II 655  
 +  $2\text{HCl} \rightleftharpoons 2\text{NH}_4\text{Cl} + \text{H}_2\text{SO}_4 + (\text{H}_2\text{O})$  ..... II 664  
 in  $\text{H}_2\text{O}$  ..... II 609, 755  
 +  $\text{H}_2\text{C}_2 + \text{H}_2\text{O}$  ..... II 756  
 +  $\text{H}_2\text{SO}_4$  f.p. .... I 774  
 +  $\text{H}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 756, 7  
 in liq.  $\text{SO}_2$  ..... II 774  
 +  $\text{SiO}_2$  in  $\text{H}_2\text{O}$  ..... II 765  
 +  $\text{TiO}_2 + \text{H}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 766  
 +  $\text{Ti}_2\text{O}_3(\text{SO}_4)_2 + \text{H}_2\text{O}$  ..... II 765  
 +  $\text{Th}(\text{SO}_4)_2 + \text{H}_2\text{O}$  ..... II 765, 1550  
 +  $\text{Ti}_2\text{SO}_4 + \text{CuSO}_4 + \text{H}_2\text{O}$  ..... I 994  
 +  $\text{UC}_2\text{SO}_4$  ..... II 766  
 + urethan +  $\text{H}_2\text{O}$  ..... II 772  
 +  $\text{ZnSO}_4 + \text{H}_2\text{O}$  ..... II 767, 8  
 +  $\text{ZnSO}_4$  in  $\text{H}_2\text{O}$  ..... II 768  
 **$(\text{NH}_4)_2\text{S}_2\text{O}_5$**  in  $\text{H}_2\text{C}$  ..... II 755  
 in  $\text{H}_2\text{SO}_4$  ..... II 775  
 +  $\text{SO}_2 + \text{H}_2\text{O}$  ..... II 755  
 **$(\text{NH}_4)_2\text{S}_2\text{O}_6$**  +  $\text{BaSO}_4 + \text{H}_2\text{O}$  ..... I 396  
 +  $\text{CuSO}_4 + \text{H}_2\text{O}$  ..... I 998  
 **$(\text{NH}_4)_2\text{S}_2\text{O}_8$**  in  $\text{H}_2\text{O}$  ..... II 776  
 +  $\text{SrSO}_4 + \text{H}_2\text{O}$  ..... II 777  
 **$(\text{NH}_4)_2\text{S}_2\text{O}_8$**  in furfural ..... II 776  
 in  $\text{H}_2\text{O}$  ..... II 774  
 in aq.  $\text{NH}_4\text{HSO}_4$  ..... II 776  
 +  $(\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 775, 6  
 in aq.  $(\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{SO}_4$  ..... II 776  
 +  $(\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 775, 6  
 **$(\text{NH}_4)_2\text{S}_2\text{O}_8$**  in  $\text{H}_2\text{O}$  ..... II 777, 8  
 **$(\text{NH}_4)_2\text{S}_4\text{O}_{16}$**  in  $\text{H}_2\text{O}$  ..... II 778  
 **$\text{NH}_4\text{SO}_3\text{NH}_2$**  in  $\text{H}_2\text{O}$  ..... II 778  
 +  $\text{HSO}_3\text{NH}_2 + \text{H}_2\text{O}$  ..... I 1167  
 +  $\text{HSO}_3\text{NH}_2 + \text{H}_2\text{O}$  ..... I 1167  
 **$2\text{NH}_4\text{SO}_3\text{NH}_2 + \text{K}_2\text{SO}_4 \rightleftharpoons (\text{NH}_4)_2\text{SO}_4 + 2\text{KSO}_3\text{NH}_2 + (\text{H}_2\text{O})$**  ..... II 328  
 **$\text{NH}_4\text{SO}_3\text{NH}_2 + \text{KSO}_3\text{NH}_2 + \text{H}_2\text{O}$**  ..... II 331, 2  
 +  $\text{NH}_4\text{Cl} + \text{H}_2\text{O}$  ..... II 666, 7  
 +  $\text{NH}_4\text{NO}_3$  ..... II 728  
 +  $(\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 758  
 +  $\text{NaSO}_3\text{NH}_2$  ..... II 778  
 **$(\text{NH}_4)_2\text{SO}_3$**  in  $\text{H}_2\text{O}$  ..... II 779  
 +  $\text{NH}_3 + \text{H}_2\text{O}$  ..... II 779  
 **$\text{NH}_4\text{SO}_3\text{NH}_2\text{SO}_3\text{NH}_2$**  in various solvents ..... II 790  
 **$(\text{NH}_4)_2\text{S}_2\text{O}_5 + (\text{NH}_4)_2\text{S}_2\text{O}_3 + \text{H}_2\text{O}$**  ..... II 755  
 **$\text{NH}_4$  selicylate** in acetone ..... II 629  
 in aq. ethanol solns. .... II 628  
 in ethyl ether ..... II 629  
 in methyl alc. .... II 628  
 **$\text{NH}_4$  salts** +  $(\text{NH}_4)_2\text{C}_2\text{O}_4$  ..... II 747  
 **$(\text{NH}_4)_2\text{S}_5\text{O}_{14}$**  in aq. alc. .... II 747  
 in  $\text{H}_2\text{O}$  ..... II 747  
 **$(\text{NH}_4)_2\text{SeO}_3$**  in  $\text{H}_2\text{O}$  ..... II 780  
 **$(\text{NH}_4)_2\text{SeO}_4$**  +  $\text{CaSeO}_4 + \text{H}_2\text{O}$  ..... II 690  
 +  $\text{CuSeO}_4 + \text{H}_2\text{SeO}_3 + \text{H}_2\text{O}$  ..... I 1000  
 in  $\text{H}_2\text{O}$  ..... II 781  
 +  $\text{H}_2\text{O}_2 + \text{H}_2\text{O}$  ..... II 782  
 in aq.  $\text{H}_2\text{SeO}_4$  ..... II 781  
 +  $\text{MgSeO}_4 + \text{H}_2\text{O}$  ..... II 541  
 **$(\text{NH}_4)_2\text{Se}_2\text{O}_5$**  in  $\text{H}_2\text{O}$  ..... II 781  
 **$(\text{NH}_4)_2\text{SiF}_6$**  in  $\text{H}_2\text{O}$  ..... II 696  
 in  $\text{H}_2\text{SiF}_6$  ..... II 697  
 +  $\text{MoSiF}_6 + \text{H}_2\text{O}$  ..... II 542  
 +  $\text{NH}_4\text{Cl} + \text{H}_2\text{O}$  ..... II 657  
 +  $\text{NH}_4\text{Cl} + \text{NH}_4\text{F} + \text{H}_2\text{O}$  ..... II 658  
 +  $\text{NH}_4\text{F} + \text{H}_2\text{O}$  ..... II 697  
 +  $\text{SrSiF}_6 + \text{H}_2\text{O}$  ..... II 697  
 **$\text{NH}_4$  [5m-EDTA]** +  $\text{NH}_4$  [La-EDTA] +  $\text{H}_2\text{O}$  ..... II 621  
 **$\text{NH}_4\text{SmBr}_3$**  in  $\text{H}_2\text{O}$  ..... II 614  
 **$(\text{NH}_4)_2\text{SmBr}_4$**  in  $\text{H}_2\text{O}$  ..... II 614  
 **$(\text{NH}_4)_4\text{SmBr}_6$**  in  $\text{H}_2\text{O}$  ..... II 615  
 **$(\text{NH}_4)_2\text{SmCl}_6$**  in  $\text{HCl} + \text{NH}_4\text{Cl}$  solns. .... II 672  
 in  $\text{HCl} + \text{NaCl}$  solns. .... II 672  
 **$\text{NH}_4\text{SmCl}_3$**  in  $\text{H}_2\text{O}$  ..... II 671  
 **$(\text{NH}_4)_2\text{SmCl}_4$**  in  $\text{H}_2\text{O}$  ..... II 672  
 **$(\text{NH}_4)_4\text{SmCl}_6$**  in  $\text{H}_2\text{O}$  ..... II 672  
 **$(\text{NH}_4)_4\text{SmCl}_6 \cdot \text{H}_2\text{O}$**  in aq.  $\text{HCl}$  ..... II 151  
 **$\text{NH}_4$  stearate** in acetone ..... II 633  
 in alcs. .... II 633  
 in ether ..... II 633  
 in ethylene trichloride ..... II 633  
 **$\text{NH}_4$  succinate** in acetone ..... II 625  
 in methyl alc. .... II 625  
 +  $\text{NH}_4\text{Cl} + \text{H}_2\text{O}$  ..... II 624  
 **$\text{NH}_4$  tartrate** + Li tartrate +  $\text{H}_2\text{O}$  ..... II 375, 6  
 **$\text{NH}_4$  acid tartrate** in dioxane solns. .... II 623  
 **$\text{NH}_4$  acid tartrate** +  $\text{NH}_4$  acid chlor succinate +  $\text{H}_2\text{O}$  ..... II 623  
 +  $\text{NH}_4$  acid malate +  $\text{H}_2\text{O}$  ..... II 623  
 in urea solns. .... II 623  
 **$\text{NH}_4$  neutral tartrate** +  $\text{NH}_4$  neutral chlor succinate  
 +  $\text{H}_2\text{O}$  ..... II 623  
 **$\text{NH}_4\text{TaO}_4$  extraction** by pyridine ..... II 782  
 **$(\text{NH}_4)_2\text{TiCl}_2$**  in  $\text{HCl} + \text{NH}_4\text{Cl}$  solns. .... II 672  
 **$(\text{NH}_4)_2\text{TiF}_6$**  in ethanol ..... II 696  
 in  $\text{H}_2\text{O}$  ..... II 696  
 +  $\text{H}_2\text{SO}_4 + \text{methanol}$  ..... II 771  
 +  $\text{H}_3\text{PO}_4 + \text{H}_2\text{O}$  ..... II 757  
 +  $\text{H}_3\text{PO}_4 + \text{NH}_4\text{H}_2\text{PO}_4 + \text{H}_2\text{O}$  ..... II 737  
 +  $2\text{KCl} \rightleftharpoons \text{K}_2\text{SO}_4 + 2\text{NH}_4\text{Cl} + (\text{H}_2\text{O})$  ..... II 135, 6  
 +  $\text{K}_2\text{CrO}_4 \rightleftharpoons (\text{NH}_4)_2\text{CrO}_4 + \text{K}_2\text{SO}_4 + (\text{H}_2\text{O})$  ..... II 315  
 +  $2\text{KNO}_3 \rightleftharpoons \text{K}_2\text{SO}_4 + 2\text{NH}_4\text{NO}_3 + (\text{H}_2\text{O})$  ..... II 315  
 +  $2\text{KNO}_3 \rightleftharpoons \text{K}_2\text{SO}_4 + 2\text{NH}_4\text{NO}_3 + (\text{H}_2\text{O})$  ..... II 261  
 +  $\text{K}_2\text{SO}_4$  ..... II 326  
 +  $\text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 313  
 +  $\text{K}_2\text{SO}_4 + \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 314  
 +  $2\text{KSO}_3\text{NH}_2 \rightleftharpoons \text{K}_2\text{SO}_4 + 2\text{NH}_4\text{SO}_3\text{NH}_2 + (\text{H}_2\text{O})$  ..... II 328  
 +  $\text{La}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$  ..... II 359  
 +  $\text{La}_2(\text{SO}_4)_3$  ..... II 759, 60  
 +  $\text{Li}_2\text{SO}_4 + \text{alc.} + \text{H}_2\text{O}$  ..... II 437  
 +  $\text{Li}_2\text{SO}_4 + \text{CuSO}_4 + \text{H}_2\text{O}$  ..... II 437  
 +  $\text{Li}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 436, 7  
 +  $\text{Li}_2\text{SO}_4 + \text{H}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 437  
 in aq. methanol ..... II 769  
 +  $\text{MgSO}_4 + \text{H}_2\text{O}$  ..... II 528-9  
 +  $\text{MgSO}_4 + \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 310, 1  
 +  $\text{MnSO}_4 + \text{H}_2\text{O}$  ..... II 564, 5  
 in  $\text{NH}_3$  ..... II 757  
 in  $\text{NH}_3 + \text{SO}_3$  ..... II 758  
 +  $(\text{NH}_4)_2\text{B}_4\text{O}_7 + \text{H}_2\text{O}$  ..... II 608  
 +  $\text{NH}_4\text{CO}_2\text{NH}_2 + \text{NH}_3 + \text{H}_2\text{O}$  ..... II 650  
 +  $\text{NH}_4\text{Cl} + \text{H}_2\text{O}$  ..... II 665, 6  
 +  $\text{NH}_4\text{ClO}_4 + \text{H}_2\text{O}$  ..... II 687  
 +  $\text{NH}_4\text{ClO}_4 + \text{Na}_2\text{SO}_4 + \text{NaClO}_4 + \text{H}_2\text{O}$  ..... II 690, 1  
 +  $(\text{NH}_4)_2\text{CrO}_4 + \text{H}_2\text{O}$  ..... II 692  
 +  $(\text{NH}_4)_2\text{C}_2\text{O}_7 + \text{H}_2\text{O}$  ..... II 644, 5  
 +  $\text{NH}_4\text{HCO}_3 + \text{H}_2\text{O}$  ..... II 645  
 +  $\text{NH}_4\text{HCO}_3 + \text{NH}_3 + \text{H}_2\text{O}$  ..... II 738  
 +  $(\text{NH}_4)_2\text{HPO}_4 + \text{H}_2\text{O}$  ..... II 736, 7  
 +  $\text{NH}_4\text{H}_2\text{PO}_4 + \text{H}_2\text{O}$  ..... II 753, 4  
 +  $\text{NH}_4\text{HSO}_3 + \text{H}_2\text{O}$  ..... II 751  
 +  $\text{NH}_4\text{HSO}_4 + (\text{NH}_4)_2\text{SO}_3 + \text{H}_2\text{O}$  ..... II 706  
 +  $(\text{NH}_4)_2\text{Mo}_2\text{O}_7 + \text{H}_2\text{O}$  ..... II 727  
 +  $\text{NH}_4\text{NO}_3$  ..... II 712, 3  
 +  $\text{NH}_4\text{NO}_3 + \text{H}_2\text{O}$  ..... II 749, 50, 1  
 +  $(\text{NH}_4)_2\text{S}_2\text{O}_8 + \text{H}_2\text{O}$  ..... II 775, 6  
 +  $(\text{NH}_4)_2\text{S}_2\text{O}_8 + \text{H}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 775, 6  
 +  $\text{NH}_4\text{SO}_3\text{NH}_2 + \text{H}_2\text{O}$  ..... II 759  
 +  $(\text{NH}_4)_2\text{W}_2\text{O}_7 + \text{H}_2\text{O}$  ..... II 609  
 +  $(\text{NH}_4)_2\text{NaSO}_4$  ..... II 609



- $+ \text{Na}_2\text{B}_4\text{O}_7 \rightleftharpoons (\text{NH}_4)_2\text{B}_4\text{O}_7 + \text{Na}_2\text{SO}_4$  ..... II 609, 10, 11  
 $+ \text{Na}_2\text{B}_4\text{O}_7 \rightleftharpoons (\text{NH}_4)_2\text{B}_4\text{O}_7 + \text{Na}_2\text{SO}_4 (+ \text{H}_2\text{O})$  ..... II 828  
 $+ 2\text{NaHCO}_3 \rightleftharpoons 2\text{NH}_4\text{HCO}_3 + \text{Na}_2\text{SO}_4$  ..... II 645, 6  
 $+ \text{NaHCO}_3 + \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 950  
 $+ 2\text{NaClO}_4 \rightleftharpoons \text{Na}_2\text{SO}_4 + 2\text{NH}_4\text{ClO}_4 (+ \text{H}_2\text{O})$  ..... II 687  
 $+ \text{Na}_2\text{SO}_4$  ..... II 1149  
 $+ \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 760, 1, 2  
 $+ \text{Na}_2\text{SO}_4 + \text{NH}_3 + \text{H}_2\text{O}$  ..... II 762  
 $+ \text{Na}_2\text{SO}_4 \rightleftharpoons 2\text{NH}_4\text{Cl} + \text{Na}_2\text{SO}_4 (+ \text{H}_2\text{O})$  ..... II 762  
 $+ \text{Na}_2\text{SO}_4 + \text{ZnSO}_4 + \text{H}_2\text{O}$  ..... II 762  
 $+ \text{Nd}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$  ..... II 1193  
 $+ \text{NiSO}_4 + \text{H}_2\text{O}$  ..... II 762, 3  
 $+ \text{PbSO}_4$  in  $\text{H}_2\text{O}$  ..... II 764  
 $+ \text{picoline} + \text{H}_2\text{O}$  ..... II 773  
 $+ \text{propyl alc.} + \text{H}_2\text{O}$  ..... II 771  
 $+ \text{Pr}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$  ..... II 764  
 $+ \text{pyridine} + \text{H}_2\text{O}$  ..... II 772  
 $+ \text{Rb}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 764  
 $+ \text{Na}_2\text{SO}_4$  in  $\text{H}_2\text{O}$  ..... II 625  
 **$\text{NH}_4\text{VO}_3$**  in  $\text{H}_2\text{O}$  ..... II 782, 3  
in hydrazine ..... II 783  
in aq.  $\text{NH}_4$  salts ..... II 783  
 $+ \text{NH}_4\text{Cl} + \text{H}_2\text{O}$  ..... II 783  
in  $\text{NH}_4\text{OH}$  solns. .... II 783  
 **$(\text{NH}_4)_2(\text{V}_2\text{O}_5) \cdot 3\text{H}_2\text{O}$**  in  $\text{H}_2\text{O}$  ..... II 784  
 **$(\text{NH}_4)_2\text{V}_2(\text{SO}_4)_4 \cdot 2\text{H}_2\text{O}$**  in  $\text{H}_2\text{O}$  ..... II 767  
 **$(\text{NH}_4)_2\text{W}_2\text{O}_7$**   $+ (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 759  
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 **$(\text{NH}_4)_2\text{Zn}(\text{C}_2\text{O}_4)_2$**  ..... II 1659  
 **$(\text{NH}_4)_2\text{Zn}(\text{C}_2\text{O}_4)_3$**  ..... II 1659  
 **$\text{NH}_4\text{ZnPO}_4$**  in  $\text{H}_2\text{O}$  ..... II 744  
 **$(\text{NH}_4)_2\text{Zn}(\text{SO}_4)_2$**   $+ (\text{NH}_4)_2\text{Cu}(\text{SO}_4)_2 + \text{H}_2\text{O}$  ..... II 769  
 $+ (\text{NH}_4)_2\text{Cu}(\text{SO}_4)_2 + \text{H}_2\text{O}$  ..... I 987, 8  
 $+ \text{NH}_4\text{Fe}(\text{SO}_4)_2 + \text{H}_2\text{O}$  ..... II 768  
 $+ (\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 + \text{H}_2\text{O}$  ..... I 1056  
 $+ (\text{NH}_4)_2\text{Ni}(\text{SO}_4)_2 + \text{H}_2\text{O}$  ..... II 763  
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 $+ \text{acetic acid}$  ..... II 785  
 $+ \text{benzoic acid}$  ..... II 785  
 $+ \text{CO}(\text{NH}_2)_2$  f.p. .... II 785  
 $+ \text{diphenylamine}$  ..... II 785  
distr. betwn.  $\text{H}_2\text{O} + \text{benzene}$  ..... II 785  
 $+ \text{ethanol}$  f.p. .... II 785  
 $+ \text{H}_2\text{O}$  f.p. .... II 784, 5  
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 $+ \text{KOH} + \text{H}_2\text{O}$  ..... II 280  
 $+ \text{lauric acid}$  ..... II 785  
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 $+ \text{palmitic acid}$  ..... II 785  
 $+ \text{phenol}$  f.p. .... II 785  
 $+ \text{salicylic acid}$  ..... II 785  
 $+ \text{thymol}$  ..... II 785  
 $+ \text{valeric acid}$  ..... II 785  
 **$\text{N}_2\text{H}_4(\text{ClO}_4)_2 \cdot 3\text{H}_2\text{O}$**  in  $\text{H}_2\text{O}$  ..... II 786  
 **$\text{N}_2\text{H}_4\text{HN}_3$**   $+ \text{NH}_3$  ..... II 785  
 $+ \text{N}_2\text{H}_4$  ..... II 785  
 $+ \text{N}_2\text{H}_4 + \text{NH}_3$  ..... II 785  
 **$\text{N}_2\text{H}_4\text{HNO}_3$**   $+ \text{CsNO}_3$  ..... II 786  
 $+ \text{CsNO}_3$  ..... I 899  
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 $+ \text{KNO}_3$  ..... II 786  
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 $+ \text{LiNO}_3$  ..... II 786  
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 **$\text{N}_2\text{H}_5\text{OC}_6\text{H}(\text{NO}_2)_3\text{CH}_3 \cdot \text{H}_2\text{O}$**  in  $\text{H}_2\text{O}$  ..... II 786, 7  
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 $+ \text{methyl ether f.pts.}$  ..... II 793  
 $+ \text{NO}_2$  ..... II 793  
 $+ \text{NO}_2 + \text{HNO}_3$  ..... II 793  
 $+ \text{NO}_2 + \text{NO}_3$  ..... II 793  
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 **$\text{NO}_2 + \text{NO}$**  ..... II 792  
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in human blood ..... I 803  
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in silica susp. .... II 804  
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 $+ \text{CHCl}_3$  f.p. .... II 793  
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 $+ \text{HNO}_3$  f.p. .... II 794  
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 $+ \text{NO}$  ..... II 793  
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 + KI  $\rightleftharpoons$  K + NaI ..... II 2  
 + KOH  $\rightleftharpoons$  NaOH + K ..... II 1, 2  
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 + LiCl  $\rightleftharpoons$  NaCl + Li ..... II 362  
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 + NH<sub>3</sub> ..... II 603  
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 + NaF ..... II 805  
 + NaI ..... II 805  
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 in aq. acetic acid ..... II 855  
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 + KNO<sub>2</sub>  $\rightleftharpoons$  K acetate + NaNO<sub>2</sub> ..... II 250  
 + KNO<sub>3</sub>  $\rightleftharpoons$  K acetate + NaNO<sub>3</sub> ..... II 274  
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 + Na iso pentanoate ..... II 859  
 + phenol + H<sub>2</sub>O ..... II 857  
 + Na propionate ..... II 859  
 + NaSCN ..... II 914  
 + Na stearate ..... II 859  
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 + Zn acetate + acetic acid ..... II 859  
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 cryoscopic of various substances in  
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 + Li<sub>3</sub>AlF<sub>6</sub> ..... II 1040  
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 + NaF + Al<sub>2</sub>O<sub>3</sub> ..... II 1086  
 + Na<sub>2</sub>O + Al<sub>2</sub>O<sub>3</sub> ..... II 1040  
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 + CaSiO<sub>3</sub> + NaSiO<sub>3</sub> ..... I 693  
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 + K<sub>2</sub>CrO<sub>4</sub>  $\rightleftharpoons$  Na<sub>2</sub>CrO<sub>4</sub> + 2KBO<sub>2</sub> ..... II 11  
 + LiBO<sub>2</sub> ..... II 366  
 + Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub> + NaCl + H<sub>2</sub>O ..... II 818, 9  
 + Na<sub>2</sub>CO<sub>3</sub> + NaCl + H<sub>2</sub>O ..... II 819  
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 + NaF + H<sub>2</sub>O ..... II 819  
 + NaPO<sub>3</sub> ..... II 828  
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 + 4H<sub>2</sub>O  $\rightleftharpoons$  NaBO<sub>3</sub>·3H<sub>2</sub>O + H<sub>2</sub>O ..... II 830  
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 + Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> + H<sub>2</sub>O (f.pts.) ..... I 643  
 + CaSO<sub>4</sub> ..... I 687  
 in H<sub>2</sub>O ..... II 609  
 in H<sub>2</sub>O ..... II 820, 1  
 + K<sub>2</sub>B<sub>4</sub>O<sub>7</sub> ..... II 11  
 + 2KCl  $\rightleftharpoons$  2NaCl + K<sub>2</sub>B<sub>4</sub>O<sub>7</sub> ..... II 11, 119  
 + 2KF  $\rightleftharpoons$  2NaF + K<sub>2</sub>B<sub>4</sub>O<sub>7</sub> ..... II 11  
 + (NH<sub>4</sub>)<sub>2</sub>B<sub>4</sub>O<sub>7</sub> ..... II 609  
 + 2NH<sub>4</sub>Cl  $\rightleftharpoons$  (NH<sub>4</sub>)<sub>2</sub>B<sub>4</sub>O<sub>7</sub> + 2NaCl ..... II 611, 2  
 + (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>  $\rightleftharpoons$  (NH<sub>4</sub>)<sub>2</sub>B<sub>4</sub>O<sub>7</sub> + Na<sub>2</sub>SO<sub>4</sub> ..... II 609, 10, 11  
 + (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>  $\rightleftharpoons$  (NH<sub>4</sub>)<sub>2</sub>B<sub>4</sub>O<sub>7</sub> + Na<sub>2</sub>SO<sub>4</sub> (+ H<sub>2</sub>O) ..... II 828  
 + NaBO<sub>2</sub> + NaCl + H<sub>2</sub>O ..... II 818, 9  
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 + Na<sub>2</sub>B<sub>2</sub>O<sub>4</sub> + Na<sub>2</sub>HPO<sub>4</sub> + Na<sub>3</sub>PO<sub>4</sub> + NaCl + H<sub>2</sub>O ..... II 819  
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 + NaF + H<sub>2</sub>O ..... II 825  
 + NaHCO<sub>3</sub> + Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 823  
 + NaHCO<sub>3</sub> + H<sub>2</sub>O ..... II 823  
 + NaHCO<sub>3</sub> + NaCl + H<sub>2</sub>O ..... II 824  
 + Na<sub>2</sub>HPO<sub>4</sub> + NaCl + H<sub>2</sub>O ..... II 825  
 + Na<sub>4</sub>P<sub>2</sub>O<sub>7</sub> ..... II 828  
 + Na<sub>2</sub>SC<sub>4</sub> + H<sub>3</sub>BO<sub>3</sub> + H<sub>2</sub>O ..... II 828  
 + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 825, 6, 7, 8  
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 + t-butyl alc. + H<sub>2</sub>O ..... II 842  
 + CaBr<sub>2</sub> ..... I 505  
 + CdBr<sub>2</sub> ..... I 702  
 + CdBr<sub>2</sub>·2½H<sub>2</sub>O in H<sub>2</sub>O ..... I 701  
 + CsF ..... II 847  
 + CsF ..... I 889  
 in D<sub>2</sub>O ..... II 832  
 in aq. ethanol ..... II 841  
 in ethyl alc. ..... II 843  
 in formic acid ..... II 842  
 in glycerol ..... II 842  
 in HBr solns. .... II 832  
 + Br ..... II 833  
 in alc. soln. of HBr ..... II 842  
 in H<sub>2</sub>O ..... II 831  
 + HgBr<sub>2</sub> ..... I 1189  
 + HgBr<sub>2</sub> + H<sub>2</sub>O ..... I 1182  
 in hydrazine ..... II 847  
 in iso amyl alc. soln. of HBr ..... II 844  
 + isopropyl alc. + H<sub>2</sub>O ..... II 842  
 + K ≡ KBr + Na ..... II 2  
 + KBr + CdBr<sub>2</sub> ..... I 702  
 + KBr + H<sub>2</sub>O ..... II 21, 2, 3  
**2NaBr** + K<sub>2</sub>CO<sub>3</sub> ≡ Na<sub>2</sub>CO<sub>3</sub> + 2KBr ..... II 31  
**NaBr** + KF ..... II 212, 847  
 + KF ≡ NaF + KBr ..... II 31  
 + KI ≡ NaI + KBr ..... II 31  
 + KNO<sub>3</sub> ≡ NaNO<sub>3</sub> + KBr ..... II 31  
 + KOH ≡ NaOH + KBr ..... II 31  
 + LiBr ..... II 371  
 + LiF ≡ NaF + LiBr ..... II 371  
 + LiI ..... II 417  
 in aq. methanol ..... II 841  
 in methyl alc. .... II 843  
 + methyl alc. + cyclohexane ..... II 844  
 + MgBr<sub>2</sub> ..... II 453  
 in mixed alcs. .... II 844  
 + NH<sub>3</sub> + H<sub>2</sub>O ..... II 833  
 in liq. NH<sub>3</sub> ..... II 846  
 + Na ..... II 805  
 + NaBrO<sub>3</sub> + H<sub>2</sub>O ..... II 833, 4  
 + NaBrO<sub>3</sub> + NaCO<sub>3</sub> + H<sub>2</sub>O ..... II 835  
 + NaBrO<sub>3</sub> + NaHCO<sub>3</sub> + H<sub>2</sub>O ..... II 834  
 + Na<sub>2</sub>CO<sub>3</sub> ..... II 847  
 + Na<sub>2</sub>CO<sub>3</sub> ..... II 946  
 + Na<sub>2</sub>CO<sub>3</sub> in ethanol ..... II 942  
 + Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 835  
 + Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 924  
 + NaCl ..... II 847  
 + NaCl + H<sub>2</sub>O ..... II 836, 7  
 + NaCl + NH<sub>3</sub> (liq) ..... II 846  
 + NaCl + NaOH ..... II 838  
 + NaClO<sub>3</sub> + H<sub>2</sub>O ..... II 838  
 + NaF ..... II 847  
 + NaHCO<sub>3</sub> + H<sub>2</sub>O ..... II 835  
 + NaI ..... II 847  
 + NaI + H<sub>2</sub>O ..... II 838, 9  
 + NaI + H<sub>2</sub>O distr. .... II 839  
 + NaIO<sub>3</sub> + H<sub>2</sub>O ..... II 839, 40  
 + NaNO<sub>2</sub> ..... II 847  
 + NaNO<sub>3</sub> + H<sub>2</sub>O ..... II 840  
 + NaOH ..... II 833, 7, 1095  
 in NaOH solns. .... II 833  
 + NaOH + NaI ..... II 1095  
 + Na<sub>2</sub>SO<sub>4</sub> ..... II 847  
 in various organic solvents ..... II 845  
 + PbBr<sub>2</sub> ..... II 847  
 + PbBr<sub>2</sub> + H<sub>2</sub>O ..... II 840, 1  
**2NaBr** + PbCl<sub>2</sub> ≡ 2NaCl + PbBr<sub>2</sub> ..... II 847  
**NaBr** + RbBr ..... II 847  
 + RbF ..... II 847  
 in SO<sub>2</sub> (liq) ..... II 847  
 + SrBr<sub>2</sub> ..... II 847  
 + TiCl<sub>4</sub> ≡ NaCl + TiBr ..... II 847  
**NaBrO<sub>3</sub>** + AgBrO<sub>3</sub> + H<sub>2</sub>O ..... I 21, 22  
 in D<sub>2</sub>O ..... II 848  
 in H<sub>2</sub>O ..... II 847  
 in hydrazine ..... II 850  
 + Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 848  
 + NaCl ..... II 848  
 + NaClO<sub>3</sub> + H<sub>2</sub>O ..... II 849  
 + NaBr ..... II 833, 4  
 + NaBr + NaCO<sub>3</sub> + H<sub>2</sub>O ..... II 835  
 + NaBr + NaHCO<sub>3</sub> + H<sub>2</sub>O ..... II 834  
 + NaI + H<sub>2</sub>O ..... II 849  
 + NaHCO<sub>3</sub> + H<sub>2</sub>O ..... II 848  
 + Na<sub>2</sub>MoO<sub>4</sub> + H<sub>2</sub>O ..... II 1062  
 + NaNO<sub>3</sub> + H<sub>2</sub>O ..... II 849  
 + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 850  
**Na butyrate** ..... II 862  
 in acetone ..... II 862  
 + (C<sub>4</sub>H<sub>7</sub>O<sub>2</sub>)<sub>2</sub>O ..... II 862  
 + KSCN ≡ K butyrate + NaSCN ..... II 80  
 in methyl alc. .... II 862  
 + NaSCN ..... II 862, 914  
 + NaNO<sub>3</sub> ..... II 1083  
**Na isobutyrate** + Na benzoate ..... II 863  
 + Na acetate ..... II 859  
 + Na formate ..... II 853  
 + NaNO<sub>3</sub> ..... II 1083  
 + pentanoate ..... II 863  
 + Na propionate ..... II 860  
 + Na isopropionate ..... II 860  
 + Na stearate ..... II 863  
 + NaSCN ..... II 914  
**Na<sub>2</sub>C<sub>3</sub>H<sub>5</sub>(OH)<sub>2</sub>PO<sub>4</sub>·5H<sub>2</sub>O** in glycerol ..... II 1112  
 in H<sub>2</sub>O ..... II 1112  
**Na<sub>2</sub>CH<sub>3</sub>PO<sub>4</sub>·6H<sub>2</sub>O** in H<sub>2</sub>O ..... II 1112  
**Na<sub>2</sub>[CH<sub>2</sub>(SO<sub>3</sub>)<sub>2</sub>]** in H<sub>2</sub>O ..... II 851  
**Na<sub>2</sub>[CHCl(SO<sub>3</sub>)<sub>2</sub>]** in H<sub>2</sub>O ..... II 851  
**NaCN** + AgCN ..... I 52  
 AgCN in H<sub>2</sub>O, aq. alcohol ..... I 52  
 + CuCN ..... I 921  
 in H<sub>2</sub>O ..... II 909  
 + KCN ..... II 68  
 + Na<sub>2</sub>CO<sub>3</sub> ..... II 911  
 + NaCl ..... II 911  
 + NaCl + NH<sub>3</sub> (liq) ..... II 911  
 in aq. NaOH ..... II 910  
 + NaOH + H<sub>2</sub>O ..... II 909, 10  
 in various solvents ..... II 911  
**NaCMS** in ethylenediamine ..... II 914  
**Na<sub>2</sub>CO<sub>3</sub>** + aliphatic amine + H<sub>2</sub>O ..... II 946  
 + allyl alc. + H<sub>2</sub>O ..... II 944  
 + BaCl<sub>2</sub> ..... I 353  
 + BaCO<sub>3</sub> ..... I 330  
 + BaTiO<sub>3</sub> + K<sub>2</sub>CO<sub>3</sub> ..... I 400  
 + BiTiO<sub>3</sub> ..... I 439  
 + butyl alc. + H<sub>2</sub>O ..... II 943  
 + CaCO<sub>3</sub> ..... I 556  
 + CaCO<sub>3</sub> + H<sub>2</sub>O ..... I 547, 8  
 + CaCrO<sub>4</sub> ≡ CaCO<sub>3</sub> + Na<sub>2</sub>CrO<sub>4</sub> ..... I 600  
 + CaSO<sub>4</sub> ≡ Na<sub>2</sub>SO<sub>4</sub> + CaCO<sub>3</sub> (+ H<sub>2</sub>O) ..... I 682  
 + CuCO<sub>3</sub> in H<sub>2</sub>O ..... I 923  
 in aq. ethyl alc. .... II 941, 2  
 + Fe<sub>2</sub>O<sub>3</sub> ..... II 946  
 + Fe<sub>2</sub>O<sub>3</sub> + Na<sub>2</sub>O ..... II 946  
 in glycerol ..... II 944  
 in glycol ..... II 944  
 in H<sub>2</sub>O ..... II 915, 6  
 + H<sub>2</sub>O<sub>2</sub> + H<sub>2</sub>O ..... II 916  
 + 2KBr ≡ K<sub>2</sub>CO<sub>3</sub> + 2NaBr ..... II 31  
 + K<sub>2</sub>CO<sub>3</sub> ..... II 101  
 + K<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 93  
 + K<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 89, 90, 1, 2  
 + K<sub>2</sub>CO<sub>3</sub> + Na<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 318  
 + KCl ..... II 946  
 + 2KCl ≡ 2NaCl + K<sub>2</sub>CO<sub>3</sub> ..... II 101  
 + 2KCl ≡ 2NaCl + K<sub>2</sub>CO<sub>3</sub> (+ H<sub>2</sub>O) ..... II 94  
 + KCl + NaCl + Na<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>CO<sub>3</sub> ..... II 94  
 + 2KClO<sub>3</sub> ≡ 2NaClO<sub>3</sub> + K<sub>2</sub>CO<sub>3</sub> in H<sub>2</sub>O ..... II 88  
 + 2KF ..... II 101  
 + 2KHCO<sub>3</sub> ≡ 2NaHCO<sub>3</sub> + K<sub>2</sub>CO<sub>3</sub> in H<sub>2</sub>O ..... II 93  
 + 2KOH ≡ 2NaOH + K<sub>2</sub>CO<sub>3</sub> ..... II 101  
 + K<sub>2</sub>SO<sub>4</sub> ≡ Na<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 92, 3  
 + Li<sub>2</sub>CO<sub>3</sub> ..... II 390  
 + Li<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 386, 7  
 + 2LiF ≡ 2NaF + Li<sub>2</sub>CO<sub>3</sub> ..... II 390  
 + 10H<sub>2</sub>O in methanol ..... II 941  
 + MgCO<sub>3</sub> + NaCl + NaOH + H<sub>2</sub>O ..... II 477  
 in aq. NH<sub>3</sub> ..... II 923, 4  
 + (NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 648  
 + 2NH<sub>4</sub>Cl ≡ (NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub> + 2NaCl ..... II 648  
 + NaBO<sub>2</sub> + NaCl + H<sub>2</sub>O ..... II 819

- $\text{Na}_2\text{B}_4\text{O}_7 + \text{H}_2\text{O}$  ..... II 821, 2  
 $\text{NaBr}$  ..... II 847, 946  
 $\text{NaBr}$  in aq.  $\text{C}_2\text{H}_5\text{OH}$  ..... II 942  
 $\text{NaBr} + \text{H}_2\text{C}$  ..... II 924  
 $\text{NaBr} + \text{NaBrO}_3 + \text{H}_2\text{O}$  ..... II 835  
 $\text{NaBrC}_3 + \text{H}_2\text{O}$  ..... II 848  
 $\text{NaCN}$  ..... II 91  
 $\text{NaCl}$  ..... II 946  
 $\text{NaCl}$  in ethanol ..... II 942  
 $\text{NaCl} + \text{H}_2\text{O}$  ..... II 931, 2  
 $\text{NaCl} + \text{H}_2\text{O} + \text{CO}_2$  ..... II 948  
 $\text{NaCl} + \text{NaF}$  ..... II 946  
 $\text{NaCl} + \text{NaOH} + \text{H}_2\text{O}$  ..... II 920, 1, 2  
 $\text{NaCl} + \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 932, 3, 4  
 $\text{NaCl} + \text{Na}_2\text{SO}_4 + \text{NaOH} + \text{H}_2\text{O}$  ..... II 922, 3  
 $\text{NaClC}_3 + \text{H}_2\text{O}$  ..... II 935  
 $\text{Na}_2\text{CrO}_4$  ..... II 946  
 $\text{Na}_2\text{CrC}_4 + \text{H}_2\text{O}$  ..... II 935  
 $\text{NaF}$  ..... II 946  
 $\text{NaF} + \text{KCl}$  ..... II 169  
 $\text{NaHCO}_3 + \text{H}_2\text{O}$  ..... II 93, 925, 6, 7  
 $\text{NaHCC}_3 + \text{Na}_2\text{B}_4\text{O}_7 + \text{H}_2\text{O}$  ..... II 823  
 $\text{NaHCO}_3 + \text{Na}_2\text{SO}_4 + \text{NaCl} + \text{H}_2\text{O}$  ..... II 935  
 $\text{NaHCO}_3 + \text{NaCl} + \text{H}_2\text{O}$  ..... II 927, 8, 9, 30  
 $\text{NaI}$  ..... II 946  
 $\text{NaI}$  in aq. ethyl alc. ..... II 1048  
 $\text{NaI} + \text{H}_2\text{O}$  ..... II 936  
 $\text{NaIO}_3 + \text{H}_2\text{O}$  ..... II 936  
 $\text{Na}_2\text{MoO}_4 + \text{H}_2\text{O}$  ..... II 936  
 $\text{NaNO}_2 + \text{H}_2\text{O}$  ..... II 1066, 7  
 $\text{NaNO}_3 + \text{H}_2\text{O}$  ..... II 936  
 $\text{NaNO}_3 + \text{KNO}_3 + \text{K}_2\text{CO}_3$  ..... II 88  
 $\text{NaNO}_3 + \text{NaNO}_2 + \text{H}_2\text{O}$  ..... II 1058  
 $\text{NaOH}$  ..... II 946, 1095  
 $\text{NaOH} + \text{H}_2\text{O}$  ..... II 917, 8, 9, 20  
 $\text{NaOH} + \text{NaCl} + \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 985  
 $\text{Na}_3\text{PO}_4 + \text{H}_2\text{O}$  ..... II 1102  
 $\text{Na phthalate} + \text{H}_2\text{O}$  ..... II 886  
 $\text{Na}_2\text{S} + \text{H}_2\text{O}$  ..... II 937  
 $\text{Na}_2\text{SO}_4$  ..... II 946  
 $\text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 938, 9  
 $\text{Na}_2\text{SO}_4 + \text{KCl}$  ..... II 169  
 $\text{Na}_2\text{SO}_4 + \text{NaOH} + \text{H}_2\text{O}$  ..... II 923, 940  
 $\text{Na}_2\text{SO}_4 + \text{NaCl}$  ..... II 946  
 $\text{Na}_2\text{SO}_4 + \text{NaF}$  ..... II 946  
 $\text{Na tartarate}$  ..... II 864  
 $\text{PbTiO}_3$  ..... II 1337  
 $\text{picoline} + \text{H}_2\text{O}$  ..... II 945  
 $\text{iso-propyl alc} + \text{H}_2\text{O}$  ..... II 943  
 $\text{pyridine} + \text{H}_2\text{O}$  ..... II 944, 5  
 $n\text{-propyl alc} + \text{H}_2\text{O}$  ..... II 942  
 $\text{SiO}_2 + \text{H}_2\text{O}$  ..... II 941  
 $\text{sugar}$  in  $\text{H}_2\text{O}$  ..... II 944  
 $\text{UO}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 940  
  
 **$\text{Na}_2\text{C}_2\text{O}_4$  solns. f.p.** ..... II 952  
in  $\text{D}_2\text{O}$  ..... II 952  
in aq. diamane ..... II 958  
in formic acid ..... II 958  
in glycols ..... II 958  
 $+ \text{H}_2\text{C}_2\text{O}_4 + \text{H}_2\text{O}$  ..... II 963, 4  
 $+ \text{H}_2\text{C}_2\text{O}_4 + \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 964  
in  $\text{H}_2\text{O}$  ..... II 961  
 $+ \text{H}_2\text{SO}_4 + \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 954  
 $+ \text{K}_2\text{C}_2\text{O}_4 + \text{H}_2\text{O}$  ..... II 110  
 $+ \text{MgC}_2\text{O}_4 + \text{H}_2\text{O}$  ..... II 478  
 $+ (\text{NH}_4)_2\text{C}_2\text{O}_4 + \text{H}_2\text{O}$  ..... II 652  
 $+ \text{NaCl} + \text{H}_2\text{O}$  ..... II 955  
 $+ \text{NaNO}_3 + \text{H}_2\text{O}$  ..... II 955  
 $+ \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 955, 6  
 $+ \text{ThC}_2\text{O}_4 + \text{H}_2\text{O}$  ..... II 956  
 $+ \text{UO}_2\text{C}_2\text{O}_4 + \text{H}_2\text{O}$  ..... II 956, 7  
in aq. used ..... II 958  
 $+ \text{ZnC}_2\text{O}_4 + \text{H}_2\text{O}$  ..... II 957  
 $+ \text{ZrC}_2\text{O}_4 + \text{H}_2\text{O}$  ..... II 957  
 $\text{Na}_2\text{CS}_2$  in ethyl alc. ..... II 958  
 **$\text{NaCo ethylene dinitrile tetracetate}$**  ..... II 529  
 **$\text{Na}_2\text{CaSiO}_4 + \text{CaF}_2$**  ..... II 603  
 **$\text{Na cacodylate}$**  in alc. ..... II 865  
in  $\text{H}_2\text{O}$  ..... II 865  
 **$\text{Na campha carbonate}$**  in alics. .... II 893  
in  $\text{H}_2\text{O}$ , chloroform ..... II 893  
 **$\text{Na camphorates}$**  in camphoric acid solns. .... II 888, 9  
  
 **$\text{Na caproate}$**  in glycols ..... II 870, 93  
 $+ \text{NaNO}_3$  ..... II 1083  
 $+ \text{NaSCN}$  ..... II 914  
 $+ \text{phenol} + \text{H}_2\text{O}$  ..... II 870  
 **$\text{Na caprylate}$**  in glycols ..... II 883  
 **$\text{NaCe EDTA}$**  in  $\text{H}_2\text{O}$  ..... I 766  
 **$\text{NaCe [Fe(CN)}_6]$**  in  $\text{H}_2\text{O}$  ..... I 767  
 **$\text{Na cetyl sulfonate}$**  in  $\text{NH}_3$  ..... II 891  
 **$\text{Na chloropierate}$**  in  $\text{H}_2\text{O}$  ..... II 875  
 **$\text{Na chloro nitro phenolate}$**  in aq. alc. .... II 872  
 **$\text{Na chloro nitro xylene sulfonate}$**  in  $\text{H}_2\text{O}$  ..... II 883  
 **$\text{Na chromates}$**  in  $\text{H}_2\text{O}$  ..... II 1029  
 **$\text{Na cinnamate}$**  in alc. .... II 887  
in  $\text{H}_2\text{O}$  ..... II 887  
 **$\text{Na citrate}$**  in aq. ethyl alc. .... II 869  
 **$\text{NaCl} + \text{acetic acid} + \text{benzene} + \text{H}_2\text{O}$**  ..... II 1007  
 $+ \text{acetone} + \text{H}_2\text{O}$  ..... II 1001  
in alc. + ether ..... II 996  
in several alics. .... II 1007, 8  
 $+ \text{AgBr} = \text{AgCl} + \text{NaBr}$  ..... I 118  
 **$3\text{NaCl} + \text{Al} = 3\text{Na} + \text{AlCl}_3$**  ..... I 177  
 **$\text{NaCl} + \text{AlBr}_3$**  ..... I 162  
 $+ \text{AgCl}$  ..... I 177  
 $+ \text{AlCl}_3$  ..... I 177  
 $+ \text{AlCl}_3 + \text{FeCl}_3 + \text{KCl} + \text{HCl} + \text{H}_2\text{O}$  ..... I 167, 8  
 $+ \text{AlCl}_3 + \text{KCl}$  ..... I 177  
 $+ \text{AlCl}_3 + \text{NbCl}_5$  ..... II 1181  
 $+ \text{AlCl}_3 + \text{TaCl}_5$  ..... II 1526  
 $+ \text{allyl alc.} + \text{H}_2\text{O}$  ..... II 998, 9  
 $+ \text{As}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 964  
 $+ \text{BaCl}_2$  ..... II 1012  
 $+ \text{BaCl}_2$  ..... I 353  
 $+ \text{BaCl}_2 + \text{CaCl}_2$  ..... I 353  
 $+ \text{BaCl}_2 + \text{CeCl}_3$  ..... I 769  
 $+ \text{BaCl}_2 + \text{CuCl}_2 + \text{H}_2\text{O}$  ..... I 345  
 $+ \text{BaCl}_2 + \text{HCl} + \text{H}_2\text{O}$  ..... I 349  
 $+ \text{BaCl}_2 + \text{H}_2\text{O}$  ..... I 348  
 $+ \text{BaCl}_2 + \text{KCl}$  ..... I 353  
 $+ \text{BaCl}_2 + \text{KCl} + \text{H}_2\text{O}$  ..... I 349  
 $+ \text{BaF}_2$  ..... I 360  
 **$2\text{NaCl} + \text{BaF}_2 = 2\text{NaF} + \text{BaCl}_2$**  ..... II 1012  
 $+ \text{Ba(HS)}_2 = 2\text{NaHS} + \text{BaCl}_2$  ..... I 387  
 $+ \text{Ba(NO}_3)_2 = 2\text{NaNO}_3 + \text{BaCl}_2 + (\text{H}_2\text{O})$  ..... II 979  
 $+ \text{Ba(NO}_3)_2 = 2\text{NaNO}_3 + \text{BaCl}_2$  in  $\text{H}_2\text{O}$  ..... I 342  
 **$\text{NaCl} + \text{BaSO}_4$**  ..... I 393  
 **$2\text{NaCl} + \text{BaSO}_4 = \text{Na}_2\text{SO}_4 + \text{BaCl}_2$**  ..... I 393  
 **$\text{NaCl} + \text{BeCl}_2$**  ..... I 406  
 $+ \text{BeCl}_2 + \text{CeCl}_3$  ..... I 406  
 $+ \text{BeCl}_2 + \text{H}_2\text{O}$  ..... II 987  
 $+ \text{BiCl}_3 + \text{H}_2\text{O}$  ..... I 431  
 $+ \text{BiTiO}_3$  ..... I 439  
 $+ \text{CaCO}_3 + \text{CaSO}_4 + \text{CO}_2 + \text{H}_2\text{O}$  ..... I 544  
 $+ \text{CaCl}_2$  ..... I 495, 597  
 $+ \text{CaCl}_2 + \text{H}_2\text{O}$  ..... I 577-9  
 $+ \text{CaCl}_2 + \text{CdCl}_2 + \text{H}_2\text{O}$  ..... I 723  
 $+ \text{CaCl}_2 + \text{CeCl}_3$  ..... I 769, 597  
 $+ \text{CaCl}_2 + \text{CaCl}$  ..... I 597  
 $+ \text{CaSO}_4$  ..... I 687  
 $+ \text{CdCl}_2$  ..... I 728  
 $+ \text{CdCl}_2 + \text{H}_2\text{O}$  ..... I 718-21  
 $+ \text{CdCl}_2$  in  $\text{H}_2\text{O}$  ..... I 721  
 $+ \text{effect on butyl alc.} + \text{H}_2\text{O}$  ..... II 999  
 $+ \text{butyl alc.} + \text{H}_2\text{O}$  ..... II 999  
 $+ \text{isobutanol} + \text{H}_2\text{O}$  ..... II 999  
 $+ \text{butyric acid} + \text{H}_2\text{O}$  ..... II 1000  
 $+ \text{iso butyric acid} + \text{H}_2\text{O}$  ..... II 1001  
 $+ \text{CoCl}_2 + \text{HCl} + \text{H}_2\text{O}$  ..... II 988  
 $+ \text{CoCl}_2 + \text{LiCl}$  ..... II 406  
in  $\text{CaCl}_2$  solns. .... II 987  
 **$2\text{NaCl} + \text{CaS}_2\text{O}_3 = \text{Na}_2\text{S}_2\text{O}_3 + \text{CaCl}_2 + (\text{H}_2\text{O})$**  ..... II 1152, 3  
 **$\text{NaCl} + \text{CdCl}_2 + \text{KCl}$**  ..... II 168  
 **$2\text{NaCl} + \text{CdCl}_2$**  in  $\text{H}_2\text{O}$  ..... I 721  
 **$3\text{NaCl} + \text{CdCl}_2 + 14\text{H}_2\text{O}$**  in  $\text{H}_2\text{O}$  ..... I 721  
 **$\text{NaCl} + \text{CdCl}_2 + \text{CoCl}_2 + \text{H}_2\text{O}$**  ..... I 721  
 $+ \text{CdCl}_2 + \text{MnCl}_2 + \text{H}_2\text{O}$  ..... I 724  
 $+ \text{CdCl}_2 + \text{NiCl}_2 + \text{H}_2\text{O}$  ..... I 721  
 **$2\text{NaCl} + \text{CdI}_2 = 2\text{NaI} + \text{CdCl}_2$**  ..... II 1012  
 $+ \text{CaSO}_4 = \text{CdCl}_2 + \text{Na}_2\text{SO}_4$  ..... I 728  
 **$\text{NaCl} + \text{CeCl}_3$**  ..... I 1012  
 $+ \text{CoCl}_2$  ..... II 1012  
 $+ \text{CoCl}_2 + \text{H}_2\text{O}$  ..... I 811  
 $+ \text{CaCl}_2$  ..... II 1012

- + CsCl ..... I 885  
 + CsCl + H<sub>2</sub>O ..... II 988, 9  
 + CsF ..... I 889  
 + CuCl ..... I 935  
 + CuCl + H<sub>2</sub>O ..... I 929  
 + CuCl<sub>2</sub> + H<sub>2</sub>O ..... I 943, 4  
 + CuSO<sub>4</sub> + CuCl<sub>2</sub> + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... I 974  
 in D<sub>2</sub>O ..... II 960  
 in Dead Sea brines ..... II 994  
**NaCl dextrase** in HCl solns., H<sub>2</sub>O ..... II 1005, 6  
**NaCl** + dioxane + H<sub>2</sub>O ..... II 1002  
 + dipropylamine + H<sub>2</sub>O ..... II 1004  
 in ethanol ..... II 1008  
 in ethyl alc. .... II 995, 6  
 in ethyl alc. + benzene ..... II 997  
 in aq. ethyl alc. + HCl ..... II 1006  
 in ethyl and amyl alc. + H<sub>2</sub>O ..... II 997  
 in ethyl ether + H<sub>2</sub>O + HCl ..... II 1002  
 + ethyl urethan + H<sub>2</sub>O ..... II 1003  
 in aq. formamide ..... II 1004  
 + FeCl<sub>3</sub> ..... I 1029  
 + FeCl<sub>3</sub> + H<sub>2</sub>O ..... I 1022, 3, 1025  
 in formic acid ..... II 1000  
 in glycerol solns. .... II 1000  
**NaCl-Glucose** in H<sub>2</sub>O ..... II 1005  
**NaCl** + glucose + H<sub>2</sub>O ..... II 1005  
 + H<sub>3</sub>BO<sub>3</sub> + H<sub>2</sub>O ..... II 964  
 + HCl ..... I 1121  
 in aq. HCl ..... II 962, 3  
 + H<sub>2</sub>O ..... II 958, 9  
 in H<sub>2</sub>O + CO<sub>2</sub> ..... II 964  
 in H<sub>2</sub>O + D<sub>2</sub>O ..... II 960  
 in H<sub>2</sub>O<sub>2</sub> ..... II 961  
 + H<sub>2</sub>O<sub>2</sub> ..... I 1148  
 in aq. H<sub>2</sub>O<sub>2</sub> ..... II 961  
**2NaCl** + H<sub>2</sub>SO<sub>4</sub> = Na<sub>2</sub>SO<sub>4</sub> + 2HCl (+ H<sub>2</sub>O) ..... II 963, 4, 1129  
**NaCl** + heptylamine + H<sub>2</sub>O ..... II 1004  
 + HgCl<sub>2</sub> ..... I 1229  
 + HgCl<sub>2</sub> + acetone ..... I 1224  
 + HgCl<sub>2</sub> + C<sub>2</sub>H<sub>5</sub>OH ..... I 1216  
 + HgCl<sub>2</sub> + H<sub>2</sub>O ..... I 1209, 10  
 + InCl<sub>3</sub> ..... I 1296  
 in inorganic solvents ..... II 1011, 2  
 + K = KCl + Na ..... II 2  
**2NaCl** + K<sub>2</sub>B<sub>4</sub>O<sub>7</sub> = 2KCl + Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub> ..... II 11, 119  
 + K<sub>2</sub>B<sub>10</sub>O<sub>16</sub> = Na<sub>2</sub>B<sub>10</sub>O<sub>16</sub> + 2KCl ..... II 119  
**NaCl** + KBr ..... II 30  
**2NaCl** + K<sub>2</sub>CO<sub>3</sub> = 2KCl + Na<sub>2</sub>CO<sub>3</sub> ..... II 101  
 + K<sub>2</sub>CO<sub>3</sub> = 2KCl + Na<sub>2</sub>CO<sub>3</sub> (+ H<sub>2</sub>O) ..... II 94  
**NaCl** + KCl ..... II 169  
 + KCl + CaCl<sub>2</sub> ..... I 597  
 + KCl + CaCl<sub>2</sub> + H<sub>2</sub>O ..... I 586, 7  
 + KCl + CaCl<sub>2</sub> at 10% MgCl<sub>2</sub> ..... I 597  
 + KCl + CaCl<sub>2</sub> + MgCl<sub>2</sub> + H<sub>2</sub>O ..... I 587  
 + KCl + CaCl<sub>2</sub> + MgCl<sub>2</sub> + SrCl<sub>2</sub> + H<sub>2</sub>O ..... I 587  
 + KCl + CsSO<sub>4</sub> ..... II 169  
 + KCl + CeCl<sub>3</sub> ..... I 769  
 + KCl in aq. HCl ..... II 148  
 + KCl + H<sub>2</sub>O ..... II 146, 7, 8  
 + KCl + LiCl ..... II 169, 405  
 + KCl + LiCl + H<sub>2</sub>O ..... II 141  
 + KCl + Na<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>SO<sub>4</sub> + Na<sub>2</sub>CO<sub>3</sub> + K<sub>2</sub>CO<sub>3</sub> ..... II 94  
 + KCl + TiCl<sub>3</sub> ..... II 169  
**Na<sup>+</sup>, K<sup>+</sup> || Cl<sup>-</sup>, NO<sub>3</sub><sup>-</sup>, SO<sub>4</sub><sup>2-</sup>** + H<sub>2</sub>O ..... II 132  
**Na<sup>+</sup>, K<sup>+</sup> || Cl<sup>-</sup>, SO<sub>4</sub><sup>2-</sup>, NO<sub>3</sub><sup>-</sup>** (+ H<sub>2</sub>O) ..... II 138  
**Na<sup>+</sup>, K<sup>+</sup> || F<sup>-</sup>, Br<sup>-</sup>, I<sup>-</sup>** ..... II 31  
**Na<sup>+</sup>, K<sup>+</sup> || F<sup>-</sup>, Br<sup>-</sup>, I<sup>-</sup>, Cl<sup>-</sup>** ..... II 31  
**Na<sup>+</sup>, K<sup>+</sup> || SO<sub>4</sub><sup>2-</sup>, F<sup>-</sup>, CO<sub>3</sub><sup>2-</sup>** ..... II 326  
**Na<sup>+</sup>, K<sup>+</sup> || SO<sub>4</sub><sup>2-</sup>, NO<sub>3</sub><sup>-</sup>, Cl<sup>-</sup>** ..... II 318  
**Na<sup>+</sup>, K<sup>+</sup> || F<sup>-</sup>, SO<sub>4</sub><sup>2-</sup>, CO<sub>3</sub><sup>2-</sup>** ..... II 101  
**Na<sup>+</sup>, K<sup>+</sup>, Ag<sup>+</sup> || Br<sup>-</sup>, Cl<sup>-</sup>, NO<sub>3</sub><sup>-</sup>** ..... II 31  
**Na<sup>+</sup>, K<sup>+</sup>, Mg<sup>++</sup> || Cl<sup>-</sup>, SO<sub>4</sub><sup>2-</sup>** (+ H<sub>2</sub>O) ..... II 138  
**Na<sup>+</sup>, K<sup>+</sup>, Mg<sup>++</sup> || Cl<sup>-</sup>, SO<sub>4</sub><sup>2-</sup>** + H<sub>2</sub>O ..... II 143  
**Na<sup>+</sup>, K<sup>+</sup>, NH<sub>4</sub><sup>+</sup> || Cl<sup>-</sup>, HCO<sub>3</sub><sup>-</sup>** + H<sub>2</sub>O ..... II 105  
**Na<sup>+</sup>, K<sup>+</sup>, NH<sub>4</sub><sup>+</sup> || Cl<sup>-</sup>, NO<sub>3</sub><sup>-</sup>, SO<sub>4</sub><sup>2-</sup>** + H<sub>2</sub>O ..... II 146  
**Na<sup>+</sup>, K<sup>+</sup>, Li<sup>+</sup> || Cl<sup>-</sup>, SO<sub>4</sub><sup>2-</sup>** ..... II 169  
**NaCl** + KClO<sub>3</sub> = KCl + NaClO<sub>3</sub> ..... II 121  
 + KClO<sub>4</sub> + H<sub>2</sub>O ..... II 183  
 + KClO<sub>4</sub> = NaClO<sub>4</sub> + KCl (+ H<sub>2</sub>O) ..... II 123  
 + KClO<sub>4</sub> + NaNO<sub>3</sub> + H<sub>2</sub>O ..... II 184, 5  
 in K<sub>2</sub>CrO<sub>4</sub> solns ..... II 992  
**2NaCl** + K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> = Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> + 2KCl ..... II 202  
 + K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> = Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> + 2KCl (+ H<sub>2</sub>O) ..... II 972  
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 + KF = NaF + KCl ..... II 169  
 + KI ..... II 234  
 in KMnO<sub>4</sub> solns. .... II 992  
**2NaCl** + K<sub>2</sub>MoO<sub>4</sub> = 2KCl + Na<sub>2</sub>MoO<sub>4</sub> ..... II 246  
 + K<sub>2</sub>MoO<sub>4</sub> = Na<sub>2</sub>MoO<sub>4</sub> + 2KCl ..... II 169  
**NaCl** in aq. KNO<sub>3</sub> ..... II 992  
 + KNO<sub>3</sub> + H<sub>2</sub>O ..... II 265, 6  
 + KNO<sub>3</sub> = NaNO<sub>3</sub> + KCl (+ H<sub>2</sub>O) ..... II 131, 2  
 + KSCN = NaSCN + KCl ..... II 169  
 + K<sub>2</sub>SO<sub>4</sub> ..... II 325  
 + K<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>CO<sub>3</sub> ..... II 101  
**2NaCl** + K<sub>2</sub>SO<sub>4</sub> = Na<sub>2</sub>SO<sub>4</sub> + 2KCl ..... II 169  
 + K<sub>2</sub>SO<sub>4</sub> = Na<sub>2</sub>SO<sub>4</sub> + 2KCl (+ H<sub>2</sub>O) ..... II 136, 7, 8  
**NaCl** + K<sub>2</sub>TiO<sub>3</sub> ..... II 339  
 + K<sub>2</sub>TiF<sub>6</sub> + KCl ..... II 169  
 + KVO<sub>3</sub> + NaVO<sub>3</sub> + KCl ..... II 169  
**2NaCl** + K<sub>2</sub>WO<sub>4</sub> = Na<sub>2</sub>WO<sub>4</sub> + 2KCl ..... II 169  
**NaCl** + Li = LiCl + Na ..... II 362  
 + LiBO<sub>2</sub> ..... II 366  
 + LiCl ..... II 405  
 + LiCl + CsCl ..... II 385  
 + LiCl + H<sub>2</sub>O ..... II 396, 7  
 + LiI ..... II 417  
 + LiNO<sub>3</sub> ..... II 427  
 + LiNO<sub>3</sub> = NaNO<sub>3</sub> + LiCl ..... II 406  
 + Li<sub>2</sub>SO<sub>4</sub> + KCl ..... II 169  
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**NaCl** in aq. methyl alc. .... II 994  
 + MgCO<sub>3</sub> + Na<sub>2</sub>CO<sub>3</sub> + NaOH + H<sub>2</sub>O ..... II 477  
 + MgCl<sub>2</sub> ..... II 494, 1012  
 in aq. MgCl<sub>2</sub> ..... II 992  
 + MgCl<sub>2</sub> + CaCl<sub>2</sub> + H<sub>2</sub>O ..... II 490  
 + MgCl<sub>2</sub> + CaCl<sub>2</sub> + H<sub>2</sub>O ..... I 585, 6  
 + MgCl<sub>2</sub> + H<sub>2</sub>O ..... II 489-90, 989  
 + MgCl<sub>2</sub> + KCl ..... II 169, 494  
 + MgCl<sub>2</sub> + MgSO<sub>4</sub> + KCl + H<sub>2</sub>O in sat NaCl solns ..... II 487  
 + MgCl<sub>2</sub> + Na<sub>2</sub>SO<sub>4</sub> + NaNO<sub>3</sub> + H<sub>2</sub>O ..... II 491  
 + MgCl<sub>2</sub> + Na<sub>2</sub>SO<sub>4</sub> + NaNO<sub>3</sub> + Mg(NO<sub>3</sub>)<sub>2</sub> + H<sub>2</sub>O ..... II 491  
**Na<sup>+</sup>, Mg<sup>++</sup>, || Cl<sup>-</sup>, NO<sub>3</sub><sup>-</sup>, SO<sub>4</sub><sup>2-</sup>** ..... II 487  
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**NaCl** effect on methanol + cyclohexane ..... II 1008  
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**2NaCl** + Mg(NO<sub>3</sub>)<sub>2</sub> = 2NaNO<sub>3</sub> + MgCl<sub>2</sub> (+ H<sub>2</sub>O) ..... II 483  
**NaCl** + MgSO<sub>4</sub> = MgCl<sub>2</sub> + Na<sub>2</sub>SO<sub>4</sub> ..... II 494  
**2NaCl** + MgSO<sub>4</sub> = MgCl<sub>2</sub> + Na<sub>2</sub>SO<sub>4</sub> ..... II 492  
 + MgSO<sub>4</sub> = MgCl<sub>2</sub> + Na<sub>2</sub>SO<sub>4</sub> (+ H<sub>2</sub>O) ..... II 485, 6, 7, 533, 985  
 + MgSO<sub>4</sub> = Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> + MgCl<sub>2</sub> ..... II 539  
**NaCl** in NH<sub>3</sub> ..... II 967  
 in NH<sub>3</sub> aq. .... II 967  
 in NH<sub>3</sub> (liq.) ..... II 1009, 10  
 in NH<sub>3</sub> + CO<sub>2</sub> ..... II 967  
 in NH<sub>3</sub> + H<sub>2</sub>O ..... II 967  
 + NH<sub>4</sub> + H<sub>2</sub>O ..... II 967  
**NaCl-5NH<sub>4</sub>** in NH<sub>3</sub> + H<sub>2</sub>O ..... II 967  
**NaCl** in NH<sub>3</sub> (liq.) + NaNO<sub>3</sub> ..... II 1010, 1  
**2NaCl** + (NH<sub>4</sub>)<sub>2</sub>B<sub>4</sub>O<sub>7</sub> = 2NH<sub>4</sub>Cl + Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub> ..... II 611, 2  
**NaCl** + NH<sub>4</sub>Cl + H<sub>2</sub>O ..... II 667  
 + NH<sub>4</sub>Cl + NaNO<sub>3</sub> ..... II 682  
**2NaCl** + (NH<sub>4</sub>)<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> = Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> + 2NH<sub>4</sub>Cl (+ H<sub>2</sub>O) ..... II 972  
 + (NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub> = 2NH<sub>4</sub>Cl + Na<sub>2</sub>CO<sub>3</sub> ..... II 648  
**NaCl** + NH<sub>4</sub>ClCO<sub>3</sub> = NH<sub>4</sub>Cl + NaHCO<sub>3</sub> ..... II 642, 3, 4  
**Na<sup>+</sup>, NH<sub>4</sub><sup>+</sup> || HCO<sub>3</sub><sup>-</sup>, OH<sup>-</sup>, SO<sub>4</sub><sup>2-</sup>** + H<sub>2</sub>O ..... II 647  
**Na<sup>+</sup>, NH<sub>4</sub><sup>+</sup>, K<sup>+</sup> || Cl<sup>-</sup>, NO<sub>3</sub><sup>-</sup>** + H<sub>2</sub>O ..... II 132  
**2NaCl** + (NH<sub>4</sub>)<sub>2</sub>HPO<sub>4</sub> = 2NH<sub>4</sub>Cl + Na<sub>2</sub>HPO<sub>4</sub> (+ H<sub>2</sub>O) ..... II 663  
**NaCl** + NH<sub>4</sub>NO<sub>3</sub> ..... II 727  
 in NH<sub>4</sub>NO<sub>3</sub> solns ..... II 993  
 + NH<sub>4</sub>NO<sub>3</sub> + NaNO<sub>3</sub> ..... II 727  
 + NH<sub>4</sub>NO<sub>3</sub> = NaNO<sub>3</sub> + NH<sub>4</sub>Cl(H<sub>2</sub>O), (NH<sub>3</sub>) ..... II 662  
 + NH<sub>4</sub>HSO<sub>3</sub> = NH<sub>4</sub>Cl + NaHSO<sub>3</sub> (+ H<sub>2</sub>O) ..... II 754  
**2NaCl** + (NH<sub>4</sub>)<sub>2</sub>SO<sub>3</sub> = 2NH<sub>4</sub>Cl + Na<sub>2</sub>SO<sub>3</sub> (+ H<sub>2</sub>O) ..... II 751, 2  
**NaCl** + NH<sub>4</sub> ..... II 805  
 + Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub> ..... II 828  
 + Na<sub>2</sub>B<sub>10</sub>O<sub>16</sub> + H<sub>2</sub>O ..... II 829, 30  
 + Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub> in MgSO<sub>4</sub> ..... II 824  
 + Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub> + NaBO<sub>2</sub> + H<sub>2</sub>O ..... II 818, 9  
 + Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub> + Na<sub>2</sub>HPO<sub>4</sub> + H<sub>2</sub>O ..... II 825  
 + NaBr ..... II 847  
 + NaBr + H<sub>2</sub>O ..... II 836, 7  
 + NaBr + NH<sub>3</sub> (liq.) ..... II 846

- NaBr + NaOH ..... II 838
- NaBrO<sub>3</sub> + H<sub>2</sub>O ..... II 848
- NaCN ..... II 911
- NaCN + NH<sub>3</sub> (liq.) ..... II 911
- Na<sub>2</sub>CO<sub>3</sub> ..... II 946
- Na<sub>2</sub>CO<sub>3</sub> in ethanol ..... II 942
- Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 931, 2
- Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>C + CO<sub>2</sub> ..... II 948
- Na<sub>2</sub>CO<sub>3</sub> + NaBO<sub>2</sub> + H<sub>2</sub>O ..... II 819
- Na<sub>2</sub>CO<sub>3</sub> + NaOH + H<sub>2</sub>O ..... II 920, 1, 2
- Na<sub>2</sub>CO<sub>3</sub> + NaHCO<sub>3</sub> + H<sub>2</sub>C ..... II 927, 6, 9, 30
- Na<sub>2</sub>CO<sub>3</sub> + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 932, 3, 4, 49
- Na<sub>2</sub>CO<sub>3</sub> + Na<sub>2</sub>SO<sub>4</sub> + NaOH + H<sub>2</sub>O ..... II 922, 3
- Na<sub>2</sub>C<sub>2</sub>O<sub>4</sub> + H<sub>2</sub>O ..... II 955
- NaClO<sub>2</sub> + H<sub>2</sub>O ..... II 968
- NaClO<sub>3</sub> soln. boiling pt. .... II 970
- NaClO<sub>3</sub> + H<sub>2</sub>C ..... II 968, 9, 70
- NaClO<sub>3</sub> + (H<sub>2</sub>O + NH<sub>3</sub>) ..... II 970
- NaClO<sub>4</sub> + H<sub>2</sub>O ..... II 970, 1
- Na<sub>2</sub>CrO<sub>4</sub> ..... II 1011
- Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> + H<sub>2</sub>O ..... II 971, 2
- Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 1028
- NaF ..... II 1011
- NaF + H<sub>2</sub>O ..... II 972, 3
- NaF + K<sub>2</sub>CrO<sub>4</sub> ..... II 196, 1012
- NaF + Na<sub>2</sub>CO<sub>3</sub> ..... II 946
- NaF + Na<sub>2</sub>CrO<sub>4</sub> ..... II 1012
- NaF + Na<sub>2</sub>SO<sub>4</sub> ..... II 1012
- NaF + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 973, 1032
- in NaHCO<sub>3</sub> + CO<sub>2</sub> ..... II 967
- NaHCO<sub>3</sub> + H<sub>2</sub>O ..... II 644
- NaHCO<sub>3</sub> + H<sub>2</sub>O ..... II 947, 8
- NaHCO<sub>3</sub> + Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub> + H<sub>2</sub>C ..... II 624
- Na<sub>2</sub>HPO<sub>4</sub> + H<sub>2</sub>O ..... II 980
- NaHS + H<sub>2</sub>O ..... II 980
- NaI ..... II 1011
- NaI + H<sub>2</sub>O ..... II 974
- NaIO<sub>3</sub> + H<sub>2</sub>O ..... II 975
- Na laurate + H<sub>2</sub>O ..... II 894
- Na laurate + Na palmitate + H<sub>2</sub>O ..... II 894
- Na<sub>2</sub>MoO<sub>4</sub> + H<sub>2</sub>O ..... II 975
- NaNO<sub>2</sub> + H<sub>2</sub>O ..... II 975, 6
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- NaNO<sub>3</sub> in aq. ethyl alc. .... II 1007
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- NaNO<sub>3</sub> in H<sub>2</sub>O + HCl ..... II 978
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- NaNO<sub>3</sub> + KNO<sub>3</sub> + H<sub>2</sub>O ..... II 265
- NaNO<sub>3</sub> + NaNO<sub>3</sub> + H<sub>2</sub>O ..... II 976
- NaNO<sub>3</sub> + NH<sub>3</sub> (liq.) ..... II 1010
- NaNO<sub>3</sub> + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 979
- NaCl + NaOCl (Na<sub>2</sub>AsO<sub>4</sub> · 11H<sub>2</sub>O)<sub>6</sub> in H<sub>2</sub>O** ..... II 813
- NaCl + NaOH** ..... II 1011
- NaOH + H<sub>2</sub>O ..... II 966
- in NaOH solns. .... II 964, 5, 6
- NaOH in steam ..... II 967
- Na oleate + ethyl acetate + H<sub>2</sub>O ..... II 901
- Na palmitate + H<sub>2</sub>O ..... II 899
- Na<sub>3</sub>PO<sub>4</sub> + H<sub>2</sub>O ..... II 979, 80
- Na<sub>3</sub>PO<sub>4</sub> + NaBO<sub>2</sub> + H<sub>2</sub>O ..... II 819
- Na<sub>3</sub>PO<sub>4</sub> + Na<sub>2</sub>HPO<sub>4</sub> + Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub> + Na<sub>2</sub>B<sub>2</sub>O<sub>4</sub> + H<sub>2</sub>O ..... II 819
- Na<sub>4</sub>P<sub>2</sub>O<sub>7</sub> + H<sub>2</sub>O ..... II 1011
- Na<sub>2</sub>SO<sub>3</sub> + H<sub>2</sub>O ..... II 980, 1
- Na<sub>2</sub>SO<sub>3</sub> ..... II 1011
- Na<sub>2</sub>SO<sub>4</sub> + CaSO<sub>4</sub> + H<sub>2</sub>O ..... II 985
- Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 982, 3, 4
- Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 1133
- Na<sub>2</sub>SO<sub>4</sub> in NH<sub>3</sub> solns. .... II 985
- Na<sub>2</sub>SO<sub>4</sub> in NH<sub>3</sub> + CO<sub>2</sub> ..... II 985
- Na<sub>2</sub>SO<sub>4</sub> + Na<sub>2</sub>CO<sub>3</sub> ..... II 946
- Na<sub>2</sub>SO<sub>4</sub> + Na<sub>2</sub>CO<sub>3</sub> + NaOH + H<sub>2</sub>O ..... II 985
- Na<sub>2</sub>SO<sub>4</sub> + NaHCO<sub>3</sub> + Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 935
- Na<sub>2</sub>SO<sub>4</sub> + NaNO<sub>3</sub> + H<sub>2</sub>O ..... II 985
- Na<sub>2</sub>SO<sub>4</sub> + NaOH + H<sub>2</sub>O ..... II 985
- Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> · 5H<sub>2</sub>O ..... II 1154
- Na<sub>2</sub>S<sub>2</sub>O<sub>4</sub> + H<sub>2</sub>O ..... II 986
- Na<sub>2</sub>SO<sub>3</sub>NH<sub>2</sub> + H<sub>2</sub>O ..... II 986
- Na<sub>2</sub>SIF<sub>6</sub> + H<sub>2</sub>O ..... II 1038
- Na<sub>2</sub>TiO<sub>3</sub> ..... II 1171
- NaVO<sub>3</sub> ..... II 1011
- NaVO<sub>3</sub> + H<sub>2</sub>O ..... II 1177
- Na<sub>4</sub>V<sub>2</sub>O<sub>7</sub> + H<sub>2</sub>O ..... II 986
- NbCl<sub>5</sub> ..... II 1012, 1181
- NbCl<sub>5</sub> + AlCl<sub>3</sub> ..... II 1012
- NbCl<sub>5</sub> ..... II 1188
- NbCl<sub>5</sub> ..... II 1012
- NbCl<sub>5</sub> + CaCl<sub>2</sub> ..... II 1012, 1188
- NiCl<sub>2</sub> ..... II 1012
- in organic solvents ..... II 1008
- oxides ..... II 1012
- 2NaCl + PbBr<sub>2</sub> = PbCl<sub>2</sub> + 2NaBr** ..... II 847
- NaCl + PbCl<sub>2</sub>** ..... II 1293
- PbCl<sub>2</sub> + H<sub>2</sub>O ..... II 990
- PbCl<sub>2</sub> + H<sub>2</sub>O ..... II 1286, 7
- 2NaCl + PbI<sub>2</sub> = 2NaI + PbCl<sub>2</sub>** ..... II 1012
- PbSO<sub>4</sub> = PbCl<sub>2</sub> + Na<sub>2</sub>SO<sub>4</sub> (+ H<sub>2</sub>O) ..... II 986, 7
- NaCl in aq. propanol** ..... II 996
- in aq. propyl alc. .... II 997
- propyl alc. + H<sub>2</sub>O ..... II 997
- iso propyl alc. + H<sub>2</sub>O ..... II 998
- in iso propyl alc. + NH<sub>4</sub>NO<sub>3</sub> ..... II 1009
- in iso propyl alc. + NaNO<sub>3</sub> ..... II 1009
- PhCl<sub>4</sub> + H<sub>2</sub>O ..... II 990, 1
- pyridine + H<sub>2</sub>O ..... II 1004
- RbCl ..... II 1366
- RbCl + CaCl<sub>2</sub> ..... 1 597
- RbNO<sub>3</sub> = NaNO<sub>3</sub> + RbCl ..... II 1012
- SrCO<sub>3</sub> ..... II 1011
- SrCl<sub>2</sub> ..... II 1011
- SrCl<sub>2</sub> + H<sub>2</sub>O ..... II 992
- SrCl<sub>2</sub> + KCl ..... II 169
- SrCl<sub>2</sub> + KCl + H<sub>2</sub>O ..... II 152
- NaCl + salts** ..... II 1012
- in aq. salt solns. .... II 993, 4
- 2NaCl + SiF<sub>2</sub> = 2NaF + SiCl<sub>2</sub>** ..... II 1012
- SiSO<sub>4</sub> ..... II 1012
- in steam ..... II 959, 60
- succinonitrile + H<sub>2</sub>O ..... II 1004
- sucrose + H<sub>2</sub>O ..... II 1006
- in aq. tartaric acid ..... II 1002
- TaCl<sub>5</sub> ..... II 1012, 1526
- TaCl<sub>5</sub> + AlCl<sub>3</sub> ..... II 1012
- in aq. thiourea ..... II 1003
- TiCl<sub>4</sub> ..... II 1553
- TiCl<sub>4</sub> + FeCl<sub>3</sub> ..... II 1553
- TiO<sub>2</sub> + H<sub>2</sub>O ..... II 1554
- TiBr = TiCl + NaBr ..... II 847
- TiCl ..... II 1011
- in aq. urea ..... II 1003
- ZnCl<sub>2</sub> ..... II 1011
- ZnCl<sub>2</sub> + KCl ..... II 169
- ZnSO<sub>4</sub> ..... II 1012
- ZnSO<sub>4</sub> + KCl ..... II 169
- 2NaCl + ZnSO<sub>4</sub> = Na<sub>2</sub>SO<sub>4</sub> + ZnCl<sub>2</sub>** ..... II 1012
- ZrCl ..... II 1691
- NaCl + ZnCl<sub>4</sub>** ..... II 1012, 1691
- NaClO in H<sub>2</sub>O** ..... II 1012, 3
- NaCl + (H<sub>2</sub>O + NH<sub>3</sub>) ..... II 970
- Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 1133
- NaClO<sub>2</sub> in H<sub>2</sub>O** ..... II 1013
- NaCl + H<sub>2</sub>O ..... II 968
- NaClO<sub>3</sub> + H<sub>2</sub>O ..... II 1014
- NaClO<sub>3</sub> + AgClO<sub>3</sub> + H<sub>2</sub>O** ..... 1 79
- Ba(ClO<sub>3</sub>)<sub>2</sub> + H<sub>2</sub>O ..... 1 355
- in aq. ethyl alc. .... II 1018
- in ethylene glycol ..... II 1018
- in glycerol ..... II 1018
- in H<sub>2</sub>O ..... II 1014, 5
- H<sub>2</sub>O<sub>2</sub> ..... II 1019
- in hydrazine ..... II 1018
- 2NaClO<sub>3</sub> + K<sub>2</sub>CO<sub>3</sub> = 2KClO<sub>3</sub> + Na<sub>2</sub>CO<sub>3</sub> in H<sub>2</sub>O** ..... II 88
- NaClO<sub>3</sub> + KCl = KClO<sub>3</sub> + NaCl (+ H<sub>2</sub>O)** ..... II 121
- KClO<sub>3</sub> + H<sub>2</sub>O ..... II 175, 6
- KNO<sub>3</sub> ..... II 274
- in monethanol amine ..... II 1018
- NaBr + H<sub>2</sub>O ..... II 838
- NaBrO<sub>3</sub> + H<sub>2</sub>O ..... II 849
- Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 935
- NaCl soln. boiling pt. .... II 970
- NaCl + H<sub>2</sub>O ..... II 968, 9, 70
- NaClO<sub>2</sub> + H<sub>2</sub>O ..... II 1014
- Na<sub>2</sub>CrO<sub>4</sub> + H<sub>2</sub>O ..... II 1015
- NaI + H<sub>2</sub>O ..... II 1016
- NaIO<sub>3</sub> + H<sub>2</sub>O ..... II 1016

- + Na<sub>2</sub>MoO<sub>4</sub> + H<sub>2</sub>O ..... II 1062  
 + NaNO<sub>3</sub> + H<sub>2</sub>O ..... II 1016  
 + NaOH + H<sub>2</sub>O ..... II 1015  
 + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 1017  
 + Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>·5H<sub>2</sub>O ..... II 1154  
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 in acetone ..... II 1021  
 in alics. .... II 1020  
 + Al(ClO<sub>4</sub>)<sub>3</sub> + H<sub>2</sub>O ..... II 1178  
 + Ba(ClO<sub>4</sub>)<sub>2</sub> ..... II 1021  
 in butyl alc. + HClO<sub>3</sub> ..... II 1021  
 in ethyl acetate ..... II 1021  
 in ethyl acetate + alics. .... II 1021  
 in ethylene diamine ..... II 1021  
 in ethylene glycol ..... II 1021  
 + H<sub>2</sub>O ..... II 1018  
 + H<sub>2</sub>O<sub>2</sub> + H<sub>2</sub>O ..... II 1019  
 + KCl ⇌ KClO<sub>4</sub> + NaCl (+ H<sub>2</sub>O) ..... II 123  
 + KClO<sub>4</sub> + H<sub>2</sub>O ..... II 182  
 + KNO<sub>3</sub> ⇌ NaNO<sub>3</sub> + KClO<sub>4</sub> (+ H<sub>2</sub>O) ..... II 183  
 in monoethanol amine ..... II 1021  
 + NH<sub>4</sub>ClO<sub>4</sub> + H<sub>2</sub>O ..... II 685, 6  
**2NaClO<sub>4</sub>** + (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> ⇌ Na<sub>2</sub>SO<sub>4</sub> + 2NH<sub>4</sub>ClO<sub>4</sub> (+ H<sub>2</sub>O) ..... II 687  
**NaClO<sub>4</sub>** + NH<sub>4</sub>NO<sub>3</sub> ⇌ NH<sub>4</sub>ClO<sub>4</sub> + NaNO<sub>3</sub> (+ H<sub>2</sub>O) ..... II 686, 7  
 + NaNO<sub>3</sub> + H<sub>2</sub>O ..... II 1020  
 + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 1020  
 + Na<sub>2</sub>SO<sub>4</sub> + NH<sub>4</sub>ClO<sub>4</sub> + (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 758  
**Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>** in benzene + acetic acid ..... II 1027  
 + CaCO<sub>3</sub> ⇌ CaCrO<sub>4</sub> + Na<sub>2</sub>CO<sub>3</sub> ..... I 600  
 + CaCrO<sub>4</sub> ..... I 600  
 in furfural ..... II 1027  
 in H<sub>2</sub>O ..... II 1022  
 + 2K<sub>2</sub>O<sub>2</sub> ⇌ K<sub>2</sub>CrO<sub>4</sub> + Na<sub>2</sub>BO<sub>2</sub> ..... II 11  
 + K<sub>2</sub>CrO<sub>4</sub> ..... II 196, 1027  
 + 2K<sub>2</sub>CrO<sub>4</sub> ..... II 193  
 + K<sub>2</sub>CrO<sub>4</sub> + H<sub>2</sub>O ..... II 194  
 + K<sub>2</sub>CrO<sub>4</sub> + NaNO<sub>3</sub> ..... II 1027  
 + 2KF ⇌ 2NaF + K<sub>2</sub>CrO<sub>4</sub> ..... II 196  
 + 2KNO<sub>3</sub> ⇌ 2NaNO<sub>3</sub> + K<sub>2</sub>CrO<sub>4</sub> ..... II 196  
 + 2KOH ⇌ 2NaOH + K<sub>2</sub>CrO<sub>4</sub> ..... II 196  
 + K<sub>2</sub>SO<sub>4</sub> ⇌ Na<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>CrO<sub>4</sub> (+ H<sub>2</sub>O) ..... II 193  
 + Li<sub>2</sub>CrO<sub>4</sub> ..... II 411  
 + 2LiOH ⇌ 2NaOH + Li<sub>2</sub>CrO<sub>4</sub> ..... II 411  
 in methyl alc. .... II 1026  
 + NaBO<sub>2</sub> ..... II 828  
 + Na<sub>2</sub>CO<sub>3</sub> ..... II 946  
 + Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 935  
 + NaCl ..... II 1011  
 + NaClO<sub>3</sub> + H<sub>2</sub>O ..... II 1015  
 + NaF ..... II 1027  
 + NaF + NaCl ..... II 1012  
 + NaMoO<sub>4</sub> + H<sub>2</sub>O ..... II 1024, 5  
 + NaNO<sub>3</sub> + H<sub>2</sub>O ..... II 1023  
 + NaOH ..... II 1027, 95  
 + Na<sub>2</sub>SO<sub>4</sub> ..... II 1027  
 + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 1025, 6  
 + Na<sub>2</sub>SO<sub>4</sub> + KNO<sub>3</sub> ..... II 274  
 + Na<sub>2</sub>SO<sub>4</sub> + NaNO<sub>3</sub> ..... II 1027  
 + Na<sub>2</sub>SiO<sub>3</sub> ..... II 1027  
 + Na<sub>2</sub>TiO<sub>3</sub> ..... II 1171  
**Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>** in ethanol ..... II 1027  
 in H<sub>2</sub>O ..... II 1027, 8  
 + 2KCl ⇌ 2NaCl + K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> ..... II 202  
 + 2KCl ⇌ 2NaCl + K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> (+ H<sub>2</sub>O) ..... II 972  
 + K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> ..... II 202  
 + K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> + H<sub>2</sub>O ..... II 200  
 + 2KNO<sub>3</sub> ⇌ 2NaNO<sub>3</sub> + K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> ..... II 202  
 + NH<sub>4</sub>Cl + H<sub>2</sub>O ..... II 1028  
 + 2NH<sub>4</sub>Cl ⇌ (NH<sub>4</sub>)<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> + 2NaCl (+ H<sub>2</sub>O) ..... II 972  
 + (NH<sub>4</sub>)<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> + H<sub>2</sub>O ..... II 1028  
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 + NaCl + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 1028  
 + NaHSO<sub>4</sub> + H<sub>2</sub>O ..... II 1028  
 + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 1028  
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**Na doxycholate** in H<sub>2</sub>O ..... II 908  
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 + KCl + Na<sub>2</sub>CO<sub>3</sub> ..... II 169  
 + K<sub>2</sub>CrO<sub>4</sub> ..... II 196  
**2NaF + K<sub>2</sub>CrO<sub>4</sub>** ⇌ 2KF + Na<sub>2</sub>CrO<sub>4</sub> ..... II 196  
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**2NaF + K<sub>2</sub>MoO<sub>4</sub>** ⇌ Na<sub>2</sub>MoO<sub>4</sub> + 2KF ..... II 211  
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 + K<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>CO<sub>3</sub> ..... II 101  
 + K<sub>2</sub>TiO<sub>3</sub> ..... II 339  
**2NaF + K<sub>2</sub>TiO<sub>3</sub>** ⇌ 2KF + Na<sub>2</sub>TiO<sub>3</sub> ..... II 339  
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$2\text{NaF} + \text{Li}_2\text{CO}_3 \rightleftharpoons 2\text{LiF} + \text{Na}_2\text{CO}_3$	II 390
$\text{NaF} + \text{LiF}$	II 414
+ $\text{LiF} + \text{KF}$	II 211
+ $\text{LiI}$	II 417
$2\text{NaF} + \text{Li}_2\text{SO}_4 \rightleftharpoons \text{Na}_2\text{SO}_4 + 2\text{LiF}$	II 414
$\text{NaF} + \text{Li}_2\text{TiCl}_3$	II 440, 1040
+ $\text{Li}_2\text{TiO}_3 \rightleftharpoons \text{Na}_2\text{TiO}_3 + 2\text{LiF}$	II 1040
+ $\text{MgF}_2$	II 498, 1040
+ $\text{MgF}_2 + \text{KF}$	II 211
+ $\text{MgF}_2 + \text{LiF}$	II 414
+ $\text{MoO}_3$	II 1040
in $\text{NH}_3$ (liq.)	II 1039
+ $\text{NH}_4\text{F} + \text{H}_2\text{O}$	II 1035
+ $\text{Na}$	II 805
+ $\text{Na}_3\text{AlF}_6 + \text{Al}_2\text{O}_3$	I 186
+ $\text{NaBF}_4$	II 1040
+ $\text{NaBO}_2 + \text{H}_2\text{O}$	II 819
+ $\text{Na}_2\text{B}_4\text{O}_7$	II 828
+ $\text{Na}_2\text{B}_4\text{O}_7 + \text{H}_2\text{O}$	II 825
+ $\text{NaBeF}_4 + \text{H}_2\text{O}$	II 1034
+ $\text{NaBr}$	II 847
+ $\text{Na}_2\text{CO}_3$	II 945
+ $\text{Na}_2\text{CCl}_3 + \text{NaCl}$	II 946
+ $\text{NaCl}$	II 1011
+ $\text{NaCl} + \text{K}_2\text{CrO}_4$	II 196
+ $\text{NaCl} + \text{K}_2\text{CrO}_4$	II 1012
+ $\text{NaCl} + \text{Na}_2\text{CrO}_4$	II 1012
+ $\text{NaCl} + \text{Na}_2\text{SO}_4$	II 1012
+ $\text{NaCl} + \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$	II 973, 1032
+ $\text{Na}_2\text{CrO}_4$	II 1027
+ $\text{NaI}$	II 1040
+ $\text{Na}_2\text{MoO}_4$	II 1040
+ $\text{NaNO}_3$	II 1040
+ $\text{NaOH}$	II 1040
in aq. $\text{NaOH}$	II 1032
+ $\text{Na}_3\text{PO}_4 + \text{H}_2\text{O}$	II 1032
+ $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$	II 1032
+ $\text{Na}_2\text{P}_2\text{O}_7$	II 1040
+ $\text{Na}_2\text{SO}_4$	II 1040
+ $\text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$	II 1033
+ $\text{Na}_2\text{SO}_4 + \text{Na}_2\text{CCl}_3$	II 946
+ $\text{Na}_2\text{SiO}_3$	II 1040
+ $\text{Na}_2\text{SiO}_4$	II 1040
+ $\text{Na}_2\text{TiO}_3$	II 1040, 1171
+ $\text{Na}_2\text{U}_2\text{O}_7$	II 1040
+ $\text{NaVO}_3$	II 1040
+ $\text{PbF}_2$	II 1040, 1299
$2\text{NaF} \cdot \text{PbF}_4$ in $\text{H}_2\text{O}$ , $\text{H}_2\text{F}_2$	II 1299
+ $\text{PbSO}_4 \rightleftharpoons \text{Na}_2\text{SO}_4 + \text{PbF}_2$	II 1040
+ $\text{PbTiO}_3 \rightleftharpoons \text{Na}_2\text{TiO}_3 + \text{PbF}_2$	II 1040
$\text{NaF} + \text{PrF}_3$	II 1040
+ $\text{RbBr}$	II 1040
+ $\text{RbCl}$	II 1040
+ $\text{RbI}$	II 1040
in $\text{SO}_2$ (liq.)	II 1039
$2\text{NaF} + \text{SrCl}_2 \rightleftharpoons 2\text{NaCl} + \text{SrF}_2$	II 1012
$\text{NaF} + \text{SrF}_2$	II 1040
+ $\text{ThF}_4$	II 1040
+ $\text{UF}_4$	II 1040
+ $\text{UF}_4 + \text{ZrF}_4$	II 1040
+ $\text{WO}_3$	II 1040
+ $\text{YF}_3$	II 1040
+ $\text{ZnF}_2$	II 1040
+ $\text{ZrF}_4$	II 1040
+ $\text{ZrF}_4 + \text{UF}_4$	II 1040
$5\text{NaF} \cdot \text{ZrF}_4$ in $\text{H}_2\text{O}$	II 1180
$\text{Na}_4\text{Fe}(\text{CN})_6 \cdot 3\text{Co}_2\text{Fe}(\text{CN})_6$	I 796
+ $\text{Co}_2\text{Fe}(\text{CN})_6 + \text{H}_2\text{O}$	I 534, 5
in aq. ethyl alc.	II 912
in $\text{H}_2\text{O}$	II 911
+ $\text{InCl}_3 + \text{H}_2\text{O}$	I 1296
+ $\text{K}_4\text{Fe}(\text{CN})_6 + \text{H}_2\text{O}$	II 73
in aq. $\text{NH}_3$	II 911
and $\text{Na}_2\text{SO}_4$ in $\text{H}_2\text{O}$	II 912
$\text{NaFeO}_2 + \text{NaAlO}_2$	II 807
$\text{Na}_2\text{Fe}(\text{SO}_4)_2$	I 1057
$\text{Na}$ fluviolate in $\text{H}_2\text{O}$	II 893
$\text{Na}$ formate + acetic acid	II 853
+ formic acid	II 854
+ formic acid + $\text{H}_2\text{O}$	II 852
+ $\text{H}_2\text{O}$	II 851
+ $\text{KSCN} \rightleftharpoons \text{K}$ formate + $\text{NaSCN}$	II 80

$\text{Na}$ formate + $\text{LiNC}_3 \rightleftharpoons \text{NaNO}_3 + \text{Li}$ formate	II 853
in methyl alc.	II 852
+ $\text{Na}$ acetate	II 853
+ $\text{Na}$ benzoate	II 853
+ $\text{Na}$ iso-butyrate	II 853
+ $\text{NaNO}_3$	II 1083
+ $\text{NaOH}$	II 1085
+ $\text{Na}$ pentanoate	II 853
+ $\text{phenol} + \text{H}_2\text{O}$	II 852
+ $\text{Na}$ propionate	II 853
+ $\text{Na}$ iso-propionate	II 853
+ $\text{NaSCN}$	II 914
+ $\text{Na}$ stearate	II 853
+ $\text{Na}$ thiocyanate	II 853
$\text{Na}$ fumarate in $\text{H}_2\text{O}$	II 865
$\text{NaCd}$ EOTA in $\text{H}_2\text{O}$	I 1069
$\text{Na}_2\text{GeF}_6$ in $\text{H}_2\text{O}$	I 1073
$\text{Na}_2\text{GeO}_3$ in $\text{H}_2\text{O}$	II 1041
$\text{Na}$ gluconate in $\text{H}_2\text{O}$	II 870
$\text{Na}$ glutamate	II 869
in $\text{H}_2\text{O}$	II 869
$\text{Na}$ gunnysite in aq. $\text{Na}$ acetate	II 888
in aq. $\text{NaCl}$	II 888
$\text{NaN}$ in $\text{Na}$	II 1042
$\text{Na}_2\text{AsO}_4 + \text{H}_3\text{BO}_3 + \text{H}_2\text{O}$	I 275
$\text{Na}_2\text{HASO}_4$ in ethyl alc.	II 813
in $\text{HCl}$ + cations	II 813
in $\text{H}_2\text{O}$	II 812, 13
in $\text{NaOH}$ + cations	II 813
$\text{NaHCO}_3 + \text{Ca}(\text{HCO}_3)_2 + \text{CaCO}_3 + \text{CO}_2$	I 539
+ $\text{CuCO}_3$ in $\text{H}_2\text{O}$	I 923
in $\text{H}_2\text{O}$	II 945, 7
in $\text{H}_2\text{O} + \text{CO}_2$	II 947
$2\text{NaHCO}_3 + \text{K}_2\text{CO}_3 \rightleftharpoons 2\text{KHCO}_3 + \text{Na}_2\text{CO}_3$ in $\text{H}_2\text{O}$	II 93
$\text{NaHCO}_3 + \text{KHCO}_3 + \text{H}_2\text{O}$	II 93, 103, 4
$2\text{NaHCO}_3 + \text{MgSO}_4 \rightleftharpoons \text{Mg}(\text{HCO}_3)_2 + \text{Na}_2\text{SO}_4 (+ \text{H}_2\text{O})$	II 533
+ $(\text{NH}_4)_2\text{SO}_4 \rightleftharpoons 2\text{NH}_4\text{HCO}_3 + \text{Na}_2\text{SO}_4$	II 645, 6
$\text{NaHCO}_3 + \text{Na}_2\text{B}_4\text{O}_7 + \text{H}_2\text{O}$	II 823
+ $\text{Na}_2\text{B}_4\text{O}_7 + \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$	II 823
+ $\text{Na}_2\text{B}_4\text{O}_7 + \text{NaCl} + \text{H}_2\text{O}$	II 824
+ $\text{NaBr} + \text{H}_2\text{O}$	II 835
+ $\text{NaBrO}_3 + \text{NaBr} + \text{H}_2\text{O}$	II 834
+ $\text{NaBrO}_3 + \text{H}_2\text{O}$	II 848
in aq. $\text{NH}_4\text{HCO}_3 + \text{CO}_2$	II 951
+ $\text{NH}_4\text{HCO}_3 + \text{H}_2\text{O}$	II 646, 7
+ $\text{NH}_4\text{Cl} \rightleftharpoons \text{NaCl} + \text{NH}_4\text{HCO}_3$	II 642, 3, 4
+ $\text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$	II 925, 6, 7
+ $\text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$	II 93
+ $\text{Na}_2\text{CO}_3 + \text{Na}_2\text{SO}_4 + \text{NaCl} + \text{H}_2\text{O}$	II 935
+ $\text{Na}_2\text{CO}_3 + \text{NaCl} + \text{H}_2\text{O}$	II 927, 8, 9, 30
in aq. $\text{NaCl} + \text{CO}_2$	II 949
+ $\text{NaCl} + \text{H}_2\text{O}$	II 644, 947, 8
+ $\text{NaCl} + \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$	II 949
+ $\text{NaNO}_2 + \text{H}_2\text{O}$	II 1067
+ $\text{Na}_2\text{SO}_4 + (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$	II 950
+ $\text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$	II 949, 50
in organic solvents	II 961
$\text{NaN}_2\text{O}_4$ in aq. $\text{HCl}$	II 954
in $\text{H}_2\text{O}$	II 954
$\text{NaNF}$ in ethylene glycol	II 1031
$\text{NaN}_2\text{PO}_2$ in glycols	II 1110
in $\text{H}_2\text{O}$	II 1110
$\text{NaN}_2\text{PO}_3$ in $\text{H}_2\text{O}$	II 1111
$\text{NaN}_2\text{NPO}_3$ in $\text{H}_2\text{O}$	II 1111
$\text{NaN}_2\text{PO}_4$ in $\text{H}_2\text{O}$	II 1104, 5
+ $\text{H}_3\text{PO}_4$	II 1105
+ $\text{H}_3\text{PO}_4$ in $\text{H}_2\text{O}$	II 1106
+ $\text{H}_3\text{PO}_4$ in $\text{H}_3\text{PO}_4$	II 1106
+ $\text{NH}_4\text{H}_2\text{PO}_4 + \text{H}_2\text{O}$	II 739, 40, 1
+ $\text{NH}_4\text{NO}_3 \rightleftharpoons \text{NaNO}_3 + \text{NH}_4\text{H}_2\text{PO}_4 (+ \text{H}_2\text{O})$	II 741, 2, 3
in aq. $\text{Na}_2\text{SO}_4$	II 1105
$\text{NaN}_2\text{NPO}_4$ in alc.	II 1104
$\text{NaN}_2\text{PO}_4 + \text{Ca}$ gluconate + $\text{H}_2\text{O}$	I 522
+ $\text{H}_3\text{BO}_3 + \text{H}_2\text{O}$	I 276
$\text{NaN}_2\text{NPO}_4$ in $\text{H}_2\text{O}$	II 1102, 3
in aq. $\text{H}_2\text{O}_2$	II 1103
+ $\text{K}_2\text{HPO}_4 + \text{H}_2\text{O}$	II 286
+ $2\text{NH}_4\text{Cl} \rightleftharpoons (\text{NH}_4)_2\text{HPO}_4 + 2\text{NaCl} (+ \text{H}_2\text{O})$	II 663
+ $\text{Na}_2\text{B}_4\text{O}_7 + \text{Na}_2\text{B}_4\text{O}_7 + \text{Na}_3\text{PO}_4 + \text{H}_2\text{O}$	II 819
+ $\text{Na}_2\text{B}_4\text{O}_7 + \text{NaCl} + \text{H}_2\text{O}$	II 825
+ $\text{NaCl} + \text{H}_2\text{O}$	II 980
+ $\text{NaNO}_3 + \text{H}_2\text{O}$	II 1077



- + NaOH + H<sub>2</sub>O ..... II 1105  
 in Na<sub>3</sub>PO<sub>4</sub> + NaCl + Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub> + Na<sub>2</sub>B<sub>2</sub>O<sub>4</sub> + H<sub>2</sub>O ..... II 819  
 in aq. urethan ..... II 1104  
 + Na<sub>2</sub>H<sub>2</sub>P<sub>2</sub>O<sub>7</sub> + Na<sub>4</sub>P<sub>2</sub>O<sub>7</sub> + H<sub>2</sub>O ..... II 1107  
 in H<sub>2</sub>O ..... II 1108  
 Na<sub>3</sub>HP<sub>2</sub>O<sub>7</sub> in H<sub>2</sub>O ..... II 1108  
 2NaHS + BaCl<sub>2</sub>  $\rightleftharpoons$  Ba(HS)<sub>2</sub> + 2NaCl ..... I 387  
 NaHS + Ba(SH)<sub>2</sub> in H<sub>2</sub>O ..... I 387  
 + NaCl + H<sub>2</sub>O ..... II 980  
 NaHSO<sub>2</sub>·CH<sub>2</sub>O·2H<sub>2</sub>O in glycerol ..... II 854  
 in methyl alc. .... II 854  
 in H<sub>2</sub>O ..... II 1117  
 + NaHSO<sub>2</sub>·CH<sub>2</sub>O·H<sub>2</sub>O + H<sub>2</sub>O ..... II 1117  
 + NaHSO<sub>2</sub>·CH<sub>2</sub>O·2H<sub>2</sub>O + H<sub>2</sub>O ..... II 1117  
 NaHSO<sub>3</sub> + NH<sub>4</sub>Cl  $\rightleftharpoons$  NaCl + NH<sub>4</sub>HSO<sub>3</sub> (+ H<sub>2</sub>O) ..... II 754  
 NaHSO<sub>4</sub> in alc. .... II 1145  
 in formic acid ..... II 1145  
 2NaHSO<sub>4</sub> + K<sub>2</sub>SO<sub>4</sub>  $\rightleftharpoons$  Na<sub>2</sub>SO<sub>4</sub> + 2KHCO<sub>3</sub> ..... II 104  
 NaHSO<sub>4</sub> + Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> + H<sub>2</sub>O ..... II 1028  
 + Na<sub>2</sub>S<sub>2</sub>O<sub>7</sub> ..... II 1129  
 Na<sub>2</sub>H<sub>2</sub>Si<sub>2</sub>O<sub>7</sub> in H<sub>2</sub>O ..... II 1159  
 Na<sub>2</sub>(Si<sub>2</sub>O<sub>5</sub>)<sub>2</sub> ..... II 1162  
 in H<sub>2</sub>O ..... II 1162  
 NaHSO<sub>3</sub>·3H<sub>2</sub>O ..... II 1162  
 NaHgl ..... II 1046  
 Na hydrogen diglycolate in H<sub>2</sub>O ..... II 863  
 Na hydrogen succinate in H<sub>2</sub>O ..... II 867  
 Na hydrogen succinate in methyl alc. .... II 867  
 Na hydrophosphates in H<sub>2</sub>O ..... II 1110  
 Na hydroxy benzoate in H<sub>2</sub>O ..... II 880, 1  
 Na p-hydroxy benzoate in H<sub>2</sub>O ..... II 882  
 Na hydroxy and pyro tartrates in H<sub>2</sub>O ..... II 865  
 NaI in acetamide ..... II 1053  
 in acetonitrile ..... II 1054  
 in acetone ..... II 1052  
 in acetone + CO<sub>2</sub> ..... II 1052  
 + acetone + H<sub>2</sub>O ..... II 1049  
 in mix. alcs. .... II 1051  
 + AgI ..... I 100  
 + AgNO<sub>3</sub>  $\rightleftharpoons$  NaNO<sub>3</sub> + AgI ..... I 100  
 + AlBr<sub>3</sub> ..... I 162  
 + BiI<sub>3</sub> + H<sub>2</sub>O ..... I 1432  
 effect on butyl alc. + H<sub>2</sub>O ..... II 1048  
 + CdI<sub>2</sub> ..... I 741  
 2NaI·CdI<sub>2</sub>·6H<sub>2</sub>O in H<sub>2</sub>O, alc., ether ..... I 736  
 NaI + CsF ..... I 889  
 + Hgl<sub>2</sub> ..... I 1243  
 ·Hg(CN)<sub>2</sub>·2H<sub>2</sub>O in H<sub>2</sub>O, alc. .... I 1197  
 in higher alcs. .... I 1051  
 2NaI + CdCl<sub>2</sub>  $\rightleftharpoons$  2NaCl + CdI<sub>2</sub> ..... II 1012  
 NaI + CdI<sub>2</sub> + PbI<sub>2</sub> ..... II 1055  
 + CsF ..... II 1055  
 in D<sub>2</sub>O ..... II 1043  
 distr. betwn. ethylene glycol and ethyl acetate ..... II 1054  
 in ethyl alc. .... II 1049, 50  
 in aq. ethyl alc. .... II 1048  
 in ethyl alc. + LiClO<sub>4</sub> ..... II 1050  
 in ethyl alc. + Lil, NaSCN ..... II 1050  
 in ethylene diamine ..... II 1054  
 in ethylene glycol ..... II 1054  
 in formic acid ..... II 1054  
 in furfural ..... II 1054  
 in H<sub>2</sub>O ..... II 1040, 3  
 in hydrazine ..... II 1055  
 + I + H<sub>2</sub>O ..... II 1047, 8  
 + K  $\rightleftharpoons$  Na + KI ..... II 2  
 + KBr  $\rightleftharpoons$  KI + NaBr ..... II 31  
 2NaI + K<sub>2</sub>CO<sub>3</sub>  $\rightleftharpoons$  2KI + Na<sub>2</sub>CO<sub>3</sub> ..... II 101  
 NaI + KCl ..... II 169  
 + KF ..... II 212, 1055  
 + KI ..... II 234  
 + KI + allyl alc. .... II 232  
 + KI + benzyl alc. .... II 232  
 + KI + ethanol ..... II 232  
 + KI + furfural ..... II 233  
 + KI + methanol ..... II 231  
 + KF  $\rightleftharpoons$  NaF + KI ..... II 234  
 2NaI + K<sub>2</sub>SO<sub>4</sub>  $\rightleftharpoons$  Na<sub>2</sub>SO<sub>4</sub> + 2KI ..... II 234  
 NaI effect on methanol and cyclohexane ..... II 1054  
 in methyl alc. .... II 1049  
 in methyl ethyl ketone ..... II 1053  
 + MgI<sub>2</sub> ..... II 505  
 in monoethanol amine ..... II 1054  
 in NH<sub>3</sub> (liq) ..... II 1054  
 + Na ..... II 805  
 + Na + NH<sub>3</sub> ..... II 805  
 + NaBr ..... II 847  
 + NaBr + H<sub>2</sub>O ..... II 838, 9  
 + NaBr + H<sub>2</sub>O distr. .... II 839  
 + NaBr + NaOH ..... II 1095  
 + NaBrO<sub>3</sub> + H<sub>2</sub>O ..... II 849  
 + Na<sub>2</sub>CO<sub>3</sub> ..... II 946  
 + Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 936  
 + Na<sub>2</sub>CO<sub>3</sub> in aq. ethyl alc. .... II 1048  
 + NaCl ..... II 1011  
 + NaCl + H<sub>2</sub>O ..... II 974  
 + NaClO<sub>3</sub> + H<sub>2</sub>O ..... II 1016  
 + NaF ..... II 1040  
 + NaIO<sub>3</sub> + H<sub>2</sub>O ..... II 1044  
 + NaNO<sub>3</sub> + H<sub>2</sub>O ..... II 1044  
 + NaOH ..... II 1055, 95  
 in NaOH soln. .... II 1043, 4  
 + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 1045  
 + NaSCN + allyl alc. .... II 914  
 in nitromethane ..... II 1054  
 2NaI + PbCl<sub>2</sub>  $\rightleftharpoons$  2NaCl + PbI<sub>2</sub> ..... II 1012  
 NaI + PbI<sub>2</sub> + H<sub>2</sub>O ..... II 1046  
 in propionitrile ..... II 1054  
 + RbF ..... II 1055  
 in SO<sub>2</sub> (liq) ..... II 1055  
 + SO<sub>2</sub> vapor pressure-temp. .... II 1055  
 + SbI<sub>3</sub> + H<sub>2</sub>O ..... II 1047, 1438  
 NaIO<sub>3</sub> + AgI<sub>2</sub>O<sub>3</sub> + H<sub>2</sub>O ..... I 104  
 + HI<sub>2</sub>O<sub>3</sub> + H<sub>2</sub>O ..... II 1056  
 in H<sub>2</sub>O ..... II 1055  
 + Mg(IO<sub>3</sub>)<sub>2</sub> + H<sub>2</sub>O ..... II 507  
 + NaBr + H<sub>2</sub>O ..... II 839, 40  
 + Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 936  
 + NaCl + H<sub>2</sub>O ..... II 975, 1016  
 + Na<sub>2</sub>MoO<sub>4</sub> + H<sub>2</sub>O ..... II 1062  
 + NaI + H<sub>2</sub>O ..... II 1044  
 + NaNO<sub>3</sub> + H<sub>2</sub>O ..... II 1056, 7  
 + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 1057  
 NaIO<sub>4</sub> in H<sub>2</sub>O ..... II 1058  
 in aq. HIO<sub>4</sub> ..... II 1058  
 + NaOH + H<sub>2</sub>O ..... II 1058  
 Na<sub>3</sub>IF<sub>6</sub> in H<sub>2</sub>O ..... I 1296  
 NaHS<sub>2</sub> hydrates in aq. soln. .... I 1300  
 Na iodosalicylates in H<sub>2</sub>O ..... II 882  
 Na<sub>2</sub>Cl<sub>6</sub> in H<sub>2</sub>O ..... I 1304  
 Na<sub>2</sub> tartrate in acetone ..... II 864  
 + t-butyl alc. + H<sub>2</sub>O ..... II 864  
 NaKCO<sub>3</sub> + butyl alc. + H<sub>2</sub>O ..... II 943  
 Na lactate ..... II 861  
 Na laurate in ethyl alc. .... II 895  
 in ethylene glycol + butyl alc. .... II 895  
 in glycols ..... II 895  
 + H<sub>2</sub>O ..... II 894  
 + NaCl + H<sub>2</sub>O ..... II 894  
 + Na palmitate + NaCl + H<sub>2</sub>O ..... II 894  
 Na maleate in H<sub>2</sub>O ..... II 865  
 Na acid maleate in H<sub>2</sub>O ..... II 865  
 Na malonate ..... II 861  
 Na mandelate + Mandelic acid + H<sub>2</sub>O ..... II 884  
 Na metasilicate + Na palmitate + H<sub>2</sub>O ..... II 889  
 Na methyl adipate in H<sub>2</sub>O ..... II 866  
 Na methyl picrate in H<sub>2</sub>O ..... II 875  
 NaMnO<sub>4</sub> + H<sub>2</sub>O ..... II 1059  
 Na<sub>2</sub>MoO<sub>4</sub> + Ag<sub>2</sub>MoO<sub>4</sub> ..... I 108  
 + Ag<sub>2</sub>MoO<sub>4</sub> + H<sub>2</sub>O ..... I 108  
 + Ag<sub>2</sub>SO<sub>4</sub>  $\rightleftharpoons$  Ag<sub>2</sub>MoO<sub>4</sub> + Na<sub>2</sub>SO<sub>4</sub> ..... I 108  
 + BaSiO<sub>3</sub> (+ other salts) ..... I 400  
 + BiTiO<sub>3</sub> ..... I 439  
 in H<sub>2</sub>O ..... II 1060  
 + 2KCl  $\rightleftharpoons$  K<sub>2</sub>MoO<sub>4</sub> + 2NaCl ..... II 169  
 + 2KCl  $\rightleftharpoons$  K<sub>2</sub>MoO<sub>4</sub> + 2NaCl ..... II 246  
 + 2KF  $\rightleftharpoons$  K<sub>2</sub>MoO<sub>4</sub> + 2NaF ..... II 211  
 2Na<sub>2</sub>MoO<sub>4</sub> + K<sub>4</sub>P<sub>2</sub>O<sub>7</sub>  $\rightleftharpoons$  Na<sub>4</sub>P<sub>2</sub>O<sub>7</sub> + 2K<sub>2</sub>MoO<sub>4</sub> ..... II 246  
 Na<sub>2</sub>MoO<sub>4</sub> + K<sub>2</sub>WO<sub>4</sub>  $\rightleftharpoons$  Na<sub>2</sub>WO<sub>4</sub> + K<sub>2</sub>MoO<sub>4</sub> ..... II 246  
 + La<sub>2</sub>(MoO<sub>4</sub>)<sub>3</sub> + H<sub>2</sub>O ..... II 353  
 + Li<sub>2</sub>MoO<sub>4</sub> ..... II 419  
 + MgMoO<sub>4</sub> + H<sub>2</sub>O ..... II 509  
 + MgSO<sub>4</sub>  $\rightleftharpoons$  Na<sub>2</sub>SO<sub>4</sub> + MgMoO<sub>4</sub> ..... II 510  
 in MoO<sub>3</sub> ..... II 1061

- $+ \text{MoO}_3$  ..... II 574, 1065  
 $+ \text{NaBrC}_3 + \text{H}_2\text{O}$  ..... II 1062  
 $+ \text{Na}_2\text{CO}_3 + \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 936  
 $+ \text{NaCl} + \text{H}_2\text{O}$  ..... II 975  
 $+ \text{NaClO}_3 + \text{H}_2\text{O}$  ..... II 1062  
 $+ \text{NaCrO}_4 + \text{H}_2\text{O}$  ..... II 1024, 5  
 $+ \text{NaF}$  ..... II 1040  
 $+ \text{NaIO}_3 + \text{H}_2\text{C}$  ..... II 1062  
 $+ \text{NaNO}_3 + \text{H}_2\text{C}$  ..... II 1063  
 $+ \text{NaOH}$  ..... II 1095  
 $+ \text{Na}_4\text{P}_2\text{O}_7$  ..... II 1065  
 $+ \text{Na}_2\text{SO}_4$  ..... II 1065  
 $+ \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1063  
 $+ \text{Na}_2\text{TiO}_3$  ..... II 1171  
 $+ \text{Na}_2\text{WO}_4$  ..... II 1065  
 $+ \text{PbMoO}_4$  ..... II 1065  
 $+ \text{PbSO}_4 = \text{Na}_2\text{SC}_4 + \text{PbMoC}_4$  ..... II 1149, 1065  
 $+ \text{PbTiO}_3$  ..... II 1337  
 $+ \text{PbTiC}_3 = \text{Na}_3\text{TiO}_3 + \text{PbMoC}_4$  ..... II 1065  
**Na oxytate** in ethylene glycol + butyl alc. .... II 896  
 in glycols ..... II 896  
 $+ \text{H}_2\text{O}$  ..... II 895  
**NaNO<sub>3</sub>** in acetone ..... II 1065  
 in alc. .... II 1065  
 in benzene ..... II 1065  
 in  $\text{CCl}_4$  ..... II 1065  
 in chloroform ..... II 1065  
 in cyclohexane ..... II 1065  
 in ethyl acetate ..... II 1065  
 in  $\text{H}_2\text{O}$  ..... II 1065  
 in methanol ..... II 1065  
 in trichloroethylene ..... II 1065  
**Na naphthalene sulfonates** in aq. HCl ..... II 892  
 in  $\text{H}_2\text{O}$  ..... II 892  
 in methanol ..... II 892  
 in aq. NaCl and  $\text{Na}_2\text{SC}_4$  ..... II 892  
**Na naphthyl amine sulfonates** in  $\text{H}_2\text{O}$  ..... II 892  
**NaNH<sub>2</sub>** +  $\text{KNH}_2$  ..... II 247  
 in  $\text{NH}_3$  (liq.) ..... II 1066  
 $+ \text{AgNO}_2 + \text{H}_2\text{O}$  ..... II 1068  
 $+ \text{AgNO}_2 + \text{H}_2\text{O}$  ..... II 1069  
 $+ \text{Ca(NO}_2)_2$  ..... II 1069  
**2NaNO<sub>3</sub>** +  $\text{Ca(NO}_3)_2 = 2\text{NaNO}_3 + \text{Ca(NO}_2)_2$  ..... II 1069  
**NaNO<sub>2</sub>** in  $\text{H}_2\text{O}$  ..... II 1066  
 + acetic acid ..... II 1082  
 + K acetate = Na acetate +  $\text{KNO}_2$  ..... II 250  
 $+ \text{KNO}_2$  ..... II 250  
 $+ \text{KNO}_3 = \text{KNO}_2 + \text{NaNO}_3$  ..... II 250, 274  
 $+ \text{KOH}$  ..... II 1069  
 $+ \text{KNO}_2 + \text{H}_2\text{O}$  ..... II 249  
 $+ \text{NH}_4\text{Cl} + \text{NH}_4\text{NO}_3$  ..... II 682  
 $+ \text{NaBr}$  ..... II 847  
 $+ \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 1066, 7  
 $+ \text{NaCl}$  ..... II 1011  
 $+ \text{NaCl} + \text{H}_2\text{O}$  ..... II 975, 6  
 $+ \text{NaHCO}_3 + \text{H}_2\text{O}$  ..... II 1067  
 $+ \text{NaNO}_3$  ..... II 1069  
 $+ \text{NaNO}_3 + \text{H}_2\text{O}$  ..... II 976  
 $+ \text{NaNO}_3 + \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 1068  
 $+ \text{NaOH}$  ..... II 1069  
 $+ \text{Pb(NO}_3)_2 + \text{H}_2\text{O}$  ..... II 1068  
 $+ \text{TiNO}_3 + \text{H}_2\text{O}$  ..... II 1068  
 in aq. acetone ..... II 1081  
 in various solvents ..... II 1068  
**NaNO<sub>3</sub>** +  $\text{AgBr} = \text{AgNO}_3 + \text{NaBr}$  ..... II 847  
 $+ \text{AgI} = \text{AgNO}_3 + \text{NaI}$  ..... II 100  
 $+ \text{AgNO}_3$  ..... II 123  
 $+ \text{AgNO}_3 + \text{BaNO}_3$  ..... II 123  
 $+ \text{AgNO}_3$  in aq.  $\text{C}_2\text{H}_5\text{OH}$  ..... II 117  
 $+ \text{AgNO}_3 + \text{KNO}_3 + \text{TiNO}_3$  ..... II 123  
 $+ \text{AgNO}_3 + \text{NH}_4\text{NO}_3$  ..... II 123  
 $+ \text{AgNO}_3 + \text{TiNO}_3$  ..... II 123  
 $+ \text{allyl alc.} + \text{H}_2\text{O}$  ..... II 1080  
 $+ \text{Al(NO}_3)_3 + \text{H}_2\text{O}$  ..... II 191  
 $+ \text{Al(NO}_3)_3 + \text{HNO}_3 + \text{H}_2\text{O}$  ..... II 1077  
 $+ \text{Al(NO}_3)_3 + \text{HNO}_3 + \text{H}_2\text{O}$  ..... II 192  
 $+ \text{Al(NO}_3)_3 + \text{KNO}_3 + \text{H}_2\text{O}$  ..... II 192  
 $+ \text{Al(NO}_3)_3 + \text{KNO}_3 + \text{H}_2\text{O}$  ..... II 264  
**Na alkyl sulfates** ..... II 1149  
**2NaNO<sub>3</sub>** +  $\text{BaCl}_2 = \text{Ba(NO}_3)_2 + 2\text{NaCl} (+ \text{H}_2\text{O})$  ..... II 979  
 $+ \text{BaCl}_2 = \text{Ba(NO}_3)_2 + 2\text{NaCl}$  in  $\text{H}_2\text{O}$  ..... II 1342  
**NaNO<sub>3</sub>** +  $\text{Ba(NO}_3)_2$  ..... II 377  
 $+ \text{Ba(NO}_3)_2 + \text{H}_2\text{O}$  ..... II 1373  
 $+ \text{Ba(NO}_3)_2 + \text{KNO}_3$  ..... II 1377  
 $+ \text{Ba(NO}_3)_2 + \text{NH}_4\text{NO}_3$  ..... II 1377  
 $+ \text{Ba(NO}_3)_2 + \text{NH}_4\text{NO}_3$  ..... II 728  
 $+ \text{butyl alc.} + \text{H}_2\text{O}$  ..... II 1080  
 effect on (butyl alc. +  $\text{H}_2\text{O}$ ) ..... II 1080  
 effect on ( $\text{CH}_3\text{OH} + \text{cyclohexane}$ ) ..... II 1081  
 $+ \text{Ca(NO}_3)_2$  ..... II 1083  
 $+ \text{Ca(NO}_3)_2$  ..... II 629  
 $+ \text{Ca(NO}_3)_2 + \text{CaS}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 1688  
 $+ \text{Ca(NO}_3)_2 + \text{H}_2\text{O}$  ..... II 621, 2  
 $+ \text{Ca(NO}_3)_2 + \text{KNO}_3$  ..... II 629  
 $+ \text{Ca(NO}_3)_2 + \text{KNO}_3 + \text{H}_2\text{O}$  ..... II 624  
 $+ \text{Ca(NO}_3)_2 + \text{Mg(NO}_3)_2$  ..... II 629  
**2NaNO<sub>3</sub>** +  $\text{Ca(NO}_2)_2 = 2\text{NaNO}_2 + \text{Ca(NO}_3)_2$  ..... II 1069  
 $+ \text{Ca(NO}_3)_2 + \text{Pb(NO}_3)_2$  ..... II 629  
 $+ \text{Ca(NO}_3)_2 + \text{Sr(NO}_3)_2$  ..... II 629  
 $+ \text{CaS}_2\text{O}_3 = \text{Ca(NO}_3)_2 + \text{Na}_2\text{S}_2\text{O}_3$  (aq.) ..... II 624  
**NaNO<sub>3</sub>** +  $\text{CaS}_2\text{O}_3 + \text{Na}_2\text{S}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 688  
 $+ \text{Ca(NO}_3)_2$  ..... II 744  
 $+ \text{Ca(NO}_3)_2 + \text{LiNO}_3$  ..... II 744  
 $+ \text{Cu(NO}_3)_2 + \text{H}_2\text{O}$  ..... II 957  
**2NaNO<sub>3</sub>** +  $\text{CuSO}_4 = \text{Cu(NO}_3)_2 + \text{Na}_2\text{SO}_4 (+ \text{H}_2\text{O})$  ..... II 992  
**NaNO<sub>3</sub>** + dioxane +  $\text{H}_2\text{O}$  ..... II 1080  
 distr. betw. methyl isobutyl ketone and  $\text{HNO}_3 +$   
 $\text{Ca(NO}_3)_2$  ..... II 1081  
 in aq. ethyl alc. .... II 1079  
 solns. f.p. .... II 1070  
 $+ \text{guanidine nitrate}$  ..... II 1083  
 $+ \text{guanidine nitrate} + \text{NH}_4\text{NO}_3$  ..... II 728  
 in  $\text{H}_2\text{O}$  ..... II 318, 1069, 70  
 in  $\text{H}_2\text{O} + \text{H}_2\text{O}_2$  ..... II 1070, 1  
 in  $\text{HNO}_3$  ..... II 1071, 2  
 $+ \text{H}_2\text{O}_2$  ..... II 1148  
 in  $\text{H}_2\text{O}_2$  ..... II 1071  
 $+ \text{K acetate} = \text{Na acetate} + \text{KNO}_3$  ..... II 274  
 $+ \text{KBr} = \text{KNO}_3 + \text{NaBr}$  ..... II 31  
 $+ \text{KCl} = \text{KNO}_3 + \text{NaCl} (+ \text{H}_2\text{O})$  ..... II 131, 2  
 $+ \text{KClO}_4 + \text{H}_2\text{O}$  ..... II 184  
 $+ \text{KClO}_4 = \text{KNO}_3 + \text{NaClO}_4 (+ \text{H}_2\text{O})$  ..... II 183  
**2NaNO<sub>3</sub>** +  $\text{K}_2\text{CrO}_4 = 2\text{KNO}_3 + \text{Na}_2\text{CrO}_4$  ..... II 196  
**NaNO<sub>3</sub>** +  $\text{K}_2\text{CrO}_4 + \text{Na}_2\text{CrO}_4$  ..... II 1027  
**2NaNO<sub>3</sub>** +  $\text{K}_2\text{Cr}_2\text{O}_7 = \text{Na}_2\text{Cr}_2\text{O}_7 + 2\text{KNO}_3$  ..... II 202  
**NaNO<sub>3</sub>** +  $\text{KF} = \text{KNO}_3 + \text{NaF}$  ..... II 211  
 $+ \text{KNO}_3$  ..... II 274  
 $+ \text{KNO}_3$  in  $\text{H}_2\text{O}$  ..... II 1078  
 $+ \text{KNO}_3$  in aq.  $\text{HNO}_3$  ..... II 264  
 $+ \text{KNO}_3 + \text{H}_2\text{O}$  ..... II 261, 2, 3  
 $+ \text{KNO}_3 + \text{I}$  ..... II 262  
 $+ \text{KNO}_3$  in aq.  $\text{KOH}$ ,  $\text{NaOH}$  ..... II 264  
 $+ \text{KNO}_2 = \text{NaNO}_2 + \text{KNO}_3$  ..... II 250, 274  
 $+ \text{KNO}_3 + \text{NH}_4\text{NO}_3$  ..... II 728  
 $+ \text{KNO}_3 + \text{Sr(NO}_3)_2$  ..... II 1083  
 $+ \text{KOH}$  ..... II 1083  
**2NaNO<sub>3</sub>** +  $\text{K}_2\text{SO}_4 = \text{Na}_2\text{SO}_4 + 2\text{KNO}_3$  ..... II 274  
 $+ \text{K}_2\text{SO}_4 = \text{Na}_2\text{SO}_4 + 2\text{KNO}_3 (+ \text{H}_2\text{O})$  ..... II 264  
**NaNO<sub>3</sub>** +  $\text{LiHCOO} = \text{NaHCOO} + \text{LiNO}_3$  ..... II 854  
 $+ \text{LiC}_2\text{H}_3\text{O}_2 = \text{LiNO}_3 + \text{NaC}_2\text{H}_3\text{O}_2$  ..... II 373  
 $+ \text{LiC}_2\text{H}_3\text{COO} = \text{NaC}_2\text{H}_3\text{COO} + \text{LiNO}_3$  ..... II 860  
 $+ \text{LiC}_2\text{H}_7\text{COO} = \text{LiNO}_3 + \text{NaC}_2\text{H}_7\text{COO}$  ..... II 862  
 $+ \text{LiCl} = \text{LiNO}_3 + \text{NaCl}$  ..... II 406  
 $+ \text{LiNO}_3$  ..... II 427  
 $+ \text{LiOH} = \text{NaOH} + \text{LiNO}_3$  ..... II 427  
 in aq. methyl alc. .... II 1078  
**2NaNO<sub>3</sub>** +  $\text{Li}_2\text{SO}_4 = \text{Na}_2\text{SO}_4 + 2\text{LiNO}_3$  ..... II 427  
 $+ \text{MgCl}_2 = \text{Mg(NO}_3)_2 + 2\text{NaCl} (+ \text{H}_2\text{O})$  ..... II 483  
**NaNO<sub>3</sub>** +  $\text{MgCl}_2 + \text{NaCl} + \text{NaSO}_4 + \text{H}_2\text{O}$  ..... II 491  
 $+ \text{MgCl}_2 + \text{NaCl} + \text{Na}_2\text{SO}_4 + \text{Mg(NO}_3)_2 + \text{H}_2\text{O}$  ..... II 491  
 $+ \text{Mg(NO}_3)_2 + \text{H}_2\text{O}$  ..... II 614  
 $+ \text{Mg(NO}_3)_2 + \text{KNO}_3 + \text{Ca(NO}_3)_2$  ..... II 629  
 $+ \text{MgSO}_4 + \text{H}_2\text{O}$  ..... II 1075  
**2NaNO<sub>3</sub>** +  $\text{MgSO}_4 = \text{Mg(NO}_3)_2 + \text{Na}_2\text{SO}_4 (+ \text{H}_2\text{O})$  ..... II 533  
 $+ \text{MgSO}_4 = \text{Na}_2\text{SO}_4 + \text{Mg(NO}_3)_2 (+ \text{H}_2\text{O})$  ..... II 1077  
**NaNO<sub>3</sub>** +  $\text{Mg(NO}_3)_2$  ..... II 515  
 $+ \text{Mg(NO}_3)_2 + \text{KNO}_3$  ..... II 274  
 in  $\text{NH}_3$  (liq.) ..... II 1072, 3, 82  
 $+ \text{NH}_4\text{Cl} = \text{NH}_4\text{NO}_3 + \text{NaCl} (\text{H}_2\text{O}), (\text{NH}_3)$  ..... II 662  
 $+ \text{NH}_4\text{ClO}_4 = \text{NH}_4\text{NO}_3 + \text{NaClO}_4 (+ \text{H}_2\text{O})$  ..... II 686, 7  
 $+ \text{NH}_4\text{NO}_3$  ..... II 727  
 $+ \text{NH}_4\text{NO}_3$  ..... II 744  
 $+ \text{NH}_4\text{NO}_3 + \text{Cd(NO}_3)_2$  ..... II 786  
 $+ \text{N}_2\text{H}_4\text{HNO}_3$  ..... II 786  
 $+ \text{NH}_4\text{H}_2\text{PO}_4 = \text{NH}_4\text{NO}_3 + \text{NaH}_2\text{PO}_4 (+ \text{H}_2\text{O})$  ..... II 741, 2, 3

- +  $\text{NH}_4\text{NO}_3 + \text{CO}(\text{NH}_2)_2$  ..... II 1082  
 +  $\text{NH}_4\text{NO}_3 + \text{H}_2\text{O}$  ..... II 714, 5, 6  
 +  $\text{NH}_4\text{NO}_3 + \text{KNO}_3$  ..... II 274  
 +  $\text{NH}_4\text{NO}_3 + \text{LiNO}_3$  ..... II 427, 727  
 +  $\text{NH}_4\text{NO}_3 + \text{NH}_3$  liq. .... II 727  
 + Na acetate ..... II 1083  
 +  $\text{NaBr} + \text{H}_2\text{O}$  ..... II 840  
 +  $\text{NaBrO}_3 + \text{H}_2\text{O}$  ..... II 849  
 + Na butyrate ..... II 1083  
 + Na isobutyrate ..... II 1083  
 +  $\text{Na}_2(\text{COO})_2 + \text{H}_2\text{O}$  ..... II 955  
 +  $\text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 936  
 +  $\text{Na}_2\text{CO}_3 + \text{KNO}_3 + \text{K}_2\text{CO}_3$  ..... II 88  
 + Na caprate ..... II 1083  
 + NaCl ..... II 1011  
 + NaCl in aq. ethyl alc. .... II 1007  
 + NaCl +  $\text{H}_2\text{O}$  ..... II 976, 7, 8  
 + NaCl in  $\text{H}_2\text{O} + \text{NaOH}$  ..... II 978  
 + NaCl in  $\text{H}_2\text{O} + \text{HCl}$  ..... II 978  
 + NaCl +  $\text{NH}_3$  (liq) ..... II 1010  
 + NaCl +  $\text{NH}_4\text{Cl}$  ..... II 682  
 + NaCl +  $\text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 979  
 +  $\text{NaClO}_4 + \text{H}_2\text{O}$  ..... II 1020  
 +  $\text{Na}_2\text{CrO}_4 + \text{H}_2\text{O}$  ..... II 1023  
 + NaCl +  $\text{KClO}_4 + \text{H}_2\text{O}$  ..... II 184, 5  
 + NaCl +  $\text{KNO}_3 + \text{H}_2\text{O}$  ..... II 265  
 + NaCl +  $\text{NH}_4\text{NO}_3$  ..... II 727  
 + NaF ..... II 1040  
 + Na formate ..... II 1083  
 +  $\text{NaH}_2\text{PO}_4 + \text{H}_2\text{O}$  ..... II 1073, 4  
 +  $\text{Na}_2\text{HPO}_4 + \text{H}_2\text{O}$  ..... II 1077  
 + NaI +  $\text{H}_2\text{O}$  ..... II 1044  
 +  $\text{NaIO}_3 + \text{H}_2\text{O}$  ..... II 1056, 7  
 +  $\text{Na}_2\text{MoO}_4 + \text{H}_2\text{O}$  ..... II 1063  
 + Na neovalerate ..... II 1083  
 +  $\text{NaNO}_2$  ..... II 1069  
 +  $\text{NaNO}_2 + \text{H}_2\text{O}$  ..... II 1067  
 +  $\text{NaNO}_2 + \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 1068  
 +  $\text{NaNO}_2 + \text{NaCl} + \text{H}_2\text{O}$  ..... II 976  
 + NaOH ..... II 1083  
 + NaOH +  $\text{H}_2\text{O}$  ..... II 1072  
 + Na isopropionate ..... II 1083  
 + NaSCN ..... II 914, 1083  
 +  $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$  ..... II 1154  
 +  $\text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1075  
 +  $\text{Na}_2\text{SO}_4 + \text{NaCl} + \text{H}_2\text{O}$  ..... II 985  
 +  $\text{Na}_2\text{SO}_4 + \text{Na}_2\text{CrO}_4$  ..... II 1027  
 +  $\text{NaSO}_3\text{NH}_2$  ..... II 1158  
 +  $\text{Na}_2\text{S}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 1077  
 + Na stearate ..... II 907  
 +  $\text{Pb}(\text{NO}_3)_2$  ..... II 1083  
 +  $\text{Pb}(\text{NO}_3)_2 + \text{H}_2\text{O}$  ..... II 1078, 1310  
 +  $\text{Pb}(\text{NO}_3)_2 + \text{H}_2\text{O}$  vapor pressure ..... II 1078  
 +  $\text{Pb}(\text{NO}_3)_2 + \text{KNO}_3$  ..... II 276  
 +  $\text{Pb}(\text{NO}_3)_2 + \text{Sr}(\text{NO}_3)_2$  ..... II 1083  
 + iso propyl alc. +  $\text{H}_2\text{O}$  ..... II 1080  
 + pyridine +  $\text{H}_2\text{O}$  ..... II 1080  
 +  $\text{RbCl} \rightleftharpoons \text{NaCl} + \text{RbNO}_3$  ..... II 1012  
 +  $\text{RbNO}_3$  ..... II 1083  
 +  $\text{Sr}(\text{NO}_3)_2$  ..... II 1083  
 +  $\text{Sr}(\text{NO}_3)_2 + \text{KNO}_3$  ..... II 274  
 +  $\text{TiNO}_3$  ..... II 1083  
 +  $\text{TiNO}_3 + \text{KNO}_3$  ..... II 274  
 +  $\text{UO}_2(\text{NO}_3)_2 + \text{H}_2\text{O}$  ..... II 1078  
 + urea ..... II 1082  
 + urea +  $\text{H}_2\text{O}$  ..... II 1081  
 + urea +  $\text{NH}_4\text{NO}_3$  ..... II 728  
 + urea nitrate +  $\text{NH}_4\text{NO}_3$  ..... II 728  
 in various solvents ..... II 1081  
**Na neovalerate** +  $\text{NaNO}_3$  ..... II 1083  
 + NaSCN ..... II 914  
**Na nitril in  $\text{H}_2\text{O}$**  ..... II 870  
**Na nitrile diphenyl ethyl succinate** in  $\text{H}_2\text{O}$  ..... II 904  
**Na nitrophenolate** in aq. alc. .... II 871, 2  
**Na nitrophenolates** in non-electrolytes ..... II 871  
 in  $\text{H}_2\text{O}$  ..... II 871  
**NaNO<sub>3</sub>** in  $\text{H}_2\text{O}$  ..... II 1083  
 +  $\text{KNO}_3$  ..... II 275  
**Na<sub>2</sub>(SeO<sub>4</sub>)<sub>2</sub> · 2H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1164  
**Na<sub>2</sub>O** in  $\text{NH}_3$  (liq) ..... II 1084  
**Na<sub>2</sub>O** +  $\text{As}_2\text{O}_3 + \text{B}_2\text{O}_3$  ..... I 126  
 +  $\text{Al}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 805, 6  
 +  $\text{Al}_2\text{O}_3 + \text{Na}_3\text{AlF}_6$  ..... II 1040  
 +  $3\text{Al}_2\text{O}_3 + \text{Na}_2\text{O} + 4\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{FeO}$  ..... I 630  
 +  $\text{Al}_2\text{O}_3 + \text{SiO}_2 + \text{H}_2\text{O}$  ..... II 807  
 +  $\text{As}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 807, 8  
 +  $\text{As}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 808, 9, 10, 11, 12  
 +  $\text{B}_2\text{O}_3 + \text{CO}_2 + \text{H}_2\text{O}$  ..... II 824  
 +  $\text{B}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 814, 5, 6, 7  
 +  $\text{B}_2\text{O}_3 + \text{SiO}_2$  ..... II 1478  
 +  $\text{CaF}_2 + \text{SiO}_2$  ..... II 1083  
 +  $4\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{FeO} + \text{Na}_2\text{O} \cdot 3\text{Al}_2\text{O}_3$  ..... I 630  
 +  $\text{CaO} + \text{B}_2\text{O}_3$  ..... I 502  
 +  $\text{CaO} + \text{CO}_2 + \text{K}_2\text{O} + \text{TiO}_2 + \text{SiO}_2$  ..... I 556  
 +  $\text{CaO} + \text{SiO}_2$  ..... I 630  
 +  $\text{CaO} + \text{SiO}_2 + \text{CO}_2$  ..... II 1083  
 +  $\text{CaO} + \text{SO}_3 + \text{SiO}_2$  ..... II 1083  
 +  $\text{CaSO}_4 + \text{CaO} + \text{Al}_2\text{O}_3 + \text{H}_2\text{O}$  ..... I 497  
 +  $\text{CrO}_3 + \text{H}_2\text{O}$  ..... II 1022, 3  
 +  $\text{Fe}_2\text{O}_3 + \text{Na}_2\text{CO}_3$  ..... II 946  
 +  $\text{Ga}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 1041, 86  
 +  $\text{GeO}_2$  ..... I 1075  
 +  $\text{MgO} + \text{B}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 444  
 +  $\text{MoO}_3 + \text{H}_2\text{O}$  ..... II 1060, 1  
 + Na ..... II 1083  
 +  $\text{Na}_2\text{S}$  ..... II 1083, 1117  
 +  $\text{Na}_2\text{SO}_4$  ..... II 1083, 1149  
 + phenolphthalein anhydride +  $\text{H}_2\text{O}$  ..... II 907, 8  
 +  $\text{P}_2\text{O}_5 + \text{CaO} \cdot \text{P}_2\text{O}_5$  ..... I 656  
 +  $\text{P}_2\text{O}_5 + \text{H}_2\text{O}$  ..... II 1109, 10  
 +  $\text{P}_2\text{O}_5 + \text{H}_2\text{O}$  ..... II 1096, 7, 8, 9, 1100  
 +  $\text{P}_2\text{O}_5 + \text{SiO}_2$  ..... II 1083  
 +  $\text{SO}_3 + \text{V}_2\text{O}_5 + \text{H}_2\text{O}$  ..... II 1136, 1629  
 +  $\text{SiO}_2 + \text{BaO}$  ..... I 383  
 +  $2\text{SiO}_2 + \text{CaO} \cdot \text{SiO}_2$  ..... I 630  
 +  $\text{SiO}_2 + \text{H}_2\text{O}$  ..... II 1455  
 +  $\text{SiO}_2 + \text{H}_2\text{O}$  ..... II 1164, 5, 6, 7  
 +  $\text{TiO}_2$  ..... II 1083  
 +  $\text{UO}_3 + \text{CO}_2 + \text{H}_2\text{O}$  ..... II 1172  
 +  $\text{UO}_3 + \text{H}_2\text{O}$  ..... II 1171, 2  
 +  $\text{UO}_3$  ..... II 1171  
 +  $\text{V}_2\text{O}_5$  ..... II 1178  
 +  $\text{V}_2\text{O}_5 + \text{H}_2\text{O}$  ..... II 1174, 5, 6  
 +  $\text{V}_2\text{O}_5$  ..... II 1174  
**5Na<sub>2</sub>O · 12WO<sub>3</sub> · 28H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1179  
**Na<sub>2</sub>O** +  $\text{ZnO} + \text{H}_2\text{O}$  ..... II 1674  
 +  $\text{ZrO}_2 + \text{H}_2\text{O}$  ..... II 1179, 80  
**NaOCN** in alc. .... II 912  
 in benzene ..... II 912  
 in  $\text{NH}_3$  (liq) ..... II 912  
 in salt solns in  $\text{NH}_3$  (liq) ..... II 913  
**NaOCH<sub>3</sub>** in various liquids ..... II 853  
**NaOCl · NaCl · (Na<sub>3</sub>AsO<sub>4</sub> · 11H<sub>2</sub>O)<sub>6</sub>** in  $\text{H}_2\text{O}$  ..... II 813  
**NaOH** + acetone +  $\text{H}_2\text{O}$  ..... II 1088, 9  
 + amylamine +  $\text{H}_2\text{O}$  ..... II 1092  
 +  $\text{Be}(\text{OH})_2$  ..... I 383  
 +  $\text{Be}(\text{OH})_2 + \text{H}_2\text{O}$  ..... I 412  
 + butylamine +  $\text{H}_2\text{O}$  ..... II 1090, 1, 2  
 + iso butyl alc. +  $\text{H}_2\text{O}$  ..... II 1088  
 + citric acid +  $\text{H}_3\text{PO}_4 + \text{H}_2\text{O}$  ..... II 869  
 +  $(\text{C}_4\text{H}_7\text{O}_2)_2\text{O} + \text{H}_2\text{O}$  ..... II 862  
 + diethyl amine +  $\text{H}_2\text{O}$  ..... II 1089  
 in dioxane +  $\text{H}_2\text{O}$  ..... II 1089  
 + ethanol +  $\text{H}_2\text{O}$  ..... II 1087  
 in ethyl alc. .... II 1085  
 + ethylenediamine +  $\text{H}_2\text{O}$  ..... II 1089  
 +  $\text{HCOONa}$  ..... II 1095  
 +  $\text{H}_2\text{C}_2\text{O}_4 + \text{H}_2\text{O}$  ..... II 952, 3  
 in  $\text{H}_2\text{O}$  ..... II 1084  
 +  $\text{H}_2\text{O}_2 + \text{H}_2\text{O}$  ..... II 1085  
 + heptylamine +  $\text{H}_2\text{O}$  ..... II 1093  
 + hexylamine +  $\text{H}_2\text{O}$  ..... II 1093  
 + hydrazine +  $\text{H}_2\text{O}$  ..... II 1086  
 +  $\text{K} \rightleftharpoons \text{KOH} + \text{Na}$  ..... II 2  
 + KBr ..... II 1095  
 +  $\text{KBr} \rightleftharpoons \text{KOH} + \text{NaBr}$  ..... II 31  
 +  $\text{K}_2\text{CO}_3$  ..... II 1095  
**2NaOH** +  $\text{K}_2\text{CO}_3 \rightleftharpoons 2\text{KOH} + \text{Na}_2\text{CO}_3$  ..... II 101  
 +  $\text{K}_2\text{CrO}_4 \rightleftharpoons 2\text{KOH} + \text{Na}_2\text{CrO}_4$  ..... II 196  
**NaOH** +  $\text{KNO}_2$  ..... II 250  
 +  $\text{KNO}_3$  ..... II 274  
 + K Na tartrate +  $\text{H}_2\text{O}$  ..... II 49  
**2NaOH** +  $\text{K}_2\text{SO}_4 \rightleftharpoons \text{Na}_2\text{SO}_4 + 2\text{KOH}$  ..... II 280  
**NaOH** + lauric acid +  $\text{H}_2\text{O}$  ..... II 894

- $2\text{NaOH} + \text{Li}_2\text{CrO}_4 \rightleftharpoons 2\text{LiOH} + \text{Na}_2\text{CrO}_4$  ..... II 411  
 $\text{NaOH} + \text{LiNO}_3 \rightleftharpoons \text{NaNO}_3 + \text{LiOH}$  ..... II 427  
in  $\text{LiOH}$  ..... II 431  
in methanol ..... II 1095  
+ methanol +  $\text{H}_2\text{O}$  ..... II 1087  
+  $\text{MgCO}_3 + \text{Na}_2\text{CO}_3 + \text{NaCl} + \text{H}_2\text{O}$  ..... II 477  
in  $\text{NH}_3$  (liq) ..... II 1095  
+  $\text{NH}_3 + \text{H}_2\text{O}$  ..... II 1085  
+  $\text{NaBr}$  ..... II 833, 7, 1095  
+  $\text{NaBr} + \text{NaCl}$  ..... II 838  
+  $\text{NaBr} + \text{NaI}$  ..... II 1095  
+  $\text{Na}_2\text{C}_2\text{H}_3\text{O}_2 + \text{H}_2\text{O}$  ..... II 856  
+  $\text{NaCN} + \text{H}_2\text{O}$  ..... II 909, 10  
+  $\text{Na}_2\text{CO}_3$  ..... II 946, 1095  
+  $\text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 917, 8, 9, 20  
+  $\text{NaCl} + \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 920, 1, 2  
+  $\text{Na}_2\text{CO}_3 + \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 940  
+  $\text{NaCl}$  ..... II 1011  
+  $\text{NaCl} + \text{H}_2\text{O}$  ..... II 966, 7  
+  $\text{NaCl} + \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 985  
+  $\text{NaCl} + \text{Na}_2\text{SO}_4 + \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 985  
+  $\text{NaClO}_3 + \text{H}_2\text{C}$  ..... II 1015  
+  $\text{Na}_2\text{CrO}_4$  ..... II 1027, 95  
+  $\text{NaF}$  ..... II 1040  
+  $\text{Na}_2\text{HPO}_4 + \text{H}_2\text{O}$  ..... II 1104  
+  $\text{NaI}$  ..... II 1055, 1095  
+  $\text{NaIO}_4 + \text{H}_2\text{O}$  ..... II 1058  
+  $\text{Na}_2\text{MoO}_4$  ..... II 1095  
+  $\text{NaNO}_2$  ..... II 1069  
+  $\text{NaNO}_3$  ..... II 1063  
+  $\text{NaNO}_3 + \text{H}_2\text{O}$  ..... II 1072  
+  $\text{Na}_2\text{SO}_3 + \text{H}_2\text{O}$  ..... II 1119  
+  $\text{Na}_2\text{SO}_4$  ..... II 1095  
+  $\text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1130, 1, 2  
+  $\text{Na}_2\text{SO}_4 + \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 923  
+  $\text{Na}_2\text{SO}_4 + \text{NaCl} + \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 922, 3  
+  $\text{Na}_2\text{SO}_4 + \text{Na}_3\text{PO}_4 + \text{H}_2\text{O}$  ..... II 1102  
+  $\text{Na}_2\text{SeO}_4 + \text{H}_2\text{O}$  ..... II 1164  
+  $\text{Na tartarate} + \text{H}_2\text{O}$  ..... II 863, 4  
+  $\text{Pb}(\text{NO}_3)_2$  ..... II 1314  
+  $\text{PbO} + \text{H}_2\text{O}$  ..... II 1314  
+  $\text{PbO} + \text{Pb}(\text{OH})_2 + \text{plumbite} + \text{H}_2\text{O}$  ..... II 1316  
+  $\text{phenol} + \text{H}_2\text{O}$  ..... II 871  
+  $\text{propylamine} + \text{H}_2\text{O}$  ..... II 1090  
+  $\text{isopropyl alc.} + \text{H}_2\text{O}$  ..... II 1088  
+  $\text{pyridine} + \text{H}_2\text{O}$  ..... II 1094, 5  
+  $\text{RbOH}$  ..... II 1378  
+  $\text{resacinal} + \text{H}_2\text{O}$  ..... II 1095  
+  $\text{Sb}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 1159  
**Na(OH)BF<sub>3</sub>** in ethanol ..... II 814  
**Na eluate** + cresols +  $\text{H}_2\text{O}$  ..... II 901  
solns. i.p. .... II 902  
in aq. bile salts ..... II 902  
in  $\text{H}_2\text{O}$  ..... II 902  
+  $\text{NaCl} + \text{ethyl acetate} + \text{H}_2\text{O}$  ..... II 901  
+  $\text{phenol} + \text{H}_2\text{O}$  ..... II 901  
+  $\text{phenol} + \text{toluene} + \text{H}_2\text{O}$  ..... II 901  
in  $\text{pinene}$  ..... II 902  
in mixed solvents ..... II 902, 3  
**Na oxalate** +  $\text{Cu acalate} + \text{H}_2\text{O}$  ..... II 924  
**NaPO<sub>3</sub>** +  $\text{BiTiO}_3$  ..... II 1439  
+  $\text{H}_2\text{O}$  ..... II 1109  
+  $\text{KPO}_3$  ..... II 292  
**4NaPO<sub>3</sub>** +  $\text{K}_4\text{P}_2\text{O}_7 \rightleftharpoons \text{Na}_4\text{P}_2\text{O}_7 + 4\text{KPO}_3$  ..... II 292  
**NaPO<sub>3</sub>** +  $\text{NaBO}_2$  ..... II 828  
+  $\text{Na}_2\text{P}_2\text{O}_7$  ..... II 1107, 1109  
in steam ..... II 1109  
**Na<sub>3</sub>PO<sub>4</sub>** in  $\text{H}_2\text{O}$  ..... II 1100  
+  $\text{NaBO}_2 + \text{NaCl} + \text{H}_2\text{O}$  ..... II 819  
+  $\text{Na}_2\text{B}_2\text{O}_4 + \text{Na}_2\text{B}_4\text{O}_7 + \text{Na}_2\text{HPO}_4 + \text{NaCl} + \text{H}_2\text{O}$  ..... II 819  
+  $\text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 1101  
+  $\text{NaCl} + \text{H}_2\text{O}$  ..... II 979, 80  
+  $\text{NaF} + \text{H}_2\text{O}$  ..... II 1032  
+  $\text{NaF} \cdot 12\text{H}_2\text{O}$  ..... II 1032  
+  $\text{Na}_2\text{HPO}_4 + \text{Na}_2\text{B}_4\text{O}_7 + \text{Na}_2\text{B}_2\text{O}_4 + \text{H}_2\text{O}$  ..... II 819  
in aq.  $\text{NaOH}$  ..... II 1101  
+  $\text{Na palmitate} + \text{H}_2\text{O}$  ..... II 899  
+  $\text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1102  
+  $\text{Na}_2\text{SO}_4 + \text{NaOH} + \text{H}_2\text{O}$  ..... II 1102  
**Na<sub>2</sub>P<sub>2</sub>O<sub>7</sub>** +  $\text{BaSiO}_3$  (+ other salts) ..... I 400  
+  $\text{BaTiO}_3$  ..... I 400, 439  
**3Na<sub>4</sub>P<sub>2</sub>O<sub>7</sub>·Fe<sub>4</sub>(P<sub>2</sub>O<sub>7</sub>)<sub>3</sub>** in aq.  $\text{NaCl}$ ,  $\text{Na citrate}$  ..... I 1044  
**Na<sub>4</sub>P<sub>2</sub>O<sub>7</sub>** in  $\text{H}_2\text{O}$  ..... II 1106  
in aq.  $\text{H}_2\text{O}$  ..... II 1107  
+  $2\text{K}_2\text{MoO}_4 \rightleftharpoons \text{K}_4\text{P}_2\text{O}_7 + 2\text{Na}_2\text{MoO}_4$  ..... II 246  
+  $\text{K}_4\text{P}_2\text{O}_7$  ..... II 1107  
+  $4\text{KPO}_3 \rightleftharpoons \text{K}_4\text{P}_2\text{O}_7 + 4\text{NaPO}_3$  ..... II 292  
+  $2\text{K}_2\text{WO}_4 \rightleftharpoons 2\text{Na}_2\text{WO}_4 + \text{K}_4\text{P}_2\text{O}_7$  ..... II 292, 340  
+  $\text{LiBO}_2$  ..... II 366  
+  $\text{Na}_2\text{B}_4\text{O}_7$  ..... II 828  
+  $\text{NaCl}$  ..... II 1011  
+  $\text{NaF}$  ..... II 1040  
+  $\text{Na}_2\text{H}_2\text{P}_2\text{O}_7 + \text{H}_2\text{O}$  ..... II 1107  
+  $\text{Na}_2\text{MoO}_4$  ..... II 1065  
+  $\text{NaPO}_3$  ..... II 1107  
+  $\text{NaPO}_3$  fusion point ..... II 1109  
+  $\text{Na}_3\text{P}_3\text{O}_9$  ..... II 1107  
+  $\text{Na palmitate} + \text{H}_2\text{O}$  ..... II 899  
+  $\text{Na}_2\text{TiO}_3$  ..... II 1171  
+  $\text{Na}_2\text{WO}_4$  ..... II 1107  
**Na<sub>3</sub>P<sub>3</sub>O<sub>9</sub>** +  $\text{Na}_4\text{P}_2\text{O}_7$  ..... II 1107  
**Na<sub>5</sub>P<sub>3</sub>O<sub>10</sub>** +  $\text{H}_2\text{O}$  ..... II 1111  
**Na palmitate** in bile salts ..... II 899  
in aq. bile salts +  $\text{lecithin}$  ..... II 899  
in  $\text{ethyl alc.}$  ..... II 899  
in  $\text{ethylene glycol} + \text{butyl alc.}$  ..... II 899  
in  $\text{glycols}$  ..... II 899  
in  $\text{H}_2\text{O}$  ..... II 383, 897, 8, 9  
+  $\text{NaCl} + \text{H}_2\text{O}$  ..... II 899  
+  $\text{NaCl} + \text{Na laurate} + \text{H}_2\text{O}$  ..... II 894  
+  $\text{Na metasilicate} + \text{H}_2\text{O}$  ..... II 899  
+  $\text{palmitic acid}$  ..... II 900  
in  $\text{pinene}$  ..... II 900  
+  $\text{tetrasodium pyrophosphate} + \text{H}_2\text{O}$  ..... II 899  
+  $\text{trisodium phosphate} + \text{H}_2\text{O}$  ..... II 899  
in various solvents ..... II 898  
**Na pentanoate** +  $\text{Na benzoate}$  ..... II 869  
+  $\text{Na isobutyrate}$  ..... II 863  
**Na pentanoate** +  $\text{NaHCOO}$  ..... II 853  
+  $\text{Na propionate}$  ..... II 860  
+  $\text{Na isopropionate}$  ..... II 860  
+  $\text{Na stearate}$  ..... II 869  
**Na iso-pentanoate** +  $\text{NaC}_2\text{H}_3\text{O}_2$  ..... II 859  
**Na phenolate** ..... II 871  
**Na phenol sulfonate** in aq.  $\text{alc.}$  ..... II 878  
in  $\text{H}_2\text{O}$  ..... II 877  
**Na phenolphthalein sulfonates** in  $\text{H}_2\text{O}$  ..... II 896  
**Na phenylacetate** +  $\text{ethyl phenylacetate}$  ..... II 860  
+  $\text{phenylacetic acid}$  ..... II 860  
+  $\text{phenylacetic acid} + \text{H}_2\text{O}$  ..... II 860  
+  $\text{phenylacetic anhydride}$  ..... II 860  
**Na phenyl salicylalkyl hydrogensulfate** in  $\text{H}_2\text{O}$  ..... II 1149  
**Na phenyl sulfate** in  $\text{alc.}$  ..... II 1149  
in  $\text{H}_2\text{O}$  ..... II 1149  
**Na phosphates** distr. betwn.  $\text{Na}_2\text{O} \cdot \text{P}_2\text{O}_5$  and  $\text{H}_2\text{O} +$   
acetone ..... II 1112  
**Na phthalate** in  $\text{H}_2\text{O}$  ..... II 885  
+  $\text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 886  
+  $\text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 886, 7  
+  $\text{phthalic acid} + \text{H}_2\text{O}$  ..... II 885  
**Na picrate** in acetonitrile ..... II 875  
distr. betwn.  $\text{H}_2\text{O} +$  diisopropyl acetone ..... II 875  
in  $\text{ethyl alc.}$  ..... II 874, 5  
in  $\text{H}_2\text{O}$  ..... II 873  
in aq. salt solns. .... II 874  
and other nitrophenols in aq.  $\text{alc.}$  and acetone ..... II 875  
**Na picric acid** in  $\text{H}_2\text{O}$  ..... II 893  
**Na polyvinylbetate** in  $\text{H}_2\text{O}$  ..... II 1065  
**Na propionate** +  $\text{K acetate} \rightleftharpoons \text{K propionate} + \text{Na acetate}$  ..... II 859  
+  $\text{LiNO}_3 \rightleftharpoons \text{NaNO}_3 + \text{Li propionate}$  ..... II 860, 862  
+  $\text{Na benzoate}$  ..... II 860  
+  $\text{Na isobutyrate}$  ..... II 860  
+  $\text{NaC}_2\text{H}_3\text{O}_2$  ..... II 859  
+  $\text{NaHCOO}$  ..... II 853  
in organic solvents ..... II 860  
+  $\text{Na pentanoate}$  ..... II 860  
+  $\text{Na isopropionate}$  ..... II 860  
+  $\text{NaSCN}$  ..... II 914  
+  $\text{phenol} + \text{H}_2\text{O}$  ..... II 860  
**Na isopropionate** +  $\text{Na benzoate}$  ..... II 860  
+  $\text{Na isobutyrate}$  ..... II 860  
+  $\text{NaHCOO}$  ..... II 853  
+  $\text{NaNO}_3$  ..... II 1083  
+  $\text{pentanoate}$  ..... II 860

- + Na propionate ..... II 860  
 + Na stearate ..... II 860  
**Na propylnitronate** in glycol ..... II 861  
**Na<sub>2</sub>PtCl<sub>6</sub>** in H<sub>2</sub>O ..... II 991  
**Na<sub>2</sub>PtF<sub>6</sub>** in H<sub>2</sub>O ..... II 1035  
**Na quinoxaline carboxylates** in H<sub>2</sub>O ..... II 889  
**Na quinoalin sulfonate** ..... II 888  
**NaReO<sub>4</sub>** distr. betwn. H<sub>2</sub>O and nitromethane ..... II 1112  
 in ethyl alc. ..... II 1112  
 in H<sub>2</sub>O ..... II 1112  
**Na<sub>6</sub>Rh<sub>2</sub>(NO<sub>2</sub>)<sub>12</sub>** in H<sub>2</sub>O ..... II 1069  
**Na rosin soap** in NaCl, NaCl + NaOH ..... II 909  
 in Na silicate solns. .... II 909  
**Na rosin soaps** ..... II 908, 9  
**Na<sub>2</sub>S** in H<sub>2</sub>O ..... II 1113  
 + H<sub>2</sub>S + H<sub>2</sub>O ..... II 1113  
 in NH<sub>3</sub> (liq) + NaBr ..... II 1117  
 + Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 937  
 + Na<sub>2</sub>O ..... II 1083, 1117  
 + Na<sub>2</sub>SO<sub>4</sub> ..... II 1117  
 + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 1113, 4, 5, 6  
 + S ..... II 1117  
 + Sb<sub>2</sub>S<sub>3</sub> + H<sub>2</sub>O ..... II 1116  
 + TiCl<sub>3</sub>H<sub>2</sub>O<sub>2</sub> + H<sub>2</sub>O ..... II 1591  
 + TiNO<sub>3</sub> + H<sub>2</sub>O ..... II 1591  
 + TiNO<sub>3</sub> + Pb(NO<sub>3</sub>)<sub>2</sub> + H<sub>2</sub>O ..... II 1591  
**NaSCN** + AgSCN + H<sub>2</sub>O ..... I 57  
 + Ba(SCN)<sub>2</sub> + H<sub>2</sub>O ..... I 327  
 in butyl alc. + H<sub>2</sub>O ..... II 913  
 + Ca(SCN)<sub>2</sub> + H<sub>2</sub>O ..... I 532, 3  
 in H<sub>2</sub>O ..... II 913  
 + K butyrate  $\rightleftharpoons$  Na butyrate + KSCN ..... II 80  
 + KCl  $\rightleftharpoons$  KSCN + NaCl ..... II 169  
 + K formate  $\rightleftharpoons$  Na formate + KSCN ..... II 80  
 + KSCN ..... II 80  
 in methanol + cyclohexane ..... II 914  
 in NH<sub>3</sub> (liq) ..... II 914  
 + Na acetate ..... II 914  
 + Na butyrate ..... II 862, 914  
 + Na isobutyrate ..... II 914  
 + Na caproate ..... II 914  
 + Na formate ..... II 914  
 + NaI + allyl alc. .... II 914  
 + NaNO<sub>3</sub> ..... II 914, 1083  
 + Na neovalerate ..... II 914  
 in organic solvents ..... II 914  
 + Na propionate ..... II 914  
 + Na stearate ..... II 907  
 + Na valerate ..... II 914  
 + Na isovalerate ..... II 914  
**Na<sub>2</sub>SO<sub>3</sub>** + H<sub>2</sub>O ..... II 1117, 2  
 + 2NH<sub>4</sub>Cl  $\rightleftharpoons$  2NaCl + (NH<sub>4</sub>)<sub>2</sub>SO<sub>3</sub> (+ H<sub>2</sub>O) ..... II 751, 2  
 in (NH<sub>4</sub>)<sub>2</sub>SO<sub>3</sub> ..... II 1121  
 + (NH<sub>4</sub>)<sub>2</sub>SO<sub>3</sub> + H<sub>2</sub>O ..... II 752  
 + NaCl + H<sub>2</sub>O ..... II 980, 1  
 + NaOH + H<sub>2</sub>O ..... II 1119  
 + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 1119, 20  
 + Na<sub>2</sub>S<sub>2</sub>O<sub>8</sub> + H<sub>2</sub>O ..... II 1120, 1  
 in SO<sub>2</sub> (liq) ..... II 1121  
**Na<sub>2</sub>SO<sub>4</sub>** + acetone + H<sub>2</sub>O ..... II 1148  
 + Ag<sub>2</sub>MoO<sub>4</sub>  $\rightleftharpoons$  Ag<sub>2</sub>SO<sub>4</sub> + Na<sub>2</sub>MoO<sub>4</sub> ..... I 108  
 + Ag<sub>2</sub>SO<sub>4</sub> ..... I 143  
 + Ag<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... I 139-141  
 in alics. .... II 1148  
 + Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> + H<sub>2</sub>O ..... I 220, 221  
**3Na<sub>2</sub>SO<sub>4</sub>** + 2Al<sub>2</sub>(SeO<sub>4</sub>)<sub>3</sub>  $\rightleftharpoons$  2Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> +  
 3Na<sub>2</sub>SeO<sub>4</sub> (+ H<sub>2</sub>O) ..... I 226  
**Na<sub>2</sub>SO<sub>4</sub>** + aliphatic amines + H<sub>2</sub>O ..... II 1147  
 + BaCl<sub>2</sub> ..... I 353  
 + BaCl<sub>2</sub>  $\rightleftharpoons$  BaSO<sub>4</sub> + 2NaCl ..... I 393  
 + BaSO<sub>4</sub> ..... I 393  
 + BaSO<sub>4</sub> (+ other salts) ..... I 400  
 + BeSO<sub>4</sub> ..... II 1149  
 + BeSO<sub>4</sub> + H<sub>2</sub>O ..... I 421, 2  
 + BiTiO<sub>3</sub> ..... I 439  
 in n-butyl alc. + H<sub>2</sub>O ..... II 1144  
 + butyl alc. + H<sub>2</sub>O ..... II 1145  
 + CaCO<sub>3</sub>  $\rightleftharpoons$  CaSO<sub>4</sub> + Na<sub>2</sub>CO<sub>3</sub> (+ H<sub>2</sub>O) ..... I 682  
 + CaSO<sub>4</sub> ..... I 687  
 + CaSO<sub>4</sub> + H<sub>2</sub>O ..... I 676, 7  
 + CaSO<sub>4</sub> + K<sub>2</sub>SO<sub>4</sub> ..... I 687  
 + CaSO<sub>4</sub> + MgSO<sub>4</sub> ..... I 687  
 + CdCl<sub>2</sub>  $\rightleftharpoons$  CdSO<sub>4</sub> + 2NaCl ..... I 728  
 + CdSO<sub>4</sub> ..... II 1149  
 + CdSO<sub>4</sub> ..... I 762  
 + CdSO<sub>4</sub> + H<sub>2</sub>O ..... I 759, 60  
 + CdSO<sub>4</sub> + C<sub>2</sub>SO<sub>4</sub> ..... II 326  
 + Ce<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> + H<sub>2</sub>O ..... I 778  
 + CoSO<sub>4</sub> ..... II 1149  
 + CoSO<sub>4</sub> ..... I 856  
 + CoSO<sub>4</sub> + H<sub>2</sub>O ..... I 852, 3  
 + Cs<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... I 903  
 + Cu(NO<sub>3</sub>)<sub>2</sub>  $\rightleftharpoons$  CuSO<sub>4</sub> + 2NaNO<sub>3</sub> (+ H<sub>2</sub>O) ..... I 992  
 + CuSO<sub>4</sub> ..... I 997  
 + CuSO<sub>4</sub> + CuCl<sub>2</sub> + NaCl + H<sub>2</sub>O ..... I 974  
 + CuSO<sub>4</sub> + H<sub>2</sub>O ..... I 991, 2  
 + CuSO<sub>4</sub> + H<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... I 992  
 + CuSO<sub>4</sub> + K<sub>2</sub>SO<sub>4</sub> ..... I 997  
 in D<sub>2</sub>O ..... II 1124  
 + ethanol + H<sub>2</sub>O ..... II 1141, 2, 3  
 in ethylene glycol solns. .... II 1145, 6, 7  
 in formic acid ..... II 1148  
 + FeSO<sub>4</sub> + H<sub>2</sub>O ..... I 1057  
 in glycerol ..... II 1148  
 + H<sub>3</sub>BO<sub>3</sub> + H<sub>2</sub>O ..... II 1129  
 + H<sub>3</sub>BO<sub>3</sub> + H<sub>2</sub>O ..... I 272  
 + H<sub>2</sub>C<sub>2</sub>O<sub>4</sub> + NaC<sub>2</sub>O<sub>4</sub> + H<sub>2</sub>O ..... II 954  
 + 2HCl  $\rightleftharpoons$  H<sub>2</sub>SO<sub>4</sub> + 2NaCl (+ H<sub>2</sub>O) ..... II 963, 4  
 + 2HCl  $\rightleftharpoons$  2NaCl + H<sub>2</sub>SO<sub>4</sub> (+ H<sub>2</sub>O) ..... II 1129  
 in H<sub>2</sub>O ..... II 318, 609  
 + H<sub>2</sub>O ..... II 1121, 2, 3  
 in H<sub>2</sub>O ..... II 1125, 6  
 + H<sub>2</sub>O<sub>2</sub> + H<sub>2</sub>O ..... II 1124, 5  
 + H<sub>2</sub>SO<sub>4</sub> ..... II 1129  
 + H<sub>2</sub>SO<sub>4</sub> + ethyl alc. .... II 1144  
 + H<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 1126, 7, 8, 9  
 + H<sub>2</sub>SO<sub>4</sub> + ZnSO<sub>4</sub> ..... II 1129  
 + K<sub>2</sub>CO<sub>3</sub>  $\rightleftharpoons$  K<sub>2</sub>SO<sub>4</sub> + Na<sub>2</sub>CO<sub>3</sub> (+ H<sub>2</sub>O) ..... II 92, 3  
 + KCl ..... II 1149  
 + 2KCl  $\rightleftharpoons$  K<sub>2</sub>SO<sub>4</sub> + 2NaCl ..... II 169  
 + 2KCl  $\rightleftharpoons$  K<sub>2</sub>SO<sub>4</sub> + 2NaCl (+ H<sub>2</sub>O) ..... II 136, 7, 8  
 + KCl + NaCl + K<sub>2</sub>SO<sub>4</sub> + Na<sub>2</sub>CO<sub>3</sub> + K<sub>2</sub>CO<sub>3</sub> ..... II 94  
 + 2KHCO<sub>3</sub>  $\rightleftharpoons$  K<sub>2</sub>SO<sub>4</sub> + 2NaHSO<sub>4</sub> (+ H<sub>2</sub>O) ..... II 104  
 + K<sub>2</sub>SO<sub>4</sub> + Na<sub>2</sub>CrO<sub>4</sub> + H<sub>2</sub>O ..... II 193  
 + 2KI  $\rightleftharpoons$  K<sub>2</sub>SO<sub>4</sub> + 2NaI ..... II 234  
 + KMnO<sub>4</sub> + H<sub>2</sub>O ..... II 243  
 + 2KOH  $\rightleftharpoons$  K<sub>2</sub>SO<sub>4</sub> + 2NaOH ..... II 280  
 + 2KNO<sub>3</sub>  $\rightleftharpoons$  K<sub>2</sub>SO<sub>4</sub> + 2NaNO<sub>3</sub> ..... II 274  
 + 2KNO<sub>3</sub>  $\rightleftharpoons$  K<sub>2</sub>SO<sub>4</sub> + 2NaNO<sub>3</sub> (+ H<sub>2</sub>O) ..... II 264  
 + K<sub>2</sub>SO<sub>4</sub> ..... II 325  
 + K<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 315, 6, 7  
 + K<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>SO<sub>4</sub> ..... II 318  
 + K<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>CO<sub>3</sub> + Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 318  
 + La<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> + H<sub>2</sub>O ..... II 358, 9  
 + Li<sub>2</sub>CO<sub>3</sub>  $\rightleftharpoons$  Na<sub>2</sub>CO<sub>3</sub> + Li<sub>2</sub>SO<sub>4</sub> ..... II 390  
 + 2LiCl  $\rightleftharpoons$  Li<sub>2</sub>SO<sub>4</sub> + 2NaCl ..... II 406  
 + 2LiF  $\rightleftharpoons$  Li<sub>2</sub>SO<sub>4</sub> + 2NaF ..... II 414  
 + 2LiNO<sub>3</sub>  $\rightleftharpoons$  Li<sub>2</sub>SO<sub>4</sub> + 2NaNO<sub>3</sub> ..... II 427  
 + Li<sub>2</sub>SO<sub>4</sub> ..... II 439, 1149  
 + Li<sub>2</sub>SO<sub>4</sub> + CdSO<sub>4</sub> ..... II 1149  
 + Li<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 438  
 + Li<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 1136, 7  
 + Li<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>SO<sub>4</sub> + NaCl ..... II 326  
 + MgCl<sub>2</sub>  $\rightleftharpoons$  MgSO<sub>4</sub> + NaCl ..... II 494  
 + MgCl<sub>2</sub>  $\rightleftharpoons$  MgSO<sub>4</sub> + 2NaCl (+ H<sub>2</sub>O) ..... II 485, 6, 7, 533  
 + MgCl<sub>2</sub> + NaCl + NaNO<sub>3</sub> + H<sub>2</sub>O ..... II 491  
 + MgCl<sub>2</sub> + NaCl + NaNO<sub>3</sub> + Mg(NO<sub>3</sub>)<sub>2</sub> + H<sub>2</sub>O ..... II 491  
 + MgCl<sub>2</sub>  $\rightleftharpoons$  2NaCl + MgSO<sub>4</sub> (+ H<sub>2</sub>O) ..... II 985  
 + Mg(HCO<sub>3</sub>)<sub>2</sub>  $\rightleftharpoons$  MgSO<sub>4</sub> + 2NaHCO<sub>3</sub> (+ H<sub>2</sub>O) ..... II 533  
 + MgMoO<sub>4</sub>  $\rightleftharpoons$  MgSO<sub>4</sub> + Na<sub>2</sub>MoO<sub>4</sub> ..... II 510  
 + Mg(NO<sub>3</sub>)<sub>2</sub>  $\rightleftharpoons$  MgSO<sub>4</sub> + 2NaNO<sub>3</sub> (+ H<sub>2</sub>O) ..... II 533, 1077  
 + MgSO<sub>4</sub> ..... II 538  
 + MgSO<sub>4</sub> + H<sub>2</sub>O ..... II 530, 1, 2  
 + MgSO<sub>4</sub> + K<sub>2</sub>SO<sub>4</sub> ..... II 326  
 + MgSO<sub>4</sub> + K<sub>2</sub>SO<sub>4</sub> + K<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 310, 11  
 + MnSO<sub>4</sub> ..... II 571  
 + MnSO<sub>4</sub> + H<sub>2</sub>O ..... II 565, 6, 7  
 in aq. NH<sub>3</sub> ..... II 1132  
 + (NH<sub>4</sub>)<sub>2</sub>B<sub>4</sub>O<sub>7</sub>  $\rightleftharpoons$  (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> + Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub> (+ H<sub>2</sub>O) ..... II 828  
 + (NH<sub>4</sub>)<sub>2</sub>B<sub>4</sub>O<sub>7</sub>  $\rightleftharpoons$  Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub> + (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> ..... II 609, 10, 11  
 + 2NH<sub>4</sub>Cl  $\rightleftharpoons$  (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> + Na<sub>2</sub>SO<sub>4</sub> (+ H<sub>2</sub>O) ..... II 666  
 + 2NH<sub>4</sub>ClO<sub>4</sub>  $\rightleftharpoons$  (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> + 2NaClO<sub>4</sub> (+ H<sub>2</sub>O) ..... II 687  
 + 2NH<sub>4</sub>HCO<sub>3</sub>  $\rightleftharpoons$  (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> + 2NaHCO<sub>3</sub> ..... II 645, 6  
 + NH<sub>4</sub>NO<sub>3</sub> ..... II 727

- +  $(\text{NH}_4)\text{NaSO}_4$  ..... II 609  
 +  $(\text{NH}_4)_2\text{SO}_4$  ..... II 1149  
 +  $(\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 760, 1, 2  
 +  $(\text{NH}_4)_2\text{SO}_4 + \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 314  
 +  $(\text{NH}_4)_2\text{SO}_4 + \text{NH}_3 + \text{H}_2\text{O}$  ..... II 762  
 +  $(\text{NH}_4)_2\text{SO}_4 = 2\text{NH}_4\text{Cl} + \text{Na}_2\text{SO}_4 (+ \text{H}_2\text{O})$  ..... II 666  
 in aq. Na acetate ..... II 1132  
 +  $\text{Na}_2\text{B}_4\text{O}_7 + \text{H}_2\text{O}$  ..... II 825, 6, 7, 8  
 +  $\text{Na}_2\text{B}_4\text{O}_7 + \text{H}_3\text{BO}_3 + \text{H}_2\text{O}$  ..... II 828  
 +  $\text{NaBr}$  ..... II 847  
 +  $\text{NaBrO}_3 + \text{H}_2\text{O}$  ..... II 850  
 +  $\text{Na}_2\text{CO}_3$  ..... II 946  
 +  $2\text{Na}_2\text{SO}_4 + \text{Na}_2\text{CO}_3$  ..... II 938  
 **$\text{Na}_2\text{SO}_4 + \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$**  ..... II 955, 6  
 +  $\text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 938, 9  
 +  $\text{Na}_2\text{C}_2\text{O}_4 + \text{H}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 954  
 +  $\text{Na}_2\text{CO}_3 + \text{KCl}$  ..... II 169  
 +  $\text{Na}_2\text{CO}_3 + \text{NaCl}$  ..... II 946  
 +  $\text{Na}_2\text{CO}_3 + \text{NaCl} + \text{NaOH} + \text{H}_2\text{O}$  ..... II 922, 3  
 +  $\text{Na}_2\text{CO}_3 + \text{NaOH} + \text{H}_2\text{O}$  ..... II 923, 40  
 +  $\text{Na}_2\text{CO}_3 + \text{NaOH} + \text{NaCl} + \text{H}_2\text{O}$  ..... II 985  
 +  $\text{NaCl} + \text{CaSO}_4 + \text{H}_2\text{O}$  ..... II 985  
 +  $\text{NaCl}$  ..... II 1011  
 +  $\text{NaCl} + \text{C}_2\text{H}_5\text{OH} + \text{H}_2\text{O}$  ..... II 985  
 +  $\text{NaCl} + \text{H}_2\text{O}$  ..... II 1133  
 +  $\text{NaCl} + \text{H}_2\text{O}$  ..... II 982, 3, 4  
 +  $\text{NaCl}$  in  $\text{NH}_3$  solns ..... II 985  
 +  $\text{NaCl}$  in  $\text{NH}_3 + \text{CO}_2$  ..... II 985  
 +  $\text{NaCl} + \text{Na}_2\text{CO}_3 + \text{H}_2\text{C}$  ..... II 932, 3, 4  
 +  $\text{NaCl} + \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$  ..... II 949  
 +  $\text{NaCl} + \text{Na}_2\text{CO}_3 + \text{NaHCO}_3 + \text{H}_2\text{O}$  ..... II 935  
 +  $\text{NaCl} + \text{NaF} + \text{H}_2\text{O}$  ..... II 973  
 +  $\text{NaCl} + \text{NaNO}_3 + \text{H}_2\text{O}$  ..... II 979  
 +  $\text{NaCl} + \text{NaOH} + \text{H}_2\text{O}$  ..... II 985  
 +  $\text{NaClO}_3 + \text{H}_2\text{O}$  ..... II 1133  
 +  $\text{NaClO}_4 + \text{H}_2\text{O}$  ..... II 1020  
 +  $\text{NaClO}_4 + \text{NH}_4 + (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 758  
 +  $\text{Na}_2\text{CrO}_4$  ..... II 1027  
 +  $\text{NaCrO}_4 + \text{H}_2\text{O}$  ..... II 1025, 6  
 +  $\text{Na}_2\text{CrO}_4 + \text{KNO}_3$  ..... II 274  
 +  $\text{Na}_2\text{Cr}_2\text{O}_7 + \text{NaCl} + \text{H}_2\text{O}$  ..... II 1028  
 +  $\text{Na}_2\text{Cr}_2\text{O}_7 + \text{H}_2\text{O}$  ..... II 1028  
 +  $\text{NaF}$  ..... II 1040  
 +  $\text{NaF} + \text{Na}_2\text{CO}_3$  ..... II 946  
 +  $\text{NaF} + \text{H}_2\text{O}$  ..... II 1033  
 +  $\text{NaF} + \text{K}_2\text{CO}_3$  ..... II 101  
 +  $\text{NaF} + \text{NaCl}$  ..... II 1012  
 +  $\text{NaF} + \text{NaCl} + \text{H}_2\text{O}$  ..... II 1032  
 +  $\text{NaHCO}_3 + (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 950  
 +  $\text{NaIO}_3 + \text{H}_2\text{O}$  ..... II 1067  
 +  $\text{Na}_2\text{MoO}_4$  ..... II 1065  
 +  $\text{Na}_2\text{MoO}_4 + \text{H}_2\text{O}$  ..... II 1063, 4  
 +  $\text{NaNO}_3 + \text{H}_2\text{O}$  ..... II 1075, 6, 7  
 +  $\text{NaNO}_3 + \text{Na}_2\text{CrO}_4$  ..... II 1027  
 +  $\text{NaNO}_3 + \text{NaCl} + \text{H}_2\text{O}$  ..... II 985  
 +  $\text{Na}_2\text{O}$  ..... II 1083, 1149  
 +  $\text{NaOH}$  ..... II 1095  
 +  $\text{NaOH} + \text{H}_2\text{O}$  ..... II 1130, 1, 2  
 +  $\text{NaOH} + \text{Na}_3\text{PO}_4 + \text{H}_2\text{O}$  ..... II 1102  
 +  $\text{Na}_3\text{PO}_4 + \text{H}_2\text{O}$  ..... II 1102  
 +  $\text{Na}_2\text{SO}_4 + \text{NaI} + \text{H}_2\text{O}$  ..... II 1045  
 +  $\text{Na}_2\text{SO}_4 + \text{Na phthalate} + \text{H}_2\text{O}$  ..... II 888, 7  
 +  $\text{Na}_2\text{S}$  ..... II 1117  
 +  $\text{Na}_2\text{S} + \text{H}_2\text{O}$  ..... II 1113, 4, 5, 6  
 +  $\text{Na}_2\text{SO}_3 + \text{H}_2\text{O}$  ..... II 1119, 20  
 +  $\text{Na}_2\text{S}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 1133, 4, 5  
 +  $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$  ..... II 1154  
 +  $\text{Na}_2\text{SeO}_4$  ..... II 1133  
 +  $\text{Na}_2\text{SiO}_3$  ..... II 1149  
 +  $\text{Na}_2\text{TiO}_3$  ..... II 1171  
 +  $\text{NaVO}_3 + \text{H}_2\text{O}$  ..... II 1135  
 +  $\text{Na}_2\text{WO}_4$  ..... II 1149  
 +  $\text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1193  
 +  $\text{NiSO}_4$  ..... II 1149  
 +  $\text{NiSO}_4 + \text{H}_2\text{O}$  ..... II 1137, 8  
 +  $\text{PbCl}_2 = \text{PbSO}_4 + 2\text{NaCl} (+ \text{H}_2\text{O})$  ..... II 986, 7  
 +  $\text{PbF}_2 = 2\text{NaF} + \text{PbSO}_4$  ..... II 1040  
 +  $\text{PbMoO}_4 = \text{Na}_2\text{MoO}_4 + \text{PbSO}_4$  ..... II 1065, 1149  
 +  $\text{PbSO}_4$  ..... II 1149, 1334  
 + picoline +  $\text{H}_2\text{O}$  ..... II 1147  
 +  $\text{Pr}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$  ..... II 1138  
 in aq propyl alc. .... II 1144  
 + isopropyl alc. +  $\text{H}_2\text{O}$  ..... II 1144  
 + pyridine +  $\text{H}_2\text{O}$  ..... II 1147  
 +  $10\text{H}_2\text{O} + \text{salts}$  ..... II 1122  
 +  $\text{Sm}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$  ..... II 1138  
 +  $\text{SrSO}_4$  ..... II 1149  
 in steam ..... II 1123  
 in sugar +  $\text{H}_2\text{O}$  ..... II 1148  
 +  $\text{Ti}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1139  
 in aq. urea ..... II 1148  
 in aq. urethane ..... II 1148  
 +  $\text{V}_2\text{O}_5$  ..... II 1149  
 +  $\text{ZnCl}_2 = 2\text{NaCl} + \text{ZnSO}_4$  ..... II 1012  
 +  $\text{ZnSO}_4$  ..... II 1149  
 +  $\text{ZnSO}_4 + \text{H}_2\text{O}$  ..... II 1139, 40  
 +  $\text{ZnSO}_4 + (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 762  
 **$\text{Na}_2\text{S}_2\text{O}_3$**  in alc. .... II 1154  
 +  $\text{Ag}_2\text{S}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 1144  
 + allyl alc. +  $\text{H}_2\text{O}$  ..... II 1154  
 + t-butyl alc. +  $\text{H}_2\text{O}$  ..... II 1154  
 +  $\text{CaCl}_2 = 2\text{NaCl} + \text{CaS}_2\text{O}_3 (+ \text{H}_2\text{O})$  ..... II 1152, 3  
 +  $\text{Ca}(\text{NO}_3)_2 = \text{CaS}_2\text{O}_3 + 2\text{NaNO}_3(\text{aq.})$  ..... 1624  
 +  $\text{CaS}_2\text{O}_3 + \text{H}_2\text{O}$  ..... 1688  
 +  $\text{CaS}_2\text{O}_3 + \text{NaNO}_3 + \text{H}_2\text{O}$  ..... 1688  
 + ethyl alc. +  $\text{H}_2\text{O}$  ..... II 1153, 4  
 +  $\text{H}_2\text{O} + \text{glucose}$  ..... II 1154  
 in  $\text{H}_2\text{O}$  ..... II 1149, 50, 1, 2  
 +  $\text{MgCl}_2 = \text{MgS}_2\text{O}_3 + 2\text{NaCl}$  ..... II 539  
 +  $\text{MgCl}_2 = \text{MgS}_2\text{O}_3 + 2\text{NaCl} (+ \text{H}_2\text{O})$  ..... II 492  
 +  $\text{H}_2\text{O} + \text{NaCl}$  ..... II 1154  
 +  $\text{H}_2\text{O} + \text{NaClO}_3$  ..... II 1154  
 +  $\text{NaNO}_3 + \text{H}_2\text{O}$  ..... II 1077  
 +  $\text{H}_2\text{O} + \text{NaNO}_3$  ..... II 1154  
 +  $\text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1133, 4, 5  
 +  $\text{H}_2\text{O} + \text{Na}_2\text{SO}_4$  ..... II 1154  
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 + pyridine +  $\text{H}_2\text{O}$  ..... II 1154  
 + cane sugar ..... II 1154  
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 **$\text{Na}_2\text{S}_2\text{O}_4$**  in ethylene glycol ..... II 1155  
 in  $\text{H}_2\text{O}$  ..... II 1155  
 +  $\text{NaCl} + \text{H}_2\text{O}$  ..... II 986  
 + urethane +  $\text{H}_2\text{O}$  ..... II 1154  
 **$\text{Na}_2\text{S}_2\text{O}_5$**  in  $\text{H}_2\text{O}$  ..... II 1155, 6  
 +  $\text{Na}_2\text{SO}_3 + \text{H}_2\text{O}$  ..... II 1120, 1  
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 **$\text{Na}_2\text{S}_2\text{O}_6$**  +  $\text{BaS}_2\text{O}_6 + \text{H}_2\text{O}$  ..... 1397  
 in  $\text{H}_2\text{O}$  ..... II 1156, 7  
 +  $\text{SrS}_2\text{O}_6 + \text{H}_2\text{O}$  ..... II 1157  
 **$\text{Na}_2\text{S}_2\text{O}_7$**  +  $\text{NaHSO}_4$  ..... II 1129  
 **$\text{Na}_2\text{S}_2\text{O}_8$**  +  $\text{Na}_2\text{S}_4\text{O}_6 + \text{H}_2\text{O}$  ..... II 1157  
 **$\text{Na}_2\text{S}_2\text{O}_8$**  +  $\text{Na}_2\text{S}_3\text{O}_6 + \text{H}_2\text{O}$  ..... II 1157  
 +  $\text{Na}_2\text{S}_3\text{O}_6 + \text{H}_2\text{O}$  ..... II 1158  
 **$\text{Na}_2\text{S}_5\text{O}_6$**  +  $\text{Na}_2\text{S}_4\text{O}_6 + \text{H}_2\text{O}$  ..... II 1158  
 **$\text{NaSO}_3\text{NH}_2$**  in  $\text{H}_2\text{O}$  ..... II 1158  
 +  $\text{NH}_4\text{SO}_3\text{NH}_2$  ..... II 778  
 +  $\text{NaCl} + \text{H}_2\text{O}$  ..... II 986  
 +  $\text{NaNO}_3$  ..... II 1158  
 **$\text{NaSbF}_6$**  ..... II 1158  
 **$\text{NaSbS}_4$**  in aq. ethyl alc. .... II 1161  
 in  $\text{H}_2\text{O}$  ..... II 1159  
 in aq. methyl alc. .... II 1160  
 in aq. NaOH ..... II 1160  
 +  $\text{Na}_2\text{S}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 1160  
 **$\text{Na}_3\text{SeO}_3$**  in  $\text{H}_2\text{O}$  ..... II 1161  
 +  $\text{H}_2\text{O}$  ..... II 1161  
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 +  $\text{H}_2\text{O}_2 + \text{H}_2\text{O}$  ..... II 1163  
 +  $\text{K}_2\text{SeO}_4 + \text{H}_2\text{O}$  ..... II 337  
 +  $\text{NaOH} + \text{H}_2\text{O}$  ..... II 1164  
 +  $\text{Na}_2\text{SO}_4$  ..... II 1133  
 +  $\text{Na}_2\text{SeO}_4 + \text{H}_2\text{O}$  ..... II 541  
 **$\text{Na}_3\text{SiF}_6$**  in HCl solns ..... II 1036  
 in HCl solns +  $\text{NaCl}$  ..... II 1037  
 in HF soln ..... II 1037  
 in  $\text{H}_2\text{O}$  ..... II 1035, 6  
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 +  $\text{NaCl} + \text{H}_2\text{O}$  ..... II 1038  
 in aq  $\text{Na}_2\text{SO}_4$  ..... II 1038  
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 + MgSiO<sub>3</sub> ..... II 543  
 + Li<sub>2</sub>SO<sub>3</sub> ..... II 440  
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 -9H<sub>2</sub>O in aq. NaCl ..... II 1168  
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 + NaF ..... II 1040  
 in aq. NaHCO<sub>3</sub> ..... II 1168  
 -9H<sub>2</sub>O in aq. NaOH ..... II 1168  
 + Na<sub>2</sub>SO<sub>4</sub> ..... II 1149  
 + Na<sub>2</sub>TiO<sub>3</sub> + TiO<sub>2</sub> ..... II 1169  
 + Na<sub>2</sub>WO<sub>4</sub> ..... II 1169  
 + PbSiO<sub>3</sub> + SiO<sub>2</sub> ..... II 1169  
 + PbTiO<sub>3</sub> ..... II 1337  
 + SrSiO<sub>3</sub> ..... II 1169  
**Na<sub>2</sub>Si<sub>4</sub>O<sub>9</sub>** + NaF ..... II 1040  
**Na salicylate** + caffeine + H<sub>2</sub>O ..... II 881  
 distr betwn olive oil + H<sub>2</sub>O ..... II 881  
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 in aq. Na salts ..... II 1170  
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 in cetane ..... II 905  
 in cetane + H<sub>2</sub>O ..... II 905  
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 in benzene + alc. .... II 906  
 in catechol + ethyl alc. .... II 906  
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 + Na benzoate f.p. .... II 880  
 + Na isobutyrate ..... II 863  
 + NaC<sub>2</sub>H<sub>3</sub>O<sub>2</sub> ..... II 859  
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 + NaNO<sub>3</sub> ..... II 904  
 + Na pentanoate ..... II 869  
 + Na propionate ..... II 860  
 + Na isopropionate ..... II 860  
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**Na stypnate** in H<sub>2</sub>O ..... II 870  
**Na succinate** in H<sub>2</sub>O ..... II 866  
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**Na tartrate** + t-butyl alc. .... II 864  
 + K tartrate + H<sub>2</sub>O ..... II 48  
 + Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 864  
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**Na<sub>2</sub>TeO<sub>3</sub>** + ethanal + H<sub>2</sub>O ..... II 1171  
**Na<sub>2</sub>TeO<sub>4</sub>** in H<sub>2</sub>O ..... II 1171  
**Na tetrachlorophthalate** in H<sub>2</sub>O ..... II 887  
**Na tetradecyl sulfonate** in NaCl solns ..... II 891  
**Na<sub>2</sub>TiF<sub>6</sub>** in H<sub>2</sub>O ..... II 1038  
**Na<sub>2</sub>TiO<sub>3</sub>** ..... II 1171  
 + BiTiO<sub>3</sub> ..... I 439  
 + Na<sub>2</sub>CrO<sub>4</sub> ..... II 1171  
 + Na<sub>2</sub>SO<sub>4</sub> ..... II 1171  
 + 2KF  $\rightleftharpoons$  K<sub>2</sub>TiO<sub>3</sub> + 2NaF ..... II 211  
 + 2KF  $\rightleftharpoons$  2NaF + K<sub>2</sub>TiO<sub>3</sub> ..... II 339  
 + 2LiF  $\rightleftharpoons$  2NaF + Li<sub>2</sub>TiO<sub>3</sub> ..... II 1040  
 + Li<sub>2</sub>TiO<sub>3</sub> ..... II 440, 1171  
 + NaCl ..... II 1171  
 + NaF ..... II 1040, 1171  
 + Na<sub>2</sub>MoO<sub>4</sub> ..... II 1171  
 + Na<sub>4</sub>P<sub>2</sub>O<sub>7</sub> ..... II 1171  
 + Na<sub>2</sub>SiO<sub>3</sub> + TiO<sub>2</sub> ..... II 1169  
 + NaVO<sub>3</sub> ..... II 1171  
 + Na<sub>2</sub>WO<sub>4</sub> ..... II 1171  
 + PbF<sub>2</sub>  $\rightleftharpoons$  2NaF + PbTiO<sub>3</sub> ..... II 1040  
 + PbMoO<sub>4</sub> ..... II 1171  
 + PbMoO<sub>4</sub>  $\rightleftharpoons$  Na<sub>2</sub>MoO<sub>4</sub> + PbTiO<sub>3</sub> ..... II 1065  
 + PbWO<sub>4</sub> ..... II 1171  
**Na thiocyanate** + NaHCOO ..... II 854  
**Na trichloroacetate** + phenol + H<sub>2</sub>O ..... II 859  
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**Na<sub>4</sub>UO<sub>2</sub>(CO<sub>3</sub>)<sub>3</sub>** ..... II 940  
 in salt solns. .... II 940  
**Na<sub>4</sub>UO<sub>3</sub>** in H<sub>2</sub>O ..... II 1173  
 -9H<sub>2</sub>O ..... II 1173  
 in HNO<sub>3</sub> ..... II 1173  
 in NaC<sub>2</sub>H<sub>3</sub>O<sub>2</sub> ..... II 1173  
 in NaHCO<sub>3</sub> ..... II 1173  
 in Na<sub>2</sub>CO<sub>3</sub> ..... II 1173  
 in NaOH ..... II 1173  
 in NaNO<sub>3</sub> ..... II 1173  
**Na<sub>2</sub>U<sub>2</sub>O<sub>7</sub>** + NaF ..... II 1040  
**Na urate** in H<sub>2</sub>O ..... II 868  
 in aq. KH<sub>2</sub>PO<sub>4</sub> + K<sub>2</sub>HPO<sub>4</sub> ..... II 868  
 in aq. NaCl ..... II 868  
 in serum ..... II 868  
**NaVO<sub>3</sub>** + BiTiO<sub>3</sub> ..... I 439  
 in H<sub>2</sub>O ..... II 1177  
 + KCl  $\rightleftharpoons$  KVO<sub>3</sub> + NaCl ..... II 169  
 + KF  $\rightleftharpoons$  KVO<sub>3</sub> + NaF ..... II 211  
 + NaCl ..... II 1011  
 + NaCl + H<sub>2</sub>O ..... II 1177  
 + NaF ..... II 1040  
 + Na<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 1135  
 + Na<sub>2</sub>TiO<sub>3</sub> ..... II 1171  
 + PbTiO<sub>3</sub> ..... II 1337  
 + V<sub>2</sub>O<sub>5</sub> ..... II 1178  
**Na<sub>2</sub>VO<sub>4</sub>** + BaSiO<sub>3</sub>(+ other salts) ..... I 400  
**Na<sub>3</sub>VO<sub>4</sub>** in H<sub>2</sub>O ..... II 1177, 8  
**Na<sub>4</sub>V<sub>2</sub>O<sub>7</sub>** + NaCl + H<sub>2</sub>O ..... II 986  
**Na valerate** in glycols ..... II 869  
 + NaSCN ..... II 914  
**Na iso valerate** + NaSCN ..... II 914  
**Na<sub>2</sub>WO<sub>4</sub>** + BaSiO<sub>3</sub>(+ other salts) ..... I 400  
 + Ce<sub>2</sub>(WO<sub>4</sub>)<sub>3</sub> + H<sub>2</sub>O ..... I 782  
 in H<sub>2</sub>O ..... II 1178  
 + 2KCl  $\rightleftharpoons$  K<sub>2</sub>WO<sub>4</sub> + 2NaCl ..... II 169  
 + 2KF  $\rightleftharpoons$  K<sub>2</sub>WO<sub>4</sub> + 2NaF ..... II 211  
 + K<sub>2</sub>MoO<sub>4</sub>  $\rightleftharpoons$  K<sub>2</sub>WO<sub>4</sub> + Na<sub>2</sub>MoO<sub>4</sub> ..... II 246  
 + K<sub>4</sub>P<sub>2</sub>O<sub>7</sub>  $\rightleftharpoons$  2K<sub>2</sub>WO<sub>4</sub> + Na<sub>4</sub>P<sub>2</sub>O<sub>7</sub> ..... II 292  
 + K<sub>4</sub>P<sub>2</sub>O<sub>7</sub>  $\rightleftharpoons$  Na<sub>4</sub>P<sub>2</sub>O<sub>7</sub> + 2K<sub>2</sub>WO<sub>4</sub> ..... II 340  
 + K<sub>2</sub>WO<sub>4</sub> ..... II 340  
 + Li<sub>2</sub>WO<sub>4</sub> ..... II 441  
 + Na<sub>2</sub>MoO<sub>4</sub> ..... II 1065  
 + Na<sub>4</sub>P<sub>2</sub>O<sub>7</sub> ..... II 1107  
 + Na<sub>2</sub>SO<sub>4</sub> ..... II 1149  
 + Na<sub>2</sub>SiO<sub>3</sub> ..... II 1169  
 + Na<sub>2</sub>TiO<sub>3</sub> ..... II 1171  
 + PbTiO<sub>3</sub> ..... II 1337  
 + WO<sub>3</sub> ..... II 1179  
 + WO<sub>3</sub> + W ..... II 1179  
 + WO<sub>3</sub> + W + K<sub>2</sub>WO<sub>4</sub> ..... II 340  
**Naphthalamine** + S ..... II 1403  
 + S + resorcinol ..... II 1403  
**Naphthalene** + AlBr<sub>3</sub> ..... I 158  
 + AsBr<sub>3</sub> ..... I 230  
 + AsI<sub>3</sub> ..... I 231  
 + HgBr<sub>2</sub> + I<sub>2</sub> ..... I 1189  
 + I<sub>2</sub> ..... I 1278  
**Naphthalenes** + SbBr<sub>3</sub> ..... II 1425, 6  
**Naphthalene** + SbCl<sub>3</sub> ..... II 1435  
**Naphthalenes** + SbCl<sub>3</sub> ..... II 1432, 3  
**Naphthalene** + Sbl<sub>3</sub> ..... II 1438  
 + SiCl<sub>4</sub> ..... II 1450  
 + TiCl<sub>4</sub> ..... II 1552  
**Naphthol** + AsBr<sub>3</sub> ..... I 230  
 + SO<sub>2</sub> ..... II 1420  
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**Na xylene sulfonates** in H<sub>2</sub>O ..... II 882  
**Na zincate** in aq. NaOH ..... II 1674  
**NbC** + TiC in aq. NaOH ..... II 1181  
 + ZnC ..... II 1181  
**NbCl<sub>5</sub>** + AlCl<sub>3</sub> ..... II 1181  
 + AlCl<sub>3</sub> + NaCl ..... II 1012, 1181  
 + FeCl<sub>3</sub> ..... II 1181  
 + FeCl<sub>3</sub> + AlCl<sub>3</sub> ..... II 1181

- +  $\text{MgCl}_2$  ..... II 495  
 +  $\text{NaCl}$  ..... II 1012, 1181  
 +  $\text{TaCl}_5 + \text{AlCl}_3$  ..... II 1181  
 in  $\text{TiCl}_4$  ..... II 1181  
 +  $\text{TiCl}_4 + \text{FeCl}_3$  ..... II 1161  
 +  $\text{ZrCl}_4$  ..... II 1181  
**NbF<sub>5</sub>** in  $\text{BF}_3$  ..... II 1181  
 distr. between  $\text{HF} + \text{diethylether}$  ..... II 1181  
**Nb<sub>2</sub>O<sub>5</sub>** in acid solns. .... II 1181, 2  
 in dil  $\text{HCl}$ ,  $\text{H}_2\text{SO}_4$  ..... II 1182  
 in  $\text{H}_2\text{O}$  ..... II 1182  
 +  $\text{xH}_2\text{O}$  in aq. acids, amines ..... II 1182  
 +  $\text{K}_2\text{CO}_3$  ..... II 101  
 +  $\text{K}_2\text{O}$  ..... II 280  
**Nd** compounds, see also D1  
 acetate in  $\text{H}_2\text{O}$  ..... II 1183  
 acetate in ethylenediamine ..... II 1183  
 benzene sulfonates in  $\text{H}_2\text{O}$  ..... II 1183  
**NdBr<sub>3</sub>** in ethylene diamine ..... II 1182  
**Nd(BrO<sub>3</sub>)<sub>3</sub>** in  $\text{H}_2\text{O}$  ..... II 1183  
**Nd(CH<sub>3</sub>COCH<sub>3</sub>)<sub>3</sub>** in various solv. .... II 1184  
**Nd(C<sub>6</sub>H<sub>7</sub>O<sub>2</sub>)<sub>3</sub>** in  $\text{H}_2\text{O}$  ..... II 1184  
**Nd(C<sub>11</sub>H<sub>15</sub>O<sub>3</sub>)<sub>3</sub>** in various solv. .... II 1184  
**Nd<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub>** in Amine oxalate solns. .... II 1186  
 +  $\text{IOH}_2\text{O}$  in aq. acids ..... II 1185, 6  
 +  $\text{IOH}_2\text{O}$  in  $\text{H}_2\text{O}$  ..... II 1185  
 +  $\text{IOH}_2\text{O} + \text{Nd(NO}_3)_3 + \text{H}_2\text{O}$  ..... II 1186  
**[Nd(COC<sub>10</sub>H<sub>13</sub>O<sub>2</sub>)<sub>2</sub>(ClO<sub>4</sub>)<sub>3</sub>]** in  $\text{H}_2\text{O}$  ..... II 1188  
**Nd<sub>2</sub>(CH<sub>3</sub>)<sub>2</sub>PO<sub>4</sub>** in  $\text{H}_2\text{O}$  ..... II 191  
**NdCl<sub>3</sub>** in abs. alc. .... II 1187  
 +  $\text{CaCl}_2$  ..... II 1188  
 +  $\text{CaCl}_2 + \text{NaCl}$  ..... II 1012  
**2NdCa(C<sub>6</sub>H<sub>5</sub>)<sub>4</sub> · 9H<sub>2</sub>O** in aq.  $\text{HCl}$  ..... II 1184  
**NdCl<sub>3</sub> + 3NH<sub>4</sub>OH**  $\rightleftharpoons$   $3\text{NH}_4\text{Cl} + \text{Nd(OH)}_3$  ..... II 1187  
 in  $\text{NH}_4\text{Cl}$  ..... II 1187  
 +  $\text{NaCl}$  ..... II 1012, 1188  
 +  $\text{NaCl} + \text{CaCl}_2$  ..... II 1188  
 in aq.  $\text{HCl}$  ..... II 1187  
 in  $\text{H}_2\text{O}$  ..... II 1187  
 in anh. pyridine ..... II 1187  
**Nd<sub>2</sub>CrO<sub>4</sub> · 8H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1188  
**Nd<sub>4</sub>Fe(CN)<sub>6</sub>** ..... II 1185  
**Nd<sub>3</sub>** in ethylene diamine ..... II 1188  
**Nd<sub>2</sub>(MeO)<sub>3</sub>** in  $\text{H}_2\text{O}$  ..... II 1188  
**Nd(NO<sub>3</sub>)<sub>3</sub> + alkali Fe(CN)<sub>6</sub>** ..... II 1185  
 distr. between 1 butanol and aq.  $\text{NH}_4\text{SCN}$  ..... II 1190  
 distr. between  $\text{H}_2\text{O}$  and methyl n-hexyl ketone ..... II 1190  
 distr. between  $\text{H}_2\text{O}$  and n-hexyl alc. .... II 1190  
 distr. between aq.  $\text{HNO}_3$  and tri n-butyl phosphate ..... II 1190  
 in ethyl ether ..... II 1190  
 in  $\text{H}_2\text{O}$  ..... II 1188  
 in aq.  $\text{HNO}_3$  ..... II 1189  
 +  $\text{M}_4\text{Fe(CN)}_6 + \text{H}_2\text{O}$  ..... II 1189  
**2Nd(NO<sub>3</sub>)<sub>3</sub> · 3Mg(NO<sub>3</sub>)<sub>2</sub> · 24H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 514, 5  
 +  $3\text{Mg(NO}_3)_2 \cdot 24\text{H}_2\text{O}$  in aq.  $\text{Mg(NO}_3)_2$  ..... II 515  
**Nd(NO<sub>3</sub>)<sub>3</sub> + Nd<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub> · 10H<sub>2</sub>O** ..... II 1186  
**NdMe<sub>2</sub>CH<sub>2</sub>N<sub>2</sub>(COO)<sub>4</sub>** in  $\text{H}_2\text{O}$  ..... II 1184  
**Nd nitrites** in  $\text{H}_2\text{O}$  ..... II 1189  
 in aq.  $\text{HNO}_3$  ..... II 1190  
**Nd<sub>2</sub>O<sub>3</sub>** ..... II 1190  
 in  $\text{H}_2\text{O}$  ..... II 1190  
 ppt from  $\text{NH}_4\text{(C}_2\text{H}_3\text{O}_2)$  ..... II 1191  
**Nd<sub>2</sub>O<sub>3</sub>** in aq.  $\text{NH}_4\text{Cl}$  ..... II 1187  
**Nd(OH)<sub>3</sub>** in acids and base ..... II 1190  
 Ksp ..... II 1190  
 +  $3\text{NH}_4\text{Cl} \rightleftharpoons \text{NdCl}_3 + 3\text{NH}_3 + 3\text{H}_2\text{O}$  ..... II 1187  
**Nd<sub>4</sub>(P<sub>2</sub>O<sub>4</sub>)<sub>3</sub>** in  $\text{HCl}$  solns. .... II 1191  
**NdRb(SeO<sub>4</sub>)<sub>2</sub> · 4H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1194  
**Nd(SCN)<sub>3</sub>** distr. between  $\text{H}_2\text{O} + \text{butanol}$  ..... II 346  
**Nd<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>** in  $\text{H}_2\text{O}$  ..... II 1191, 2  
 in aq.  $\text{H}_2\text{SO}_4$  ..... II 1192  
 +  $(\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1193  
 +  $\text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1192  
 in aq.  $\text{Na}_2\text{SO}_4$  ..... II 1193  
 +  $\text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1193  
 +  $\text{Rb}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1193  
 +  $\text{Ti}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1194  
**Nd<sub>2</sub>(SeO<sub>4</sub>)<sub>3</sub>** in  $\text{H}_2\text{O}$  ..... II 1194  
 in  $\text{H}_2\text{SeO}_4$  ..... II 1195  
**Nd<sub>2</sub>(WO<sub>4</sub>)<sub>3</sub>** in  $\text{H}_2\text{O}$  ..... II 1195  
**Ne** in  $\text{H}_2\text{O}$  ..... II 1195, 6  
 and  $\text{He}$  in argon (liq.) ..... II 1198  
 +  $\text{He}$  in  $\text{H}_2\text{O}$  ..... I 1172  
 in  $\text{KI}$  ..... II 1196  
 in  $\text{LiCl}$  ..... II 1196  
 in methylcyclohexane ..... II 1196  
 in  $\text{NaCl}$  solns. .... II 1197  
 in  $\text{NaF} + \text{ZrF}_4$  ..... II 1196  
 in nitroethane ..... II 1197  
 in polyvinyl acetate ..... II 1198  
 in various solvents ..... II 1196, 7  
**Ni** +  $\text{As} + \text{Cu}$  ..... I 229  
 +  $\text{Cu} + \text{S}$  ..... I 905  
 +  $\text{FeO} \rightleftharpoons \text{Fe} + \text{NiO}$  ..... I 1006  
 +  $\text{FeSiO}_3 \rightleftharpoons \text{Fe} + \text{NiSiO}_3$  ..... I 1006  
 in  $\text{Hg}$  ..... II 1198  
 in milk ..... II 1198  
 +  $\text{Ni}_2\text{S}_3$  ..... II 1219  
**Ni<sub>2</sub>(AsO<sub>4</sub>)<sub>2</sub>** in  $\text{HNO}_3$ ,  $\text{H}_2\text{SO}_4$ ,  $\text{HCl}$  solns. .... II 1198  
 Ksp in dil.  $\text{HCl}$ ,  $\text{H}_2\text{SO}_4$ ,  $\text{HNO}_3$  ..... II 1199  
**Ni amines** in aq.  $\text{NH}_3 + \text{ethyl alc.}$  ..... II 1215  
**Ni amine acid salts** in  $\text{H}_2\text{O}$  ..... II 1201  
 in methanol ..... II 1201  
**NiBr<sub>2</sub> · 10 · 10H<sub>2</sub>O** in aq.  $\text{H}_3\text{BO}_3$  ..... II 1199  
**Ni<sub>2</sub>Si<sub>2</sub>(OH<sub>2</sub>)<sub>12</sub> · 24H<sub>2</sub>O** in conc.  $\text{HNO}_3$  ..... I 434  
**NiBr<sub>2</sub>** in acetone ..... II 1199  
 +  $6\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$  ..... II 1199  
 +  $\text{KSCN}$  ..... II 1180  
 in methyl alc. .... II 1199  
**Ni(BrO<sub>3</sub>)<sub>2</sub> · 6H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1200  
**Ni(CH<sub>3</sub>CONHC(NHC(CH<sub>3</sub>)<sub>2</sub>))<sub>2</sub>** in chloroform ..... II 1202  
 in aq. ethanol ..... II 1202  
 in  $\text{HCl} + \text{KCl}$  ..... II 1202  
 in aq. salts ..... II 1201  
**Ni(CH<sub>3</sub>CONHC(COO))<sub>2</sub> · 3H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1200  
**Ni acetate** +  $\text{NH}_4$  acetate + acetic acid ..... II 621  
 in acetic acid ..... II 1200  
**Ni hexaazote** in  $\text{H}_2\text{O}$  ..... II 1202  
 in methy. alc. .... II 1203  
**Ni(C<sub>6</sub>H<sub>5</sub> · NNO)<sub>2</sub> · O<sub>2</sub>** in  $\text{H}_2\text{O}$  ..... II 1203  
**Ni · C<sub>10</sub>H<sub>15</sub>(NH<sub>2</sub>)<sub>2</sub>(SO<sub>4</sub>)<sub>2</sub>** in  $\text{H}_2\text{O}$  ..... II 1205  
**Ni(C<sub>14</sub>H<sub>19</sub>N<sub>5</sub>SO<sub>3</sub>)<sub>2</sub> · 4H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1203  
**Ni(C<sub>6</sub>H<sub>5</sub>O<sub>2</sub>)<sub>2</sub> · 3H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1202  
**Ni · C<sub>4</sub>H<sub>9</sub>O<sub>4</sub> · 5H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1200  
**Ni(C<sub>2</sub>H<sub>5</sub>OCS<sub>2</sub>)<sub>2</sub>** in  $\text{H}_2\text{O}$  ..... II 1201  
**Ni(C<sub>2</sub>H<sub>5</sub>SO<sub>3</sub>)<sub>2</sub> · 6H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1203, 4  
**Ni(C<sub>10</sub>H<sub>15</sub>SO<sub>3</sub>)<sub>2</sub> · 6H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1204  
**Ni(C<sub>14</sub>H<sub>19</sub>SO<sub>3</sub>)<sub>2</sub> · 6H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1203  
**Ni(C<sub>2</sub>H<sub>4</sub>N<sub>2</sub>)<sub>2</sub> · 2H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1225  
 in aq. ethanol ..... II 1225  
**Ni · C<sub>18</sub>H<sub>31</sub>O<sub>4</sub> · 2H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1203  
**Ni(C<sub>14</sub>H<sub>19</sub>O<sub>2</sub>(SO<sub>2</sub>)<sub>2</sub>)** in  $\text{H}_2\text{O}$  ..... II 1206  
**Ni chlor., oxy., nitro benzates** in  $\text{H}_2\text{O}$  ..... II 1202  
**Ni(CN)<sub>2</sub>** in  $\text{H}_2\text{O}$  ..... II 1206  
 +  $\text{KCN} + \text{H}_2\text{O}$  ..... II 67  
**NiC<sub>2</sub>O<sub>4</sub>** in aq. formic acid ..... II 1207  
 in  $\text{H}_2\text{O}$  ..... II 1207  
**NiCO<sub>2</sub>** in  $\text{H}_2\text{O}$  ..... II 1207  
**NiC<sub>2</sub>O<sub>4</sub> + K<sub>2</sub>C<sub>2</sub>O<sub>4</sub> + H<sub>2</sub>O** ..... I 1111  
 in aq.  $\text{K}_2\text{C}_2\text{O}_4$  ..... II 1207  
**[Ni(COC<sub>10</sub>H<sub>12</sub>M<sub>2</sub>)<sub>2</sub>(BF<sub>4</sub>)<sub>2</sub>]** in  $\text{H}_2\text{O}$  ..... II 1213  
**[Ni(COC<sub>10</sub>H<sub>12</sub>M<sub>2</sub>)<sub>2</sub>(ClO<sub>4</sub>)<sub>2</sub>]** in  $\text{H}_2\text{O}$  ..... II 1212  
**Ni<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>2</sub> · 2H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1200  
**NiCe nitrate** ..... I 772  
**NiCl<sub>2</sub> + CdCl<sub>2</sub> + H<sub>2</sub>O** ..... I 725  
 +  $\text{CdCl}_2 + \text{NaCl} + \text{H}_2\text{O}$  ..... I 721  
 +  $\text{CoCl}_2$  ..... II 1211  
 +  $\text{CoCl}_2$  distr. between capryl alcohol +  $\text{H}_2\text{O}$  ..... I 817  
 +  $\text{CoCl}_2 + \text{H}_2\text{O}$  ..... I 812  
 +  $\text{CoCl}_2 + \text{FeCl}_3 + \text{H}_2\text{O}$  ..... I 802  
 +  $\text{FeCl}_2 + \text{H}_2\text{O}$  ..... I 1016  
 +  $\text{FeCl}_3 + \text{H}_2\text{O}$  ..... I 1025  
 in inorganic liquids ..... II 1210  
 in diethyl ether +  $\text{H}_2\text{O} + \text{HCl}$  ..... II 1210  
 distr. between capryl alc. and  $\text{H}_2\text{O}$  ..... II 1209  
 distr. between  $\text{H}_2\text{O}$  and tributyl phosphate ..... II 1210  
 extraction by ether ..... II 1210  
 in formic acid ..... II 1209  
 in aq.  $\text{HCl}$  ..... II 1208, 9  
 in  $\text{HCl}$  (aq.) + ether ..... II 1209  
 in  $\text{H}_2\text{O}$  ..... II 1208  
 +  $\text{LiCl} + \text{H}_2\text{O}$  ..... II 397  
 +  $\text{NH}_4\text{Cl} + \text{H}_2\text{O}$  ..... II 668  
 +  $\text{NH}_4\text{Cl} + \text{H}_2\text{O}$  distr. .... II 669



- +  $\text{NH}_4\text{Cl} + \text{H}_2\text{O}$  ..... II 1209  
 +  $\text{NaCl}$  ..... II 1012  
 in organic solvents ..... II 1210  
**NI**( $\text{ClO}_3$ )<sub>2</sub> in  $\text{H}_2\text{O}$  ..... II 1211  
**NI**( $\text{ClO}_4$ )<sub>2</sub> · 9 $\text{H}_2\text{O}$  in  $\text{H}_2\text{O}$  ..... II 1211  
 · 7 $\text{H}_2\text{O}$  in cellosolve ..... II 1212  
 · 7 $\text{H}_2\text{O}$  in furfural ..... II 1212  
**NI**( $\text{SO}_4$ )<sub>2</sub> in  $\text{H}_2\text{O}$  ..... I 902  
**Ni** cyclohexanedione in  $\text{H}_2\text{O}$  ..... II 1202  
**Ni** cyclohexanedione dioxime in  $\text{H}_2\text{O}$  ..... II 1202  
**NiF**<sub>2</sub> distr. betwn. HF solns. and ethyl ether ..... II 1213  
**Ni** extraction with 8-hydroxy-quinoline ..... II 1205  
**NiF**<sub>2</sub> in  $\text{BrF}_3$  ..... II 1213  
 in HF ..... II 1212  
 in  $\text{H}_2\text{O}$  ..... II 1212  
 +  $\text{KF}$  ..... II 211  
 +  $\text{KF} + \text{H}_2\text{O}$  ..... II 205, 1213  
 +  $\text{NH}_4\text{F} + \text{H}_2\text{O}$  ..... II 1213  
**Ni**<sub>2</sub> $\text{Fe}(\text{CN})_6$  in  $\text{H}_2\text{O}$  ..... II 1206  
**NiFe**( $\text{CN})_5\text{NO}$  in  $\text{H}_2\text{O}$  ..... II 1206  
**Ni**<sub>3</sub> $\text{Gd}(\text{NO}_3)_2$  · 24 $\text{H}_2\text{O}$  ..... I 1071  
**Ni**( $\text{HNCSCH}_3$ ) in  $\text{H}_2\text{O}$  ..... I 1201  
**Ni**( $\text{HN} - \text{CH}_2\text{CH}_2\text{O}$ )<sub>2</sub> in various solvents ..... II 1205, 6  
**Ni** hexamine perchlorate in aq.  $\text{NH}_3$  ..... II 1215  
**Ni** 8-hydroxyquinolates *Ksp* ..... II 1205  
**Ni** 8-hydroxyquinolin-5-sulfonic acid ..... II 1205  
**NiI**<sub>2</sub> in  $\text{H}_2\text{O}$  ..... II 1214  
**Ni**( $\text{IO}_3$ )<sub>2</sub> in  $\text{H}_2\text{O}$  ..... II 1214, 5  
**Ni**( $\text{SO}_4$ )<sub>2</sub> +  $\text{CuK}_2(\text{SO}_4)_2 + \text{H}_2\text{O}$  ..... I 981  
 +  $\text{ZnK}_2(\text{SO}_4)_2 + \text{H}_2\text{O}$  ..... II 1223  
**Ni** methylidopate in  $\text{H}_2\text{O}$  ..... II 1200  
**Ni**( $\text{NH}_3$ )<sub>6</sub> $\text{I}_2$  in acetonitrile ..... II 1214  
**Ni**( $\text{NH}_3$ )<sub>6</sub> $\text{I}_2$  ..... I 1287  
 in nitrobenzene ..... II 1214  
**Ni**( $\text{NH}_3$ )<sub>6</sub>[ $\text{PF}_6$ ]<sub>2</sub> in  $\text{H}_2\text{O}$  ..... II 1214  
**Ni**( $\text{NH}_4$ )<sub>2</sub>( $\text{SO}_4$ )<sub>2</sub> +  $\text{Co}(\text{NH}_4)_2(\text{SO}_4)_2 + \text{H}_2\text{O}$  ..... I 851  
 +  $\text{Cu}(\text{NH}_4)_2(\text{SO}_4)_2 + \text{H}_2\text{O}$  ..... I 985-7  
 +  $\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2 + \text{H}_2\text{O}$  ..... I 1055, 6  
 · 6 $\text{H}_2\text{O}$  ..... II 1223  
**Ni**( $\text{NO}_3$ )<sub>2</sub> +  $\text{Co}(\text{NO}_3)_2 + \text{H}_2\text{O}$  ..... I 837  
 · 6 $\text{H}_2\text{O}$  in tri-*n*-butyl phosphate ..... II 1217  
 in glycol ..... II 1218  
 in  $\text{H}_2\text{O}$  ..... II 1216  
 +  $\text{HNO}_3 + \text{H}_2\text{O}$  ..... II 1216  
 -*n*-hexyl alc. +  $\text{H}_2\text{O}$  ..... II 1217  
 in hydrazine ..... II 1218  
 +  $\text{La}(\text{NO}_3)_3 + \text{H}_2\text{O}$  ..... II 1217  
 +  $\text{Ni}(\text{OH})_2 + \text{H}_2\text{O}$  ..... II 1216  
**NiO** +  $\text{Cr}_2\text{O}_3$  ..... I 871  
 +  $\text{Fe} \rightleftharpoons \text{FeO} + \text{Ni}$  ..... I 1006  
 +  $\text{LiBO}_2$  ..... I 366  
 in steam ..... II 1218  
 +  $\text{SiO}_2 + \text{H}_2\text{O}$  ..... II 1227  
 +  $\text{ZnO} + \text{Cr}_2\text{O}_3$  ..... I 871  
**Ni**( $\text{OH})_2$  ..... II 1218  
 in  $\text{HCl}$  ..... II 1218  
 in aq.  $\text{NH}_3$  ..... II 1218  
 in  $\text{NaOH}$  ..... II 1218  
 +  $\text{Ni}(\text{NO}_3)_2 + \text{H}_2\text{O}$  ..... II 1216  
**Ni** oxylol sulfonate in  $\text{H}_2\text{O}$  ..... II 1205  
**Ni**<sub>2</sub> $\text{P}_2\text{O}_7$  ..... II 1219  
**Ni** phenol sulfonate in  $\text{H}_2\text{O}$  ..... II 1204  
**Ni** phospho fluorides, organic in  $\text{H}_2\text{O}$  ..... II 1214  
**NiS** ..... II 1219  
 +  $\text{CoS}$  ..... I 842  
 +  $\text{FeS}$  ..... II 1219  
 +  $\text{FeS} + \text{CoS}$  ..... II 1219  
 in aq.  $\text{H}_2\text{SO}_4$  ..... II 1219  
**Ni**<sub>2</sub> $\text{S}_3$  +  $\text{Cu}_2\text{S}$  ..... I 964  
 +  $\text{Cu}_2\text{S} + \text{FeS}$  ..... I 964  
 +  $\text{FeS}$  ..... II 1219  
 +  $\text{Ni}$  ..... II 1219  
**Ni**( $\text{SCN}$ )<sub>2</sub> +  $\text{Co}(\text{SCN})_2 + \text{H}_2\text{O}$  ..... II 1206  
 +  $\text{Co}(\text{SCN})_2 + \text{H}_2\text{O}$  ..... I 796  
 in  $\text{H}_2\text{O}$  ..... II 1206  
 +  $\text{KSCN} + \text{H}_2\text{O}$  ..... II 1206  
**NiSO**<sub>4</sub> +  $\text{Al}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$  ..... I 212  
 +  $\text{CaSO}_4 + \text{H}_2\text{O}$  ..... I 677  
 +  $\text{CoSO}_4 + \text{H}_2\text{O}$  ..... I 854, 5  
 +  $\text{CuSO}_4 + \text{H}_2\text{O}$  ..... I 990, 1  
 +  $\text{CuSO}_4 + \text{FeSO}_4 + \text{H}_2\text{O}$  ..... I 977  
 distr. betwn. butyl alc. and aq.  $\text{H}_2\text{SO}_4$  ..... II 1225  
 distr. betwn.  $\text{Na}_2\text{SO}_4$  and  $(\text{NH}_4)_2\text{SO}_4$  ..... II 1225  
 +  $\text{FeSO}_4 + \text{H}_2\text{O}$  ..... I 1057  
 in ethyl alc. ..... II 1225  
 in glycol ..... II 1225  
 in  $\text{H}_2\text{O}$  ..... II 1219, 20, 1  
 +  $\text{H}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1221, 2  
 +  $\text{K}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 319, 1222  
 in methyl alc. ..... II 1225  
 in aq. methyl alc. ..... II 1224  
 +  $\text{MgSO}_4 + \text{H}_2\text{O}$  ..... II 533-4  
 +  $(\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 762, 3  
 +  $\text{Na}_2\text{SO}_4$  ..... II 1149  
 +  $\text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1137, 8  
 +  $\text{Rb}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1223  
 +  $\text{Ti}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1224  
 · 3 $\text{CH}_3\text{OH} \cdot 3\text{H}_2\text{O}$  in aq.  $\text{CH}_3\text{OH}$  ..... II 1225  
**NiSeO**<sub>3</sub> ..... II 1226  
**NiSeO**<sub>4</sub> in  $\text{H}_2\text{O}$  ..... II 1226  
 +  $\text{H}_2\text{SeO}_4 + \text{H}_2\text{O}$  ..... II 1226  
**NiSiO**<sub>3</sub> +  $\text{Fe} \rightleftharpoons \text{FeSiO}_3 + \text{Ni}$  ..... I 1006  
**NiTiF**<sub>6</sub> in ethyl alc. ..... II 1038  
*p*-nitranisole +  $\text{HgCl}_2$  ..... I 1229  
**Nitriles** +  $\text{SnCl}_4$  ..... II 1468  
**Nitrobenzene** ..... I 1165  
 +  $\text{AlBr}_3$  ..... I 158  
 +  $\text{AlBr}_3 + \text{CoCl}$  ..... I 161  
 +  $\text{AlBr}_3 + \text{LiCl}$  ..... I 161  
 +  $\text{AlBr}_3 + \text{RbCl}$  ..... I 161  
 +  $\text{AlBr}_3 + \text{RbI}$  ..... I 161  
 +  $\text{AlCl}_3 + \text{NH}_4\text{Cl}, \text{NH}_4\text{Br}, \text{acetamide}$  ..... I 174  
 +  $\text{AsBr}_3$  ..... I 229  
 +  $\text{BiBr}_3$  ..... I 425  
 +  $\text{CO}_2$ (*p-v*) ..... I 494  
 +  $\text{H}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... I 1164, 5  
 +  $\text{HgCl}_2$  ..... I 1229  
 +  $\text{SbBr}_3$  ..... II 1423  
 +  $\text{SbI}_3$  ..... II 1438  
**Nitro guanidine** +  $\text{NH}_4\text{NO}_3$  ..... II 728  
**Nitromethane** +  $\text{N}_2\text{O}_4$  f.p. ..... II 794  
*o*-Nitronaphthalene +  $\text{HgCl}_2$  ..... I 1229  
**Nitronaphthalene** +  $\text{H}_2\text{Cl}_2$  + urethan ..... I 1229  
 +  $\text{SbBr}_3$  ..... II 1425  
 +  $\text{SbCl}_3$  ..... II 1435  
*o*-Nitrophenol +  $\text{CO}_2$ (*w.p.*) ..... I 484  
**Nitrophenol** +  $\text{SbBr}_3$  ..... II 1427  
*o*-Nitrotoluene +  $\text{AlBr}_3$  ..... I 158  
*m,p*-Nitrotoluenes +  $\text{AlBr}_3$  ..... I 159  
*o*-Nitrotoluene +  $\text{AlCl}_3$  ..... I 174  
*m,p*-Nitrotoluenes +  $\text{AlCl}_3$  ..... I 175  
*o,m,p*-Nitrotoluenes +  $\text{HgCl}_2$  ..... I 1229  
*p*-Nitrotoluene +  $\text{HgCl}_2$  + urethan ..... I 1229  
**Nitrotoluene** +  $\text{N}_2\text{O}_4$  f.p. ..... I 794  
 +  $\text{TiCl}_4$  ..... II 1552  
**Nitro trichlor methane** +  $\text{N}_2\text{O}_4$  f.p. ..... II 793  
**Nitroxyl** +  $\text{TiCl}_4$  ..... II 1552  
**Ni** xylol selenates in  $\text{H}_2\text{O}$  ..... II 1205  
**Np** ..... II 1227  
**Np**<sub>iv</sub>, **Np**<sub>v</sub>, **Np**<sub>vi</sub> distr. betwn. aq.  $\text{HNO}_3$  and  
 dibutyl carbitol ..... II 1227  
 distr. betwn. aq.  $\text{HNO}_3$  and ether, methyl-*i*-butyl  
 ketone ..... II 1227  
**Np**( $\text{NO}_3$ )<sub>4</sub> distr. betwn. aq.  $\text{HNO}_3$  and tributyl  
 phosphate ..... II 1227  
**NpO**<sub>2</sub> in  $\text{HNO}_3 + \text{H}_2\text{O}$  ..... II 1227  
**Np**( $\text{OH})_2$  in  $(\text{NH}_4)_2\text{SO}_4$  ..... II 1227  
**Np**( $\text{OH})_3$  in  $(\text{NH}_4)_2\text{SO}_4 + \text{NH}_3$  ..... II 1227  
**Np**( $\text{OH})_4$  in  $(\text{NH}_4)_2\text{SO}_4 + \text{NH}_3$  ..... II 1227  
**NpO**<sub>2</sub>( $\text{NO}_3$ )<sub>2</sub> distr. betwn. aq.  $\text{HNO}_3$  and tributyl  
 phosphate ..... II 1227  
**Np**<sub>3</sub>( $\text{PO}_4$ )<sub>4</sub> in  $\text{HNO}_3 + \text{H}_3\text{PO}_4$  ..... II 1227  
**O**<sub>2</sub> ..... II 1228  
 +  $\text{Co}$  ..... I 790  
 +  $\text{CO}_2$ (*p-v*) ..... I 493  
 in aq. acids and bases ..... II 1229, 30  
 in aq. alc. ..... II 1232  
 in  $\text{Bi}$  ..... II 1239  
 in blood ..... II 1233, 4, 5  
 in aq. cane sugar ..... II 1238  
 in chlorine ..... II 1238  
 in aq. chloro hydrate ..... II 1233  
 in  $\text{Fe}$  ..... II 1239  
 in  $\text{Fe} + \text{Al}$  ..... II 1239

- in Fe + FeO + SiO<sub>2</sub> ..... II 1239  
 in Fe + Mn ..... II 1239  
 in Fe + Si ..... II 1239  
 in aq. glucose ..... II 1233  
 in aq. glycerol ..... II 1233  
 in hemoglobin ..... II 1234  
 in H<sub>2</sub>O ..... II 1228  
 in H<sub>2</sub>O + air ..... II 1228  
 in H<sub>2</sub>O high pressure ..... II 1229  
 in HNO<sub>3</sub> + N<sub>2</sub>O<sub>4</sub> + H<sub>2</sub>O ..... II 1239  
 + H + Zr ..... II 1689  
 in metals ..... II 1239  
 in Mn ..... II 1239  
 in NaCl solns ..... II 1232  
 in Nb ..... II 1239  
 in Ni ..... II 1239  
 + 2NO = 2NO<sub>2</sub> ..... II 793  
 in N<sub>2</sub>O<sub>4</sub> + HNO<sub>3</sub> + H<sub>2</sub>O ..... II 1239  
 + O<sub>3</sub> ..... II 1239  
 in oils and other solvents ..... II 1236  
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   + BiCl<sub>3</sub> ..... I 431  
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   + CdCl<sub>2</sub> ⇌ PbCl<sub>2</sub> + CdBr<sub>2</sub> ..... II 1254  
   + HgBr<sub>2</sub> ..... I 1189  
   + LiBr + H<sub>2</sub>O ..... II 368, 9  
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   in aq. HBr ..... II 1251  
   + KBr ..... II 30  
   + KBr + H<sub>2</sub>O ..... II 1252  
   + LiBr ..... II 371  
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   + NH<sub>4</sub>Br + H<sub>2</sub>O ..... II 613  
   + PbCl<sub>2</sub> ..... II 1254  
   + PbCl<sub>2</sub> in H<sub>2</sub>O ..... II 1253  
   + PbF<sub>2</sub> ..... II 1254  
   + PbI<sub>2</sub> ..... II 1254  
   + PbO ..... II 1254  
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   + Sn ⇌ SnBr<sub>2</sub> + Pb ..... II 1248  
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   + PbCl<sub>2</sub> + CH<sub>3</sub>COOH + H<sub>2</sub>O ..... II 1259  
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**PbCH<sub>2</sub>O<sub>5</sub>·2H<sub>2</sub>O** in H<sub>2</sub>O ..... II 1256  
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   in aq. solns. .... II 264, 5  
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   in H<sub>2</sub>O ..... II 1263  
**Pb(C<sub>4</sub>H<sub>4</sub>O<sub>5</sub>)** in H<sub>2</sub>O ..... II 1263  
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   in H<sub>2</sub>O ..... II 1265  
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   in CCl<sub>4</sub> ..... II 1254  
   in CHCl<sub>3</sub> ..... II 1254  
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   in benzene ..... II 1254  
   in CCl<sub>4</sub> ..... II 1254  
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**Pb(C<sub>6</sub>H<sub>11</sub>)<sub>2</sub>PbBr<sub>2</sub>** in benzene ..... II 1254  
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   in C<sub>6</sub>H<sub>6</sub> ..... II 1267  
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**Pb(C<sub>6</sub>H<sub>11</sub>O<sub>7</sub>)<sub>2</sub>** in H<sub>2</sub>O ..... II 1266  
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**Pb<sub>2</sub>(CO<sub>3</sub>)<sub>2</sub>(OH)<sub>2</sub>** in salt solns. .... II 1275  
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   in H<sub>2</sub>O ..... II 1275  
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**Pb carbonate** in ether ..... II 1271, 2  
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   in pet. ether ..... II 1271, 2  
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   + 2Ag = 2Ag<sub>2</sub>Cl + Pb ..... II 1248  
   + AgCl ..... I 77  
   in AgCl ..... II 1293  
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   in CaCl<sub>2</sub> + NaCl<sub>2</sub> ..... II 1281  
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   + CdBr<sub>2</sub> = PbBr<sub>2</sub> + CdCl<sub>2</sub> ..... II 1254  
   + CdCl<sub>2</sub> ..... I 728  
   + CdCl<sub>2</sub> + AgCl ..... I 78  
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   + CdCl<sub>2</sub> + KCl ..... II 168  
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   in aq. ethylene glycol ..... II 1289  
   in aq. ethylene glycol + KCl ..... II 1289  
   + FeCl<sub>2</sub> ..... I 1016  
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   in aq. HgCl<sub>2</sub> ..... II 1284  
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   + 2NaI = 2NaCl + PbI<sub>2</sub> ..... II 1012  
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   + PbBr<sub>2</sub> ..... II 1254  
   + PbBr<sub>2</sub> in H<sub>2</sub>O ..... II 1253  
   + Pb(CH<sub>3</sub>COO)<sub>2</sub> + H<sub>2</sub>O ..... II 1259  
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   + ZnCl<sub>2</sub> ..... II 1293  
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   in ammonium acetate ..... II 1297  
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   in aq. HClO<sub>4</sub> ..... II 1296  
   in aq. HClO<sub>4</sub> + PbClO<sub>4</sub> ..... II 1296  
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   + PbSO<sub>4</sub> ..... II 1297  
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   + KF ..... II 211  
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- $+ K_2SO_4 \rightleftharpoons PbSO_4 + 2KF$  ..... II 211  
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 in NaF ..... II 1298  
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 $+ PbBr_2$  ..... II 1254  
 $+ PbI_2$  ..... II 1299  
 $+ PbO$  ..... II 1299  
 $+ Pb_3(PO_4)_2$  ..... II 1299  
 $+ PbSO_4$  ..... II 1299  
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 in aq. salt solns. .... II 1298  
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 $+ Pb_3(VO_4)_2$  ..... II 1299  
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**PbF<sub>2</sub> tri methyl** in several solvents ..... II 1299  
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 in  $H_2O$  ..... II 1249  
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**Pb heptylate** in ether ..... II 1271, 2  
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 $+ AgI$  ..... I 100  
 $+ AgI$  ..... II 1304  
 in amyl alc. .... II 1303  
 in aniline ..... II 1303  
 in  $Ca(NO_3)_2$  ..... II 1302  
 $+ CdCl_2 \rightleftharpoons CdI_2 + PbCl_2$  ..... II 1293  
 in aq.  $CdI_2$  ..... II 1303  
 $+ CdI_2 + NaI$  ..... II 1055  
 in  $Ca(NO_3)_2$  solns. .... II 1301  
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 $+ 2KCl \rightleftharpoons 2KI + PbCl_2$  ..... II 169  
 $+ KI$  ..... II 234  
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 in  $KNO_3$  ..... II 1302  
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 $+ NH_4I + H_2O$  ..... II 1302  
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 $+ 2NaCl \rightleftharpoons 2NaI + PbCl_2$  ..... II 1012  
 $+ NaI + H_2O$  ..... II 1046  
 $+ PbBr_2$  ..... II 1254  
 $+ PbCl_2 + H_2O$  ..... II 1279  
 $+ PbF_2$  ..... II 1299  
 in  $Pb(NO_3)_2$  solns. .... II 1301  
 $+ PbO$  ..... II 1304  
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 in KCl solns. .... II 1305  
 in  $KIO_3$  solns. .... II 1305  
 in  $KNO_3$  solns. .... II 1305  
 in monochloroacetate solns. .... II 1305  
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 in NaCl solns. .... II 1305  
 in Na lactate solns. .... II 1305  
 in  $NaNO_3$  solns. .... II 1305  
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 in  $Pb(NO_3)_2$  solns. .... II 1272  
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**Pb lignocerate** in ether ..... II 1271, 2  
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 in aq.  $HNO_3$  ..... II 1306  
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 in  $HClO_4$  + salts ..... II 1306  
 $+ K_2TiO_3 \rightleftharpoons PbTiO_3 + K_2MoO_4$  ..... II 246  
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 $+ Na_2TiO_3 \rightleftharpoons PbTiO_3 + Na_2MoO_4$  ..... II 1065  
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**Pb(NO<sub>3</sub>)<sub>2</sub>** +  $AgNO_3$  ..... I 123  
 $+ AgNO_3 + H_2O$  ..... II 1117  
 $+ Ba(NO_3)_2 + H_2O$  ..... I 375  
 $+ Ca(NO_3)_2 + NaNO_3$  ..... I 629  
 $+ CsNO_3$  ..... I 899  
 $+ NH_4NO_3 + AgNO_3 + H_2O$  ..... II 1117  
**Pb(NO<sub>3</sub>)<sub>2</sub>-Pb(NO<sub>3</sub>)<sub>2</sub>-2Pb(OH)<sub>2</sub>-2H<sub>2</sub>O** in aq. acetic acid ..... II 1307  
**Pb(NO<sub>3</sub>)<sub>2</sub>** distr. betwn.  $HNO_3$  +  $Ca(NO_3)_2$  + methyl isobutyl ketone ..... II 1352  
**Pb(NO<sub>3</sub>)<sub>2</sub>** +  $LiNO_3 + H_2O$  ..... II 424  
 $+ NaNO_3 + H_2O$  ..... II 1078  
 in aq. methyl alc. .... II 1311  
 in aq.  $Cu(NO_3)_2$  ..... II 1309  
 distr. betwn.  $PbSO_4$  +  $Li_2SO_4$  ..... II 1354  
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 in ethyl alc. .... II 1311  
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 in methyl alc. .... II 1311  
 $+ NaNO_2 + H_2O$  ..... II 1068  
 $+ NaNO_3$  ..... II 1083  
 $+ NaNO_3 + H_2O$  ..... II 1310  
 $+ NaNO_3 + H_2O$  v.p. .... II 1078  
 $+ NH_4NO_3$  ..... II 727  
 $+ NH_4NO_3 + H_2O$  ..... II 717  
 $+ NH_4NO_3 + H_2O$  v.p. .... II 717  
 $+ NH_4NO_3 + KNO_3$  ..... II 274  
 $+ NaNO_3 + KNO_3$  ..... II 274  
 $+ NaNO_3 + Sr(NO_3)_2$  ..... II 1083  
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**Pb(NO<sub>3</sub>)<sub>2</sub>-Pb(NO<sub>3</sub>)<sub>2</sub>-2Pb(OH)<sub>2</sub>-2H<sub>2</sub>O** in aq. acetic acid ..... II 1307  
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**Pb(NO<sub>3</sub>)OH** in  $H_2O$  ..... II 1309  
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 in pet. ether ..... II 1271, 2  
**PbO** + acetic acid +  $H_2O$  ..... II 1257  
 $+ As_2O_3 + H_2O$  ..... II 1248  
 $+ As_2O_5 + H_2O$  ..... II 1249  
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 in  $H_2O$  ..... II 1312, 3  
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- in hydrazine ..... II 1313  
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+  $\text{NaOH} + \text{H}_2\text{O}$  ..... II 1314  
in aq.  $\text{NaOH}$  ..... II 1316  
+  $\text{P}_2\text{O}_5$  ..... II 1313  
+  $\text{P}_2\text{O}_5 + \text{H}_2\text{O}$  ..... II 1318  
+  $\text{Pb}$  ..... II 1248  
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 $\text{PbO} + \text{PbCl}_2$  ..... II 1293  
 $\text{PbO} \cdot \text{PbCl}_2 \cdot \text{H}_2\text{O}$  in  $\text{H}_2\text{O}$  ..... II 1247  
 $3\text{PbO} \cdot \text{PbCl}_2 \cdot \text{H}_2\text{O}$  in  $\text{H}_2\text{O}$  ..... II 1247  
 $\text{PbO} + \text{PbF}_2$  ..... II 1299  
+  $\text{PbI}_2$  ..... II 1304  
+  $\text{Pb(OH)}_2 + \text{plumbite} + \text{NaOH} + \text{H}_2\text{O}$  ..... II 1316  
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+  $\text{PbS}$  ..... II 1313  
+  $\text{PbS} + \text{Pb}$  ..... II 1313  
+  $\text{PbSO}_4$  ..... II 1313  
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+  $\text{SO}_3$  ..... II 1313  
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+  $\text{V}_2\text{O}_5$  ..... II 1313  
+  $\text{WO}_3$  ..... II 1313  
 $\text{PbO} \cdot \text{H}_2\text{O}$  ..... II 1314  
in  $\text{H}_2\text{O}$  ..... II 1314  
in  $\text{H}_2\text{SO}_4$  ..... II 1314  
in  $\text{KOH}$  ..... II 1315  
in  $\text{NaOH}$  solns. .... II 1315  
 $\text{Pb}_2\text{O}_4$  in  $\text{H}_2\text{SO}_4$  ..... II 1317  
+  $\text{Na}_2\text{TiO}_3$  ..... II 1171  
+  $\text{PbSO}_4$  ..... II 1334  
 $\text{Pb}_2\text{O}_3$  in aq.  $\text{NaOH}$  ..... II 1317  
 $\text{Pb}_2\text{O}_4$  in  $\text{H}_2\text{O}$  ..... II 1316  
+  $\text{Pb(NO}_3)_2 + \text{KNO}_3$  ..... II 274  
 $\text{Pb(OH)}_2$  ..... II 1314  
 $\text{Pb(OH)}_2 \text{ Ksp}$  ..... II 1314  
 $\text{Pb(OH)}_2$  in  $\text{HClO}_3$  ..... II 1314  
in  $\text{H}_2\text{O}$  ..... II 1314  
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 $\text{Pb(OH)}_2$  various forms in aq.  $\text{NaOH}$  ..... II 1315, 6  
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 $\text{Pb(OH)}_2 + \text{PbO} + \text{plumbite} + \text{NaOH} + \text{H}_2\text{O}$  ..... II 1316  
 $\text{Pb(OH)}_4$  in  $\text{H}_2\text{O}$  ..... II 1316  
 $\text{Pb oleate}$  in ether ..... II 1273  
 $\text{Pb(PO}_3)_2 + \text{BiTiO}_3$  ..... I 439  
 $\text{Pb(PO}_3)_2 + \text{BiTiO}_3$  ..... I 439  
 $\text{Pb}_2(\text{PO}_4)_2$  in aq. acetic acid ..... II 1317  
+  $\text{BiTiO}_3$  ..... I 439  
in  $\text{H}_2\text{O}$  ..... II 1317  
+  $\text{PbCl}_2$  ..... II 1293  
+  $\text{PbF}_2$  ..... II 1299  
+  $\text{PbO}$  ..... II 1313  
 $\text{Pb}_2\text{P}_2\text{O}_7 + 4\text{Ag} = \text{Ag}_4\text{P}_2\text{O}_7 + 2\text{Pb}$  ..... II 1248  
+  $4\text{Ag} = \text{Ag}_4\text{P}_2\text{O}_7 + 2\text{Pb}$  ..... I 7  
 $\text{PbPO}_3\text{F}$  in  $\text{H}_2\text{O}$  ..... II 1300  
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in  $\text{H}_2\text{O}$  ..... II 1272  
 $\text{Pb palmitate}$  in several solvents ..... II 1268  
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 $\text{PbS} + \text{Ag}$  ..... I 7  
+  $2\text{Ag} = \text{Ag}_2\text{S} + \text{Pb}$  ..... I 7  
+  $2\text{AgCl} = \text{Ag}_2\text{S} + \text{PbCl}_2$  ..... I 78  
+  $\text{Ag}_2\text{S}$  ..... II 1319  
+  $\text{Ag}_2\text{S}$  ..... I 130  
+  $\text{Ag}_2\text{S} + \text{Cu}_2\text{S}$  ..... I 130  
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+  $\text{Fe} = \text{FeS} + \text{Pb}$  ..... I 1006  
in  $\text{H}_2\text{O}$  ..... II 1318  
+  $\text{Pb}$  ..... II 1248  
+  $\text{PbCl}_2$  ..... II 1293  
+  $\text{PbO}$  ..... II 1313  
+  $\text{PbO} + \text{Pb}$  ..... II 1313  
+  $\text{Sb}_2\text{S}_3$  ..... II 1319, 1440  
+  $\text{SiS}_2$  ..... II 1319  
+  $\text{Sn} = \text{Pb} + \text{SnS}$  ..... II 1248  
+  $\text{Ti}_2\text{S}$  ..... II 1319  
+  $\text{ZnS}$  ..... II 1319  
 $\text{Pb(SCN)}_2$  in  $\text{H}_2\text{O}$  ..... II 1273  
in  $\text{KSCN}$  ..... II 1274  
in  $\text{SO}_2$  (liq.) ..... II 1274  
 $\text{PbSO}_3$  ..... II 1319  
in aq.  $\text{NH}_4\text{OAc}$  ..... II 1319  
 $\text{Pb(SO}_3)_2\text{NH}_2$  in  $\text{H}_2\text{O}$  ..... II 1336  
 $\text{PbSO}_4$  ..... II 1320  
in aq. acetone ..... II 1333  
in  $t$ -butyl alc. +  $\text{H}_2\text{O}$  ..... II 1332  
in aq. dioxane ..... II 1333  
in aq. ethanol ..... II 1331  
in aq. ethylene glycol ..... II 1332  
in aq. glycerol ..... II 1332  
in aq.  $\text{HClO}_4$  ..... II 1325  
in aq.  $\text{K acetate}$  ..... II 1329  
in aq.  $\text{K}_2\text{SO}_4$  ..... II 1327  
in aq.  $\text{NH}_4$  acetate ..... II 1329, 30  
in aq.  $(\text{NH}_4)_2\text{SO}_4$  ..... II 1328  
in aq.  $\text{Na acetate}$  ..... II 1329, 1330  
in aq.  $\text{NaCl}$  ..... II 1330  
in aq.  $\text{Na}_2\text{SO}_4$  ..... II 1328  
in electrolytes ..... II 1327, 8, 9  
in  $\text{H}_2\text{O}$  ..... II 1247, 1320, 1331  
in  $\text{H}_2\text{O} + \text{CO}_2$  ..... II 1320  
in isodielectric solvents ..... II 1333  
+  $\text{K}_2\text{SO}_4$  ..... II 1334  
in  $\text{HCl}$  ..... II 1324  
in  $\text{HCl} + \text{H}_2\text{SO}_4$  ..... II 1324  
in  $\text{HCl} + (\text{NH}_4)_2\text{SO}_4$  ..... II 1324  
in  $\text{HClO}_4 + \text{H}_2\text{SO}_4$  ..... II 1325  
in  $\text{HNO}_3$  ..... II 1325  
in  $\text{HNO}_3 + \text{H}_2\text{SO}_4$  ..... II 1326  
in  $\text{HNO}_3 + (\text{NH}_4)_2\text{SO}_4$  ..... II 1326  
in  $\text{H}_2\text{SO}_4$  ..... II 1320, 1, 2, 3  
+  $\text{H}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 1323  
in  $\text{H}_2\text{SO}_4 + \text{PbNO}_3$  ..... II 1323  
in  $\text{K}^+$  ..... II 1330  
in  $\text{KCl} + \text{HCl}$  ..... II 1330  
+  $2\text{KF} = \text{K}_2\text{SO}_4 + \text{PbF}_2$  ..... II 211  
+  $\text{K}_2\text{MoO}_4 = \text{PbMoO}_4 + \text{K}_2\text{SO}_4$  ..... II 246  
+  $\text{K}_2\text{SO}_4$  ..... II 325  
 $\text{PbK}_2(\text{SO}_4)_2$  ..... II 1329  
 $\text{PbSO}_4 + \text{K}_2\text{SO}_4$  in  $\text{H}_2\text{O}$  ..... II 319  
 $\text{PbSO}_4 + \text{K}_2\text{WO}_4 = \text{PbWO}_4 + \text{K}_2\text{SO}_4$  ..... II 326  
in  $\text{Li}^+$  ..... II 1330  
+  $2\text{LiF} = \text{PbF}_2 + \text{Li}_2\text{SO}_4$  ..... II 1299  
+  $\text{Li}_2\text{SO}_4$  ..... II 439  
in  $\text{Li}_2\text{SO}_4 + \text{Th(NO}_3)_4$  ..... II 1331  
+  $\text{Li}_2\text{WO}_4 = \text{PbWO}_4 + \text{Li}_2\text{SO}_4$  ..... II 439  
in  $\text{Mg}^{++} + \text{Al}^{+++}$  ..... II 1330  
in  $\text{Na}^+$  ..... II 1330  
+  $2\text{NaCl} = \text{PbCl}_2 + \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  ..... II 986, 7  
+  $2\text{NaF} = \text{Na}_2\text{SO}_4 + \text{PbF}_2$  ..... II 1040  
in  $\text{NaNO}_3$  ..... II 1331  
+  $\text{Na}_2\text{MoO}_4 = \text{Na}_2\text{SO}_4 + \text{PbMoO}_4$  ..... II 1065  
+  $\text{Na}_2\text{MoO}_4 = \text{PbMoO}_4 + \text{Na}_2\text{SO}_4$  ..... II 1149  
+  $\text{Na}_2\text{SO}_4$  ..... II 1149  
+  $\text{Na}_2\text{SO}_4$  ..... II 1334  
in  $\text{Na}_2\text{SO}_4 + \text{C}_2\text{H}_5\text{OH}$  ..... II 1332  
in  $\text{NO}_3^- + \text{SO}_4^{--}$  ..... II 1330  
+  $\text{PbCrO}_4$  ..... II 1297  
+  $\text{PbCrO}_4$  in aq.  $\text{HCl}$  ..... II 1296  
+  $\text{PbF}_2$  ..... II 1299  
+  $\text{PbMoO}_4$  ..... II 1306  
in  $\text{Pb(NO}_3)_2$  ..... II 1327  
+  $\text{PbO}$  ..... II 1313  
+  $\text{PbO} + \text{Pb}$  ..... II 1313  
+  $\text{Pb}_2\text{O}_4$  ..... II 1334  
in salt solns. .... II 1331  
+  $\text{SnCl}_4$  ..... II 1293  
in aq.  $\text{ThCl}_4$  ..... II 1331  
in  $\text{ZnSO}_4$  ..... II 1330  
 $\text{PbSO}_4$ , basic, in  $\text{H}_2\text{O}$  ..... II 1334  
 $\text{Pb}_2\text{O}_3$  in  $\text{H}_2\text{O}$  ..... II 1334  
in  $\text{NH}_4\text{OAc}$  ..... II 1334  
 $\text{Pb}_2\text{O}_4 + \text{SrSO}_4$  ..... II 1335  
 $\text{Pb}_2\text{O}_4$  in aq.  $\text{H}_2\text{SO}_4$  ..... II 1335  
 $\text{PbSeO}_3$  in  $\text{HNO}_3$  ..... II 1336  
in  $\text{H}_2\text{O}$  ..... II 1336

- in  $\text{H}_2\text{SO}_4$  ..... II 1336  
**PbSeO<sub>4</sub>** ..... II 1336  
 in  $\text{K}_2\text{SeO}_4$  ..... II 1336  
 in aq.  $\text{Li}_2\text{SeO}_4$  ..... II 1336  
 in  $\text{Na}_2\text{SeO}_4$  ..... II 1336  
**PbSiF<sub>6</sub>** in  $\text{H}_2\text{O}$  ..... II 1300  
 +  $\text{H}_2\text{SiF}_6$  +  $\text{H}_2\text{O}$  ..... II 1300  
**PbSiO<sub>3</sub>** -  $\text{Na}_2\text{SiO}_3$  ..... II 1169  
**Pb salt of methyl adipic acid** ..... II 1266  
**Pb salts** in blood serum ..... II 1274  
**Pb stearate** in chloroform ..... II 1272  
 in several solvents ..... II 1272  
**Pb sulfonates** in  $\text{H}_2\text{O}$  ..... II 1268, 9  
**Pb<sub>8</sub>Ti<sub>12</sub>O<sub>38</sub>·33H<sub>2</sub>O** ..... II 1336  
**PbTiO<sub>3</sub>** ..... II 1337  
 + BaTi ..... II 1337  
 + BaTiO<sub>3</sub> + CaTiO<sub>3</sub> ..... II 1337  
 + BaTiO<sub>3</sub> + K<sub>2</sub>F<sub>2</sub> ..... II 1337  
 + K<sub>2</sub>CO<sub>3</sub> ..... II 1337  
 + KF ..... II 1337  
 + K<sub>2</sub>MoO<sub>4</sub> ..... II 1337  
 + K<sub>2</sub>MoO<sub>4</sub>  $\rightleftharpoons$  K<sub>2</sub>TiO<sub>3</sub> + PbMoO<sub>4</sub> ..... II 246  
 + K<sub>2</sub>SiO<sub>3</sub> ..... II 1337  
 + KVO<sub>3</sub> ..... II 1337  
 + 2NaF  $\rightleftharpoons$  Na<sub>2</sub>TiO<sub>3</sub> + PbF<sub>2</sub> ..... II 1040  
 + Na<sub>2</sub>CO<sub>3</sub> ..... II 1337  
 + Na<sub>2</sub>MoO<sub>4</sub> ..... II 1337  
 + Na<sub>2</sub>MoO<sub>4</sub>  $\rightleftharpoons$  Na<sub>2</sub>TiO<sub>3</sub> + PbMoO<sub>4</sub> ..... II 1065  
 + NaSiO<sub>3</sub> ..... II 1337  
 + NaVO<sub>3</sub> ..... II 1337  
 + Na<sub>2</sub>WO<sub>4</sub> ..... II 1337  
**Pb tetraphenyl distr. betwn. silicon** + Sn tetraphenyls ..... II 1273  
**Pb trinitro resorcinate** in glycol diacetate ..... II 1270  
**Pb(VO<sub>3</sub>)<sub>2</sub> K<sub>sp</sub>** ..... II 1337  
**Pb<sub>3</sub>(VO<sub>4</sub>)<sub>2</sub> + 6LiCl  $\rightleftharpoons$  2Li<sub>3</sub>VO<sub>4</sub> + 3PbCl<sub>2</sub>** ..... II 406  
 + PbCl<sub>2</sub> ..... II 1293  
 + PbF<sub>2</sub> ..... II 1299  
 + PbO ..... II 1313  
**PbWO<sub>4</sub> + Bi<sub>2</sub>(WO<sub>4</sub>)<sub>3</sub>** ..... I 439  
 + Ce<sub>2</sub>(WO<sub>4</sub>)<sub>3</sub> ..... I 782  
 in  $\text{H}_2\text{O}$  ..... II 1337  
 + K<sub>2</sub>SO<sub>4</sub>  $\rightleftharpoons$  K<sub>2</sub>WO<sub>4</sub> + PbSO<sub>4</sub> ..... II 326  
 + Li<sub>2</sub>SO<sub>4</sub>  $\rightleftharpoons$  Li<sub>2</sub>WO<sub>4</sub> + PbSO<sub>4</sub> ..... II 439  
 + PbCrO<sub>4</sub> ..... II 1297  
**Pd** ..... II 1337  
**Pd acetoxime** in acetone ..... II 1338  
**Pd ammine chloride** in HCl ..... II 1338  
**Pd + dimethylglyoxime** in HCl ..... II 1337  
**Pd distr. betwn Fe + FeS** ..... II 1337  
**Pd extr. from HCl by ether** ..... II 1338  
**Pd + H** ..... II 1337  
**PdCl<sub>2</sub>** in ether ..... II 1338  
 in hydrazine ..... II 1338  
**PdI<sub>2</sub>** in KI ..... II 1338  
**Pentene** + CO<sub>2</sub>(p-v) ..... I 490  
 + SO<sub>2</sub> ..... II 1421  
**PH<sub>3</sub>** in  $\text{H}_2\text{O}$  ..... II 1244  
**Phenacetin** + S ..... II 1403  
**Phenanthrene** + AsI<sub>3</sub> ..... I 231  
**Phenotolo** + GeCl<sub>4</sub> ..... II 1073  
 + SbBr<sub>3</sub> ..... II 1425  
 + SbCl<sub>3</sub> ..... II 1433  
 + SiCl<sub>4</sub> ..... II 1450  
 + SnCl<sub>4</sub> ..... II 1469  
**Phenol** + AgNO<sub>3</sub> ..... I 120  
 + AgNO<sub>3</sub> +  $\text{H}_2\text{O}$  ..... I 118  
 + AsBr<sub>3</sub> ..... I 230  
 + Ba(OH)<sub>2</sub> +  $\text{H}_2\text{O}$  ..... I 382  
 + Ca(OH)<sub>2</sub> +  $\text{H}_2\text{O}$  ..... I 641, 2  
 + caproate +  $\text{H}_2\text{O}$  ..... II 870  
 + H<sub>3</sub>BO<sub>3</sub> +  $\text{H}_2\text{O}$  ..... I 279  
 + HCl +  $\text{H}_2\text{O}$  ..... I 1113  
 + H<sub>3</sub>PO<sub>3</sub> ..... I 1148  
 + H<sub>3</sub>PO<sub>4</sub> +  $\text{H}_2\text{O}$  ..... I 1151  
 + H<sub>2</sub>S ..... I 1158  
 + H<sub>2</sub>SO<sub>4</sub> ..... I 1165  
 + H<sub>2</sub>SO<sub>4</sub> +  $\text{H}_2\text{O}$  ..... I 1165  
 + HgI<sub>2</sub> acetate ..... I 1192  
 + KOH +  $\text{H}_2\text{O}$  ..... II 53, 279  
 + lauric acid +  $\text{H}_2\text{O}$  ..... II 894  
 + LiOH +  $\text{H}_2\text{O}$  ..... II 430  
 + MgSO<sub>4</sub> +  $\text{H}_2\text{O}$  ..... II 538  
 + N<sub>2</sub>H<sub>5</sub> f.p. .... II 785  
 + Na acetate +  $\text{H}_2\text{O}$  ..... II 857  
 + Na formate +  $\text{H}_2\text{O}$  ..... II 852  
 + NaOH +  $\text{H}_2\text{O}$  ..... II 871  
 + Na oleate +  $\text{H}_2\text{O}$  ..... II 901  
 + Na oleate + toluene +  $\text{H}_2\text{O}$  ..... II 901  
 + Na propionate ..... II 860  
 + Na trichloroacetate +  $\text{H}_2\text{O}$  ..... II 859  
 + NH<sub>4</sub>SCN +  $\text{H}_2\text{O}$  ..... II 637  
 + SO<sub>2</sub> ..... II 1421  
 + SbBr<sub>3</sub> ..... II 1425  
 + SbCl<sub>3</sub> ..... II 1433  
 + Sr(OH)<sub>2</sub> +  $\text{H}_2\text{O}$  ..... II 1488  
 + Sr(OH)<sub>2</sub> +  $\text{H}_2\text{O}$  ..... II 1515  
**Phenolphthalein anhydride** + Na<sub>2</sub>O +  $\text{H}_2\text{O}$  ..... II 907, 8  
**Phenolphthalein** + KOH +  $\text{H}_2\text{O}$  ..... II 64  
**Phenylacetic acid** + K phenyl acetate ..... II 60  
 + Li phenylacetate ..... II 374  
**Phenylacetic acid** + Na phenylacetate ..... II 860  
 + Na phenylacetate +  $\text{H}_2\text{O}$  ..... II 860  
 + Rb phenylacetate ..... II 1358  
**Phenylacetic anhydride** + Na phenylacetate ..... II 860  
 + Li phenyl acetate ..... II 375  
**Phenylendiamines** + NH<sub>4</sub>NO<sub>3</sub> ..... II 728  
**Phenyl hydrazine** + H<sub>2</sub>S ..... I 1159  
**Phenyltrimethyl ammonium sodida** + I<sub>2</sub> f.p. .... II 704  
**Phosphate rock** in  $\text{H}_2\text{O}$  ..... I 648  
**Phospho molybdic acid** in  $\text{H}_2\text{O}$  ..... I 1152  
**Phthalic acid** + K phthalate +  $\text{H}_2\text{O}$  ..... II 57, 8  
 + Li phthalate +  $\text{H}_2\text{O}$  ..... II 379  
 + Mg Phthalate +  $\text{H}_2\text{O}$  ..... II 459  
 + Na phthalate +  $\text{H}_2\text{O}$  ..... II 885  
**Picoline** + Na<sub>2</sub>CO<sub>3</sub> +  $\text{H}_2\text{O}$  ..... II 945  
 + Na<sub>2</sub>SO<sub>4</sub> +  $\text{H}_2\text{O}$  ..... II 1147  
 + (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> +  $\text{H}_2\text{O}$  ..... II 773  
 + SO<sub>2</sub> ..... II 1420  
**Picric acid** + NH<sub>4</sub>NO<sub>3</sub> ..... II 728  
**Piperidine** +  $\text{H}_2\text{O}$  ..... I 1147  
**Piperalol** + H<sub>2</sub>PO<sub>3</sub> ..... I 1148  
**Pirssonite** in  $\text{H}_2\text{O}$  ..... I 547, 8  
**Plumbite** + NaOH + PbO + Pb(OH)<sub>2</sub> +  $\text{H}_2\text{O}$  ..... II 1316  
**Po acetate** in KOH ..... II 1339  
**Po cyanide** in KOH ..... II 1339  
**Po hydroxide** in KOH ..... II 1339  
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**Polysilicic acid**, effect of partial size ..... II 1455  
**Ponceau red. distr. betwn. mixed crystals** + K<sub>2</sub>SO<sub>4</sub> ..... II 321  
**Porcelain glazes** in citric acid ..... II 1247  
 in vinegar ..... II 1247  
**Pr** ..... II 1339  
**Pr cmpds.**, see also Di  
**Pr<sup>+++</sup> ext. from acid by acetylacetone** ..... II 1341  
**Pr(BiO<sub>3</sub>)<sub>3</sub>·9H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1339  
**Pr(C<sub>2</sub>H<sub>3</sub>O<sub>3</sub>)<sub>3</sub>** in  $\text{H}_2\text{O}$  ..... II 1339  
**Pr(C<sub>3</sub>H<sub>5</sub>O<sub>3</sub>)<sub>3</sub>·2H<sub>2</sub>O** ..... II 1339  
**Pr(C<sub>3</sub>H<sub>7</sub>COO)<sub>3</sub>** in  $\text{H}_2\text{O}$  ..... II 1339  
**Pr<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub>** in aq. acids ..... II 1341  
 in aq. HNO<sub>3</sub> ..... II 1341  
 in HNO<sub>3</sub> + H<sub>2</sub>Cr<sub>2</sub>O<sub>4</sub> ..... II 1341  
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**Pr<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub>·10H<sub>2</sub>O** ..... II 1340  
**Pr<sub>2</sub>(CH<sub>3</sub>)<sub>2</sub>PO<sub>4</sub>)<sub>6</sub>** in  $\text{H}_2\text{O}$  ..... II 1345  
**PrCl<sub>3</sub>** in HCl aq. .... II 1342  
 in  $\text{H}_2\text{O}$  ..... II 1342  
 in aq. NH<sub>4</sub>Cl ..... II 1342  
 in pyridine ..... II 1342  
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**PrF<sub>3</sub>** + CsF ..... I 889  
 + KF ..... II 211  
 + NaF ..... II 1040  
 + RbF ..... II 1370  
**Pr<sub>2</sub>(MoO<sub>4</sub>)<sub>3</sub>** in  $\text{H}_2\text{O}$  ..... II 1342  
**2Pr(NO<sub>3</sub>)<sub>2</sub>·3Co(NO<sub>3</sub>)<sub>2</sub>·24H<sub>2</sub>O** in  $\text{H}_2\text{O}$ , HNO<sub>3</sub> ..... II 1343, 4  
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 distr. betwn. aq. acid + tributyl phosphate ..... II 1344  
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**2Pr(NO<sub>3</sub>)<sub>3</sub>·3Mn(NO<sub>3</sub>)<sub>2</sub>·24H<sub>2</sub>O** in  $\text{H}_2\text{O}$ , HNO<sub>3</sub> ..... II 1343, 4  
**2Pr(NO<sub>3</sub>)<sub>3</sub>·3Ni(NO<sub>3</sub>)<sub>2</sub>·24H<sub>2</sub>O** in  $\text{H}_2\text{O}$ , HNO<sub>3</sub> ..... II 1344  
**2Pr(NO<sub>3</sub>)<sub>3</sub>·3Zn(NO<sub>3</sub>)<sub>2</sub>·24H<sub>2</sub>O** in  $\text{H}_2\text{O}$ , HNO<sub>3</sub> ..... II 1344

- P: Ne ethylenediamine tetra acetate** in  $H_2O$  ..... II 1340  
 **$Pr_2O_3$**  in ethyl ether ..... II 1344  
   in  $H_2O$  ..... II 1345  
   in  $NH_4Cl$  ..... II 1342  
 **$Pr_6O_{11}$**  in  $H_2O$  ..... II 1345  
 **$Pr(OH)_3$**  in  $H_2O$  ..... II 1345  
 **$Pr(OH)_3$  ppt. from  $NH_4OAc$**  ..... II 1345  
 **$Pr_2(SO_4)_3$**  +  $CS_2SO_4 + H_2O$  ..... I 901  
   in  $H_2O$  ..... II 1345  
   +  $K_2SO_4 + H_2O$  ..... II 320  
   +  $(NH_4)_2SO_4 + H_2O$  ..... II 764  
   +  $Na_2SO_4 + H_2O$  ..... II 1138  
   +  $Rb_2SO_4 + H_2O$  ..... II 1345  
   +  $Tl_2SO_4 + H_2O$  ..... II 1346  
 **$Pr_2(SO_4)_3$**  in  $H_2O$  ..... II 1346  
**Pr sulfates** in  $H_2O$  ..... II 1340  
 **$Pr_2(WO_4)_3$**  in  $H_2O$  ..... II 1346  
**Propane** -  $CO_2$  (p-v) ..... I 490  
   +  $CO_2 + n$ -hexadecane ..... I 489  
   +  $CO_2 +$  stripped crude oil ..... I 489  
   +  $HF$  ..... II 1124  
   +  $H_2S$  ..... II 1160  
**Propionic acid** -  $SO_2 +$  methylene ..... II 1420  
**Propionic acid** -  $HCl$  ..... II 1121  
**Propionitrile** -  $BeCl_2$  ..... I 406  
   +  $TiCl_4$  ..... II 1552  
**Isopropoxyethanol** +  $KCl + H_2O$  ..... II 159  
**Propyl acetate** +  $TiCl_4$  ..... II 1552  
**Propyl alc.** -  $K_2CO_3 + H_2O$  ..... II 96  
   +  $KF + H_2O$  ..... II 206  
   +  $LiBr$  ..... II 370  
   +  $NH_3$  ..... II 603  
   +  $(NH_4)_2SO_4 + H_2O$  ..... II 771  
   +  $NaCl + H_2O$  ..... II 997, 8  
   +  $NaNO_3 + H_2O$  ..... II 1080  
   +  $NaOH + H_2O$  ..... II 1088  
   +  $Na_2CO_3 + H_2O$  ..... II 942  
   +  $Na_2SO_4 + H_2O$  ..... II 1144  
   +  $NH_3$  ..... II 603  
**Isopropyl alc.** +  $K_2CO_3 + H_2O$  ..... II 97  
**Isopropyl alc.** +  $(NH_4)_2HPO_4 + H_2O$  ..... II 744  
**Isopropyl alc.** +  $NaBr + H_2O$  ..... II 842  
**Isopropyl alc.** +  $Na_2CO_3 + H_2O$  ..... II 943  
**Propylamine** +  $NaCl + H_2O$  ..... II 1004  
   +  $NaOH + H_2O$  ..... II 1090  
**Propyl benzoate** -  $HBr$  ..... I 1105  
**Propyl benzoate** -  $SbBr_3$  ..... II 1423  
**Propyl chloride** -  $BCl_3$  ..... I 257  
**n-Propyl phenyl ether** +  $CaCl_2$  ..... I 1073  
**Propylene** +  $H_2S$  ..... I 1160  
**Propoxyethanol** -  $KCl$  ..... II 159  
**Propoxyethanol** +  $KF + H_2O$  ..... II 209  
**Pr + Ag** in  $HNO_3$  ..... II 1347  
**Pt amines** ..... II 1350, 1  
**Pr + Bi** in  $HNO_3$  ..... II 1347  
   +  $Cu$  in  $HNO_3$  ..... II 1347  
   distr. betwn.  $Fe + FeS$  ..... II 1347  
   in  $Hg$  ..... II 1345  
   +  $Pb$  in  $HNO_3$  ..... II 1347  
   +  $Zn$  in  $HNO_3$  ..... II 1347  
 **$PtBr_4$**  in  $H_2O$  ..... II 1347  
 **$PtCl_4$**  distr. betwn.  $H_2O +$  ether ..... II 1348  
   in  $H_2O$  ..... II 1348  
   in hydrazine ..... II 1348  
   +  $NaCl + H_2O$  ..... II 990, 1  
 **$PtC_2Cl_6$**  in  $H_2O$  ..... I 883  
   in  $H_2O$  ..... II 1348  
 **$PtC_2F_6$**  in  $H_2O$  ..... I 889  
 **$Pt_4$**  in aq.  $KI$  ..... II 1351  
 **$PtK_2Br_6$**  in  $H_2O$  ..... II 1347  
 **$PtK_2Cl_6$**  in  $H_2O$  ..... II 1348  
 **$Pt(NH_4)_2Cl_6$**  in  $H_2O$  ..... II 1348  
   +  $Ir(NH_4)_2Cl_6 + H_2O$  ..... I 1304  
 **$PtRb_2Cl_6$**  in  $H_2O$  ..... II 1348  
 **$PtTi_2Cl_6$**  in  $H_2O$  ..... II 1348  
**Pu acetylacetone** distr. betwn. benzene +  $H_2O$  ..... II 1352  
   distr. betwn. chloroform +  $H_2O$  ..... II 1352  
   distr. betwn. methyl isobutyl ketone +  $H_2O$  ..... II 1352  
 **$Pu(C_2O_4)_2$**  in  $HNO_3 + HClO_4$  ..... II 1351  
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   in aq.  $HNO_3$  ..... II 1351  
   in aq.  $H_2SO_4$  ..... II 1351  
   in  $H_2O$  ..... II 1351  
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   in  $NaF + BeF_2$  ..... II 1352  
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 **$Pu_2H(PO_4)_3 \cdot XH_2O$**  in  $HNO_3$  ..... II 1353  
 **$Pu(HPO_4)_2 \cdot YH_2O$**  in  $HNO_3 + H_3PO_4$  ..... II 1353  
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   tributyl phosphate ..... II 1352  
 **$PuO_2F_2$**  in  $H_2O$  ..... II 1352  
 **$Pu(OH)_4$ ,  $Ksp$**  ..... II 1352  
 **$Pu(SO_4)_2 \cdot 4H_2O$**  in alc. .... II 1352  
   in  $H_2SO_4$  ..... II 1352  
 **$PuTi(SO_4)_2 \cdot 4H_2O$**  in  $H_2SO_4$  ..... II 1352  
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   +  $AgNO_3$  ..... I 121  
   +  $CdCl_2$  in  $H_2O$ , aq. solvents ..... I 727  
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**3Pyridine- $Cu(NO_3)_3$**  in pyridine ..... I 840  
**4Pyridine- $2CuBr$**  in  $H_2O$  ..... I 907  
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   +  $K_2CO_3 + H_2O$  ..... II 99-101  
   +  $KF + H_2O$  ..... II 201  
   +  $KOH + H_2O$  ..... II 278  
   +  $MgSO_4 + H_2O$  ..... II 536  
   +  $(NH_4)_2SO_4 + H_2O$  ..... II 772  
   +  $Na_2CO_3 + H_2O$  ..... II 944, 5  
   +  $NaCl + H_2O$  ..... II 1004  
   +  $NaNO_3 + H_2O$  ..... II 1080  
   +  $NaOH + H_2O$  ..... II 1094, 5  
   +  $Na_2SO_4 + H_2O$  ..... II 1147  
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   +  $POCl_3$  ..... II 1244  
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   +  $KBr + H_2O$  ..... II 30  
   +  $KCl \rightleftharpoons RbCl + KBr$  ..... II 31  
   +  $KF$  ..... I 212  
   +  $LiBr$  ..... II 1357  
   +  $LiI$  ..... I 417  
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- + NaF ..... II 1040  
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 + CsCl + CaCl<sub>2</sub> ..... I 597  
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 + CsF ..... I 889  
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 + RbF ..... II 1366  
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**Rb<sub>3</sub>Co(NO<sub>2</sub>)<sub>6</sub>·H<sub>2</sub>O** in H<sub>2</sub>O ..... I 835  
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**Rb<sub>2</sub>CoO<sub>4</sub>** in H<sub>2</sub>O ..... II 1368  
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**Rb<sub>2</sub>Cr<sub>3</sub>O<sub>7</sub>** in H<sub>2</sub>O ..... II 1369  
**RbCr(SO<sub>4</sub>)<sub>2</sub>·12H<sub>2</sub>O** in H<sub>2</sub>O ..... II 1380  
**Rb<sub>2</sub>Cu(SO<sub>4</sub>)<sub>2</sub>·6H<sub>2</sub>O** in H<sub>2</sub>O ..... II 1379  
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**Rb dipicrylamine** in H<sub>2</sub>O ..... II 1361  
**RbF** in acetone ..... II 1370  
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 + CsBr ..... I 875  
 + CsCl ..... II 1370  
 + CsCl ..... I 886  
 + CsI ..... II 1370  
 + CsI ..... I 896  
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 + KF ..... II 211  
 + KI ..... II 234  
 + LaF<sub>3</sub> ..... II 350, 1370  
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**RbF** + LiCl = RbCl + LiF ..... II 406  
 + LiF ..... II 414  
 + LiI ..... II 417  
 + Li<sub>2</sub>TiO<sub>3</sub> ..... II 440  
 + MgF<sub>2</sub> ..... II 498  
 + MgF<sub>2</sub> + KF ..... II 211  
 + MoO<sub>3</sub> ..... II 1370  
 + NaBr ..... II 847  
 + NaI ..... II 1055  
 + PtF<sub>3</sub> ..... II 1370  
 + Rb<sub>2</sub>CO<sub>3</sub> ..... II 1361  
 + RbCl ..... II 1366  
 + Rb<sub>2</sub>CrO<sub>4</sub> ..... II 1370  
 + Rb<sub>2</sub>MoO<sub>4</sub> ..... II 1370  
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**RbHSO<sub>4</sub>** + RbHTeO<sub>4</sub> ..... II 1380  
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 + PO(C<sub>6</sub>H<sub>5</sub>)<sub>3</sub> ..... II 1441  
 + PS(C<sub>6</sub>H<sub>5</sub>)<sub>3</sub> ..... II 1441  
**SbCl<sub>3</sub> + acetic acid** ..... II 1429  
 in acetone ..... II 1434  
 + acetophenone ..... II 1429  
 in acetylene tetrachloride ..... II 1434  
 + AlCl<sub>3</sub> ..... I 177  
 + aniline ..... II 1429  
 + anisole ..... II 1429  
 + azobenzene ..... II 1435  
 + benzaldehyde ..... II 1429  
 + benzaniline ..... II 1435  
 + benzene ..... II 1435  
 + benzene cmpds. .... II 1431  
 + benzene sulphonic acid ..... II 1430  
 + benzil ..... II 1435  
 + benzoic acid ..... II 1430  
 + benzophenone ..... II 1429  
 + benzoyl chloride ..... II 1430  
 + BiCl<sub>3</sub> ..... I 431  
 + C<sub>6</sub>H<sub>5</sub>Cl in aq. HCl ..... I 884  
 + chloroacetic acid ..... II 1435  
 + chlor naphthalene ..... II 1435  
**2SbCl<sub>3</sub>·3C<sub>6</sub>H<sub>5</sub>Cl in aq. HCl** ..... I 884  
**SbCl<sub>3</sub> + cyanotoluene** ..... II 1435  
 + cyclohexane ..... II 1431  
 + cymene ..... II 1432  
 + diphenyl ..... II 1432  
 + diphenyl ethane ..... II 1435  
 + diphenyl methane ..... II 1432, 5  
 distr. betwn. HCl + ether ..... II 1429  
 in ethyl acetate ..... II 1434  
 + halide benzenes ..... II 1430  
 in HCl ..... II 1428  
 + HgCl<sub>2</sub> ..... I 1229  
 in H<sub>2</sub>O ..... II 1428  
 + I<sub>2</sub> ..... I 1286  
 + KCl ..... II 169

- + KCl + H<sub>2</sub>O ..... II 1428  
 + mesitylene ..... II 1432  
 + NH<sub>4</sub>Cl ..... II 682  
 extr'n. NH<sub>4</sub>SCN ..... II 1428  
 + naphthalene ..... II 1435  
 + naphthalenes ..... II 1432, 3  
 + nitro naphthalene ..... II 1435  
 + phenetol ..... II 1433  
 + phenol ..... II 1433  
 + SbBr<sub>3</sub> ..... II 1427  
 + SbCl<sub>5</sub> ..... II 1435  
 + Sbl<sub>3</sub> ..... II 1435  
 + Sbl<sub>3</sub> + SbBr<sub>3</sub> ..... II 1435  
 + SnCl<sub>4</sub> ..... II 1435  
 + stilbene ..... II 1435  
 + tetrahydrobenzene ..... II 1430  
 + TiCl<sub>4</sub> ..... II 1435  
 + toluenes ..... II 1433, 4  
 + trichloro acetic acid ..... II 1435  
 + trinitrotoluene ..... II 1435  
 + triphenyl methane ..... II 1432, 35  
 + xylenes ..... II 1434
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**SbCl<sub>5</sub>** + I<sub>2</sub> ..... I 1286  
 in ICl ..... II 1435  
 + SbCl<sub>3</sub> ..... II 1435  
 + SbF<sub>5</sub> ..... II 1435  
 in SeOCl<sub>2</sub> ..... II 1435  
**SbF<sub>3</sub>** in aq. HF ..... II 1436  
 in H<sub>2</sub>O ..... II 1436  
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**SbF<sub>5</sub>** + SbCl<sub>5</sub> ..... II 1435  
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 in CS<sub>2</sub> ..... II 1437  
 in H<sub>2</sub>O ..... II 1437  
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 + C<sub>6</sub>H<sub>5</sub>CN ..... II 1438  
 extrn. from HCl ..... II 1438  
 + I ..... II 1438  
 + KI + H<sub>2</sub>O ..... II 223  
 + Lil ..... II 415  
 in methylene iodide ..... II 1438  
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 + NaF + H<sub>2</sub>O ..... II 1047  
 + NaI + H<sub>2</sub>O ..... II 1438  
 + nitrobenzene ..... II 1438  
 + P<sub>2</sub>O<sub>3</sub> ..... II 1438  
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 + SbBr<sub>3</sub> + SbCl<sub>3</sub> ..... II 1435  
 + SbCl<sub>3</sub> ..... II 1435  
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 in NaOH ..... II 1439  
 in Na, K tartarate ..... II 1439  
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**Se** extrn. from HCl, HNO<sub>3</sub> ..... II 1443  
 from nitrate ..... II 1443
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 + HgBr<sub>2</sub> ..... I 1229  
 + HgCl<sub>2</sub> ..... I 1229  
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 + diphenyl ether ..... II 1450  
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   +  $\text{CaO} + \text{Fe}_2\text{O}_3$  ..... I 630  
   +  $\text{CaO} + \text{Na}_2\text{O}$  ..... I 630  
   +  $\text{CaO} + \text{Na}_2\text{O}$  ..... I 629  
   +  $\text{CaO} + \text{Na}_2\text{O} + \text{CO}_2$  ..... I 630  
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   +  $\text{FeO} + \text{FeS}$  ..... I 1038  
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   in aq.  $\text{KOH}$  ..... II 1452  
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   +  $\text{MgO} + \text{CaO}$  ..... II 630  
   +  $2\text{Mn} \rightleftharpoons 2\text{MnO} + \text{Si}$  ..... II 558  
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   +  $\text{Na}_2\text{O} + \text{Al}_2\text{O}_3 + \text{H}_2\text{O}$  ..... II 807  
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   in aq.  $\text{HNO}_3$ ,  $\text{H}_2\text{C}_2\text{O}_4$  ..... II 1458  
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   +  $\text{Cd}$  in  $\text{CdBr}_2 + \text{SnBr}_2$  ..... I 694  
   +  $\text{Cd}$  in  $\text{CdCl}_2 + \text{SnCl}_2$  ..... I 694  
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   +  $\text{PbCl}_2 \rightleftharpoons \text{SnCl}_2 + \text{Pb}$  ..... II 1248  
   +  $\text{PbS} \rightleftharpoons \text{SnS} + \text{Pb}$  ..... II 1248  
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   +  $\text{SnBr}_2$  ..... II 1462  
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   +  $\text{CaCl}_2$  ..... II 1466  
   +  $\text{CuCl}$  ..... I 935  
   in ether ..... II 1466  
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   +  $\text{LiCl}$  ..... II 405  
   +  $\text{MgCl}_2$  ..... II 494  
   +  $\text{MnCl}_2$  ..... II 553  
   +  $\text{PCl}_3$  ..... II 1244  
   +  $\text{Pb} \rightleftharpoons \text{Sn} + \text{PbCl}_2$  ..... II 1248  
   +  $\text{PbCl}_2$  ..... II 1293  
   +  $\text{RbCl}$  ..... II 1366  
   +  $\text{Sn}$  ..... II 1462  
   +  $\text{SnI}_2$  ..... II 1466  
   +  $\text{TiCl}_4$  ..... II 1556  
   +  $\text{ZnCl}_2$  ..... II 1466  
 $\text{SnCl}_4 + \text{AlCl}_3$  ..... I 177  
   + anisole ..... I 230  
   +  $\text{AsCl}_3$  ..... II 1469  
   +  $\text{B}(\text{OC}_2\text{H}_5)_3$  ..... II 1469  
   +  $\text{B}(\text{OCH}_3)_3$  ..... II 1469

- + benzoic acid ethyl ester ..... II 1469  
+  $\text{CCl}_4$  ..... II 1469  
+  $\text{C}_7\text{F}_{18}$  ..... II 1469  
+  $\text{CO}(\text{OC}_2\text{H}_5)_2$  ..... II 1469  
+  $\text{Cl}_2$  ..... I 787  
+ diphenylether ..... II 1469  
distr. betwn.  $\text{H}_2\text{O}$  and ethyl ether ..... II 1467  
distr. betwn. xylene and  $\text{H}_2\text{O}$  ..... II 1466, 7  
+ Formic acid ethyl ester ..... II 1469  
+ Formic acid methyl ester ..... II 1469  
+  $\text{HCl}$  ..... II 1467  
+ methyl-m-cresyl ether ..... II 1469  
+ nitriles ..... II 1468  
+ organic cmpds. .... II 1468  
+  $\text{PbSO}_4$  ..... II 1293  
+ phenetole ..... II 1469  
+  $\text{SO}_2$  ..... II 1420, 69  
+  $\text{SbCl}_3$  ..... II 1435  
in  $\text{SeOCl}_2$  ..... II 1469  
+  $\text{SiCl}_4$  ..... II 1450  
+  $\text{SnBr}_4$  ..... II 1464  
+  $\text{SnI}_4$  ..... II 1469  
+  $\text{TiCl}_4$  ..... II 1469  
+ T.N.T. .... II 1469  
**Sn cupferrate (II)** in  $\text{H}_2\text{O}$  ..... II 1465  
**Sn cupferrate (IV)** in  $\text{H}_2\text{O}$  ..... II 1465  
**SnI<sub>2</sub>** extn. from  $\text{HCl}$  ..... II 1470  
in aq.  $\text{HI}$  ..... II 1470  
in  $\text{H}_2\text{O}$  ..... II 1470  
+  $\text{SnBr}_2$  ..... II 1462  
+  $\text{SnCl}_2$  ..... II 1466  
**SnI<sub>4</sub>** +  $\text{AsI}_3$  ..... I 231  
+  $\text{BBBr}_3$  ..... II 1470  
in  $\text{CS}_2$  ..... II 1471  
in liq. paraffins ..... II 1471  
in organic. cmpds. .... II 1471  
in S ..... II 1470  
+  $\text{SO}_2$  ..... II 1420  
in  $\text{SiCl}_4$  ..... II 1472  
+  $\text{SnCl}_4$  ..... II 1469  
in tetrahydrofuran ..... II 1472  
in tetrahydropyran ..... II 1470  
**SnI $(\text{CH}_3)_3$**  +  $\text{C}_6\text{H}_5\text{NH}_2$  ..... II 1470  
**Sn fluorides** in several solvents ..... II 1470  
**SnO** in  $\text{HClO}_4$  ..... II 1473  
in  $\text{NaOH}$  ..... II 1473  
+  $\text{SO}_3$  +  $\text{H}_2\text{O}$  ..... II 1475  
in  $\text{HCl}$  ..... II 1473  
**SnS** ..... II 1473  
+  $\text{Pb} \rightleftharpoons \text{Sn} + \text{PbS}$  ..... II 1248  
+  $\text{Sb}_2\text{S}_3$  ..... II 1440  
+  $\text{Sn}$  ..... II 1462  
**SnS<sub>2</sub>** in aq.  $\text{HCl}$  ..... II 1475  
in aq.  $\text{NH}_4$  ..... II 1473  
**SnSO<sub>4</sub>** in  $\text{H}_2\text{O}$  ..... II 1475  
**Sn tetraphenyl** + Si tetraphenyl ..... II 1465  
+ Hg diphenyl ..... I 1194  
**Soil phosphates** in acid and base ..... I 647  
**Sr** ..... II 1476  
+  $\text{CaCl}_2 \rightleftharpoons \text{SrCl}_2 + \text{Ca}$  ..... II 1476  
+  $\text{SrBr}_2$  ..... II 1476  
**Sr acetate** + acetic acid +  $\text{H}_2\text{O}$  ..... II 1484  
in  $\text{H}_2\text{O}$  ..... II 1483  
in methyl alc. .... II 1484  
**Sr alkyl phosphates** in  $\text{H}_2\text{O}$  ..... II 1518  
**Sr antipyrine fluoroborate** in  $\text{H}_2\text{O}$  ..... II 1505  
**Sr anthraquinone sulfonates** in  $\text{H}_2\text{O}$  ..... II 1492  
**Sr<sub>3</sub>(AsO<sub>4</sub>)<sub>2</sub>** in  $\text{H}_2\text{O}$  ..... II 1476  
**SrBr<sub>2</sub>** + t-butyl alc. +  $\text{H}_2\text{O}$  ..... II 1480  
in acetone ..... II 1481  
in iso-amyl alc. .... II 1481  
**Sr(BOCH<sub>3</sub>)<sub>2</sub>** in benzene ..... II 1478  
in cyclohexane ..... II 1478  
in tetrahydrofuran ..... II 1478  
**Sr benzoate sulfonate** in benzene sulfonic acid ..... II 1491  
**Sr benzoate** in  $\text{H}_2\text{O}$  ..... II 1488, 9  
**Sr bromobenzoate** in acetone ..... II 1489  
**SrBr<sub>2</sub>** +  $\text{As}_2\text{O}_3$  +  $\text{H}_2\text{O}$  ..... I 238  
+  $\text{BaBr}_2$  +  $\text{BaI}_2$  +  $\text{SrI}_2$  ..... I 298  
+  $\text{BaI}_2$  ..... I 363  
+  $\text{InBr}_3$  +  $\text{H}_2\text{O}$  ..... I 1293  
**SrBr<sub>2</sub>** fpts. .... II 1479  
**SrBr<sub>2</sub>** in aq.  $\text{HBr}$  ..... II 1480  
**SrBr<sub>2</sub>·6H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1479  
**SrBr<sub>2</sub>** +  $\text{KBr}$  ..... II 30  
+  $\text{LiBr}$  ..... II 371  
in methyl, ethyl alc. .... II 1481  
in  $\text{NH}_3$  liq. .... II 1482  
+  $\text{NaBr}$  ..... II 847  
in  $\text{SO}_2$  liq. .... II 1482  
+  $\text{Sr}$  ..... II 1476  
+  $\text{SrH}_2$  ..... II 1506  
in aq.  $\text{Sr}(\text{NO}_3)_2$  ..... II 1480  
+  $\text{SrO}$  +  $\text{H}_2\text{O}$  ..... II 1480  
+ urea +  $\text{H}_2\text{O}$  ..... II 1481  
**Sr(BrO<sub>3</sub>)<sub>2</sub>** +  $\text{H}_2\text{O}$  ..... II 1482  
**Sr[(CH<sub>3</sub>)<sub>2</sub>AsO<sub>2</sub>]<sub>2</sub>** in alics. .... II 1478  
**Sr[(CH<sub>3</sub>)<sub>2</sub>AsO<sub>2</sub>]<sub>2</sub>·12H<sub>2</sub>O** in  $\text{H}_2\text{O}$  ..... II 1477, 8  
**SrCO<sub>3</sub>** in aq. alkali chlorides ..... II 1493  
in  $\text{H}_2\text{O}$  ..... II 1493  
in  $\text{H}_2\text{O}$  +  $\text{CO}_2$  ..... II 1493  
in aq.  $\text{NH}_4\text{Cl}$  ..... II 1493  
+  $\text{NaCl}$  ..... II 1011  
+  $\text{SrCl}_2$  ..... II 1493  
**Sr<sub>2</sub>CO<sub>4</sub>** in aq. acetic acid ..... II 1495  
in  $\text{H}_2\text{O}$  ..... II 1494  
in  $\text{H}_2\text{C}_2\text{O}_4$  aq. .... II 1494  
in  $\text{KCl}$  solns. .... II 1495  
+  $\text{UO}_2\text{C}_2\text{O}_4$  +  $\text{H}_2\text{O}$  ..... II 1495  
**[Sr(COC<sub>10</sub>H<sub>12</sub>M<sub>2</sub>)<sub>6</sub>(ClO<sub>4</sub>)<sub>4</sub>]** in  $\text{H}_2\text{O}$  ..... II 1503  
**Sr camphorate** in aq. camphoric acid ..... II 1492  
**Sr camphor sulfonate** in  $\text{H}_2\text{O}$  ..... II 1492  
**Sr cinnamate** in  $\text{H}_2\text{O}$  ..... II 1490  
**Sr citrate** in  $\text{H}_2\text{O}$  ..... II 1488  
**Sr chlorobenzoate** in acetone ..... II 1489  
**SrCl<sub>2</sub>** in acetic acid ..... II 1501  
in aq. acids ..... II 1499  
+ allyl alc. +  $\text{H}_2\text{O}$  ..... II 1501  
in aq. ethanol ..... II 1500, 1  
+  $\text{As}_2\text{O}_3$  +  $\text{H}_2\text{O}$  ..... I 238  
+  $\text{BaCl}_2$  ..... I 353  
+  $\text{BaCl}_2$  +  $\text{CaCl}_2$  ..... I 353  
+  $\text{BaF}_2 \rightleftharpoons \text{SrF}_2 + \text{BaCl}_2$  ..... II 1502  
+  $\text{BaO}$  ..... I 383  
+ t-butyl alc. +  $\text{H}_2\text{O}$  ..... II 1501  
+  $\text{Ca} \rightleftharpoons \text{Sr} + \text{CaCl}_2$  ..... II 1476  
+  $\text{CaCl}_2$  ..... I 597  
+  $\text{CaCl}_2$  +  $\text{H}_2\text{O}$  ..... I 588, 9  
+  $\text{CaCl}_2$  +  $\text{MgCl}_2$  +  $\text{KCl}$  +  $\text{NaCl}$  +  $\text{H}_2\text{O}$  ..... I 587  
+  $\text{CaF}_2 \rightleftharpoons \text{CaCl}_2 + \text{SrF}_2$  ..... I 597  
+  $\text{CaCl}_2$  ..... I 728  
+  $\text{CoCl}_2$  ..... I 818  
+  $\text{CoCl}_2$  +  $\text{H}_2\text{O}$  ..... I 812  
in  $\text{D}_2\text{O}$  ..... II 1497  
**SrCl<sub>2</sub>** f.pts. .... II 1497  
**SrCl<sub>2</sub>** +  $\text{FeCl}_2$  ..... I 1016  
in aq.  $\text{HBr}$  ..... II 1498  
aq.  $\text{HCl}$  ..... II 1497, 8  
in  $\text{H}_2\text{O}$  ..... II 1496, 7  
+  $\text{HgCl}_2$  +  $\text{H}_2\text{O}$  ..... I 1212  
+  $\text{InCl}_3$  +  $\text{H}_2\text{O}$  ..... I 1295  
+  $\text{KCl}$  ..... II 169  
in aq.  $\text{KMnO}_4$  ..... II 1500  
+  $\text{KCl}$  +  $\text{H}_2\text{O}$  ..... II 151  
+  $\text{KCl}$  +  $\text{NaCl}$  +  $\text{H}_2\text{O}$  ..... II 152  
+  $\text{LiCl}$  ..... II 405  
+  $\text{LiCl}$  +  $\text{H}_2\text{O}$  ..... II 399  
+  $2\text{LiCl} \rightleftharpoons 2\text{LiNO}_3 + \text{SrCl}_2$  ..... II 1502  
+  $2\text{LiF} \rightleftharpoons \text{SrF}_2 + 2\text{LiCl}$  ..... II 406  
+  $2\text{LiNO}_3 \rightleftharpoons \text{SrCl}_2 + 2\text{LiCl}$  ..... II 1502  
+  $\text{Li}_2\text{SO}_4 \rightleftharpoons \text{SrSO}_4 + 2\text{LiCl}$  ..... II 1502  
+  $\text{MgCl}_2$  ..... II 494  
+  $\text{MgCl}_2$  +  $\text{H}_2\text{O}$  ..... II 491-2  
+  $\text{NaCl}$  ..... II 1011  
+  $\text{NaCl}$  +  $\text{KCl}$  ..... II 169  
+  $2\text{NaF} \rightleftharpoons 2\text{NaCl} + \text{SrF}_2$  ..... II 1012  
+  $\text{PbCl}_2$  ..... II 1293  
+  $\text{RbCl}$  ..... II 1366  
in aq. salts ..... II 1499  
+  $\text{SrCO}_3$  ..... II 1493  
+  $\text{SrF}_2$  ..... II 1501  
+  $\text{Sr}(\text{NO}_3)_2$  ..... II 1502  
+  $\text{Sr}(\text{NO}_3)_2$  +  $\text{H}_2\text{O}$  ..... II 1500  
+  $\text{SrO}$  ..... II 1502

+ SrO + H <sub>2</sub> O	II 1499	+ HNO <sub>3</sub> + H <sub>2</sub> O	II 1510
+ SrSO <sub>4</sub>	II 1502	in H <sub>2</sub> O	II 1509, 10
+ TlCl	II 1502	in hydrazine	II 1512
+ ZnCl <sub>2</sub>	II 1507	+ KNO <sub>3</sub>	II 274
in other solvents	II 1501	+ KNO <sub>3</sub> + H <sub>2</sub> O	II 267
<b>Sr(ClO<sub>3</sub>)<sub>2</sub></b> in H <sub>2</sub> O	II 1502	+ KNO <sub>3</sub> + NaNO <sub>3</sub>	II 1083
<b>Sr(ClO<sub>3</sub>)<sub>2</sub></b> in H <sub>2</sub> O	II 1502	+ LiNO <sub>3</sub>	II 1513
<b>Sr(ClO<sub>4</sub>)<sub>2</sub></b> in H <sub>2</sub> O	II 1503	in NH <sub>3</sub> (liq.)	II 1513
in several solvents	II 1503	+ NaNO <sub>3</sub>	II 1083
<b>SrCO<sub>3</sub></b>	II 1503	+ NaNO <sub>3</sub> + KNO <sub>3</sub>	II 274
in acetic acid	II 1504	+ Pb(NO <sub>3</sub> ) <sub>2</sub> + H <sub>2</sub> O	II 1311
in ethyl alc.	II 1504	+ Pb(NO <sub>3</sub> ) <sub>2</sub> + NaNO <sub>3</sub>	II 1083
in H <sub>2</sub> O	II 1504	in propanol	II 1512
in NH <sub>4</sub> Cl	II 1504	in pyridine	II 1512
<b>Sr(Ca(S<sub>2</sub>O<sub>3</sub>)<sub>2</sub>·4H<sub>2</sub>O</b> in H <sub>2</sub> O	II 1523	+ RbNO <sub>3</sub>	II 1377
<b>SrF<sub>2</sub></b> + Al <sub>2</sub> O <sub>3</sub> + SiO <sub>2</sub>	II 1505	+ SrCl <sub>2</sub>	II 1502
+ BaCl <sub>2</sub>	I 353	+ SrCl <sub>2</sub> + H <sub>2</sub> O	II 1500
+ BaCl <sub>2</sub> = BaF <sub>2</sub> + SrCl <sub>2</sub>	II 1502	+ Sr(OH) <sub>2</sub>	II 1513
+ BaF <sub>2</sub>	I 360	+ Sr(OH) <sub>2</sub> + H <sub>2</sub> O	II 1514
+ CaCl <sub>2</sub> = CaF <sub>2</sub> + SrCl <sub>2</sub>	I 597	in tri-n-butyl phosphate	II 1512
+ CaF <sub>2</sub>	I 603	+ UO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> + H <sub>2</sub> O	II 1612
in aq. HCl	II 1505	<b>Sr(NO<sub>3</sub>)<sub>2</sub></b> in H <sub>2</sub> O	II 1513
in H <sub>2</sub> O	II 1504	<b>SrO</b> + As <sub>2</sub> O <sub>3</sub> + H <sub>2</sub> O	II 1476
·Hot(CN) <sub>2</sub> ·6H <sub>2</sub> O in H <sub>2</sub> O, alc.	I 1197	+ As <sub>2</sub> O <sub>5</sub> + H <sub>2</sub> O	II 1477
+ In <sub>2</sub> + H <sub>2</sub> O	I 1298	+ B <sub>2</sub> O <sub>3</sub> + Na <sub>2</sub> O	II 1478
in KF solns.	II 1505	+ CaCl <sub>2</sub>	I 597
+ LiF	II 414	+ HCl + H <sub>2</sub> O	II 1498
+ 2LiCl = SrCl <sub>2</sub> + 2LiF	II 406	<b>25O·(NH<sub>4</sub>)<sub>2</sub>O·B<sub>2</sub>O<sub>3</sub>·2Ca·H<sub>4</sub>O<sub>5</sub>·10H<sub>2</sub>O</b>	II 612
+ NaF	II 1040	<b>SrO</b> + SiO <sub>2</sub> + SrF <sub>2</sub>	II 1505
in NaF	II 1505	+ SrBr <sub>2</sub> + H <sub>2</sub> O	II 1480
+ 2NaCl = 2NaF + SrCl <sub>2</sub>	II 1012	in SrCl <sub>2</sub>	II 1513
in SO <sub>2</sub> liq.	II 1505	+ SrCl <sub>2</sub>	II 1502
+ SrCl <sub>2</sub>	II 1502	+ SrCl <sub>2</sub> + H <sub>2</sub> O	II 1499
+ SiO + SiO <sub>2</sub>	II 1505	+ P <sub>2</sub> O <sub>5</sub> + H <sub>2</sub> O	II 1518
+ UF <sub>3</sub>	II 1609	+ SrI <sub>2</sub> + H <sub>2</sub> O	II 1506
<b>Sr formate</b> in H <sub>2</sub> O	II 1487	<b>Sr<sub>2</sub>O<sub>4</sub></b> in H <sub>2</sub> O	II 1525
<b>Sr glycera phosphates</b> in H <sub>2</sub> O	II 1519	<b>Sr(OH)<sub>2</sub></b> in aq. cane sugar	II 1516
<b>SrH<sub>2</sub></b> + SrBr <sub>2</sub>	II 1506	in aq. solns.	II 1515
+ Srl	II 1508	in aq. ethanol	II 1516
<b>SrHA<sub>2</sub>O<sub>4</sub></b> in aq. salts	II 1477	<b>Sr(OH)<sub>2</sub>·2H<sub>2</sub>O</b> in H <sub>2</sub> O	II 1514
<b>Sr<sub>2</sub>H<sub>2</sub>(AsO<sub>4</sub>)<sub>2</sub></b> in H <sub>2</sub> O	II 1476	<b>Sr(OH)<sub>2</sub></b> + Sr(NO <sub>3</sub> ) <sub>2</sub>	II 1513
<b>Sr(HCO<sub>3</sub>)<sub>2</sub></b> in H <sub>2</sub> O	II 1493	+ Sr(NO <sub>3</sub> ) <sub>2</sub> + H <sub>2</sub> O	II 1514
<b>Sr(HCOO)<sub>2</sub></b> in H <sub>2</sub> O	II 1482	+ phenol + H <sub>2</sub> O	II 1488, 1515
+ HCOOH	II 1483	+ Sr(SH) <sub>2</sub> + H <sub>2</sub> O	II 1515
<b>SrIPO<sub>4</sub></b>	II 1518	+ sucrose + H <sub>2</sub> O	II 1516
<b>Sr isothionate</b> in H <sub>2</sub> O	II 1493	<b>Sr<sub>2</sub>(PO<sub>4</sub>)<sub>2</sub></b>	II 1518
<b>Sr<sub>2</sub></b> in acetone	II 1507	<b>SrPO<sub>2</sub>F</b> in H <sub>2</sub> O	II 1505
<b>Sr<sub>2</sub></b> + BaBr <sub>2</sub> = Ba <sub>2</sub> + SrBr <sub>2</sub>	I 298	<b>Sr phenolate</b>	II 1488
+ BaI <sub>2</sub>	I 363	<b>Sr galinolin sulfonic acid</b>	II 1491
in H <sub>2</sub> O	II 1506	<b>Sr(SH)<sub>2</sub></b> + Sr(OH) <sub>2</sub> + H <sub>2</sub> O	II 1515
in ethanol	II 1507	<b>SrSO<sub>4</sub></b> in aq. chloroacetic acid	II 1520
in NH <sub>3</sub> (liq.)	II 1507	in aq. salt soln.	II 1521
in SO <sub>2</sub> (liq.)	II 1507	in aq. solvents	II 1523
+ SrH <sub>2</sub>	II 1506	in aq. Ca(NO <sub>3</sub> ) <sub>2</sub>	II 1522
+ SrO + H <sub>2</sub> O	II 1506	in aq. ethanol	II 1523
<b>SrI<sub>4</sub></b>	II 1507	in formic acid	II 1521
<b>Sr(IO<sub>3</sub>)<sub>2</sub></b> in NaOH aq.	II 1508	in aq. formic acid	II 1520
in aq. Na <sub>4</sub> P <sub>4</sub> O <sub>12</sub>	II 1508	in aq. HCl	II 1520
in aq. Na <sub>3</sub> P <sub>3</sub> O <sub>9</sub>	II 1508	in HCl, H <sub>2</sub> O	II 1521
+ H <sub>2</sub> O	II 1507, 8	in aq. HNO <sub>3</sub>	II 1520
<b>Sr iodo benzoate</b> in acetone	II 1489	in HNO <sub>3</sub> + K, Mg, Al, Sr nitrates	II 1521
<b>Sr maleate</b> in H <sub>2</sub> O	II 1485, 6	in H <sub>2</sub> O	II 1519, 20
in SrCl <sub>2</sub>	II 1486	in H <sub>2</sub> SO <sub>4</sub> solns.	II 1520
<b>Sr maleate</b> in SrCl <sub>2</sub>	II 1487	+ K <sub>2</sub> SO <sub>4</sub>	II 325
in H <sub>2</sub> O	II 1486	+ K <sub>2</sub> SO <sub>4</sub> in H <sub>2</sub> O	II 319
<b>Sr mandelate</b> + mandelic acid + H <sub>2</sub> O	II 1490	+ Li <sub>2</sub> SO <sub>4</sub>	II 439
<b>Sr methionate</b> in H <sub>2</sub> O	II 1483	+ 2LiCl = Li <sub>2</sub> SO <sub>4</sub> + SrCl <sub>2</sub>	II 1502
<b>SrMoO<sub>4</sub></b> in H <sub>2</sub> O	II 1508	in aq. NH <sub>4</sub> acetate	II 1522
<b>Sr(MnO<sub>4</sub>)<sub>2</sub></b> in H <sub>2</sub> O	II 1508	in aq. (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	II 1521
<b>Sr(N<sub>3</sub>)<sub>2</sub></b> in H <sub>2</sub> O	II 1509	in aq. Na <sub>2</sub> CO <sub>3</sub>	II 1522
<b>Sr(NO<sub>3</sub>)<sub>2</sub></b> + AgNO <sub>2</sub> + H <sub>2</sub> O	I 1111	+ NaCl	II 1012
in alc.	II 1509	in NaNO <sub>3</sub>	II 1522
in H <sub>2</sub> O	II 1509	+ Na <sub>2</sub> SO <sub>4</sub>	II 1149
<b>Sr(NO<sub>3</sub>)<sub>2</sub></b> in aq. alc.	II 1511, 2	+ SrCl <sub>2</sub>	II 1502
+ Ba(NO <sub>3</sub> ) <sub>2</sub> + KNO <sub>3</sub>	I 377	<b>Sr<sub>2</sub>O<sub>3</sub></b> in H <sub>2</sub> O	II 1523
in butyl cellosolve + H <sub>2</sub> O	II 1512	in H <sub>2</sub> O + acetone	II 1523
+ Ca(NO <sub>3</sub> ) <sub>2</sub> + H <sub>2</sub> O	I 624	<b>Sr<sub>2</sub>O<sub>6</sub></b> in aq. ethyl alc.	II 1524
+ Ca(NO <sub>3</sub> ) <sub>2</sub> + NaNO <sub>3</sub>	I 629	in H <sub>2</sub> O	II 1523
in cellosolves	II 1512	<b>Sr<sub>2</sub>O<sub>6</sub></b> + (NH <sub>4</sub> ) <sub>2</sub> S <sub>2</sub> O <sub>8</sub> + H <sub>2</sub> O	II 777
+ CaNO <sub>3</sub>	II 1513	+ Na <sub>2</sub> S <sub>2</sub> O <sub>8</sub> + H <sub>2</sub> O	II 1157
in ethyl alc.	II 1512	+ PbS <sub>2</sub> O <sub>8</sub>	II 1335
in furfural	II 1512	<b>Sr<sub>2</sub>O<sub>7</sub></b> in H <sub>2</sub> O	II 1525



- Sr<sub>5</sub>O<sub>8</sub>** in H<sub>2</sub>O ..... II 1524  
**Sr silicylate** in aq. alc. .... II 1489  
   in H<sub>2</sub>O ..... II 1489  
**Sr<sub>5</sub>O<sub>3</sub>** ..... II 1524  
**Sr<sub>5</sub>O<sub>4</sub>** in H<sub>2</sub>O ..... II 1524  
**SrSiF<sub>6</sub>** in H<sub>2</sub>O ..... II 1506  
   in H<sub>2</sub>O + HCl + (NH<sub>4</sub>)<sub>2</sub>SiF<sub>6</sub> + C<sub>2</sub>H<sub>5</sub>OH ..... II 1506  
   + (NH<sub>4</sub>)<sub>2</sub>SiF<sub>6</sub> + H<sub>2</sub>O ..... II 697  
**SrSiO<sub>3</sub>** + Na<sub>2</sub>SiO<sub>3</sub> ..... II 1169  
**Sr succinate** in H<sub>2</sub>O ..... II 1487  
   in aq. Na succinate ..... II 1487  
**Sr sulfonates** in H<sub>2</sub>O ..... II 1491  
**Sr(TeO<sub>3</sub>)<sub>2</sub>** in H<sub>2</sub>O ..... II 1524  
**Sr<sub>18</sub>Te<sub>12</sub>O<sub>38</sub>·33H<sub>2</sub>O** in H<sub>2</sub>O ..... II 1524  
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   in H<sub>2</sub>O ..... II 1484, 5  
**Sr<sub>2</sub>[UO<sub>2</sub>(CO<sub>3</sub>)<sub>3</sub>]·8H<sub>2</sub>O** in H<sub>2</sub>O ..... II 1494  
**SrWO<sub>4</sub>** ..... II 1525  
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**Stilbene** + SbBr<sub>3</sub> ..... II 1427  
   + SbCl<sub>3</sub> ..... II 1435  
**Strychnine·AlCl<sub>3</sub>, IrBr<sub>3</sub> salts** ..... I 1302  
**Styrene** + SO<sub>2</sub> ..... II 1421  
**Succinic acid** + Na succinate + H<sub>2</sub>O ..... II 866, 7  
**Succinonitrile** + AgNO<sub>3</sub> + H<sub>2</sub>O ..... I 118  
   + NaCl + H<sub>2</sub>O ..... II 1004  
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   + CaCl<sub>2</sub> + H<sub>2</sub>O ..... I 590  
   + CdI<sub>2</sub> + H<sub>2</sub>O ..... I 736  
   + CuSO<sub>4</sub> + H<sub>2</sub>O ..... I 996  
   + KCl + H<sub>2</sub>O ..... II 162  
   + NaCl + H<sub>2</sub>O ..... II 1006  
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   + Na<sub>2</sub>CO<sub>3</sub> in H<sub>2</sub>O ..... II 944  
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   + FeCl<sub>3</sub> ..... II 1526  
   + FeCl<sub>3</sub> + AlCl<sub>3</sub> ..... II 1526  
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   in glycolic acid ..... II 1527  
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**Tb(NO<sub>3</sub>)<sub>3</sub>** distr. betwn. butyl phosphate + HNO<sub>3</sub> ..... II 1528  
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   + Au ..... II 1528  
   + Br ..... II 1528  
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   + I<sub>2</sub> ..... II 1528  
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   + S ..... II 1403  
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   + Se ..... II 1445  
   + Se + S ..... II 1445  
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   in H<sub>2</sub>O ..... I 222  
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   + NH<sub>4</sub>Al(SO<sub>4</sub>)<sub>2</sub> + H<sub>2</sub>O ..... I 224  
**Tl acetate** + Na<sub>2</sub>S + H<sub>2</sub>O ..... II 1591  
   in SO<sub>2</sub> (liq.) ..... II 1559  
**TiBO<sub>3</sub>** ..... II 1554  
**Ti<sub>3</sub>BO<sub>3</sub>** ..... II 1554  
**Ti<sub>4</sub>B<sub>2</sub>O<sub>5</sub>** ..... II 1554  
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   in aq. salts ..... II 1554, 7  
   in H<sub>2</sub>O ..... II 1554  
   + InBr<sub>3</sub> + H<sub>2</sub>O ..... I 1293  
   + KBr ..... II 30

- + KCl  $\rightleftharpoons$  KBr + TlCl ..... II 31  
 + KNO<sub>3</sub> ..... II 274, 5  
 + NaCl  $\rightleftharpoons$  TlCl + NaBr ..... II 847  
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 + TlCl ..... II 1556  
 + TlI ..... II 1556, 7  
 + TiNO<sub>3</sub> ..... II 1556  
 in aq. TiNO<sub>3</sub> ..... II 1556  
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 in SO<sub>2</sub> (liq.) ..... II 1565  
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 in K<sub>2</sub>C<sub>2</sub>O<sub>4</sub> ..... II 1565  
 in aq. TiNO<sub>3</sub> ..... II 1565  
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 + CdCl<sub>2</sub> ..... I 728  
 + CdCl<sub>2</sub> ..... II 1578  
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 + CdSO<sub>4</sub> ..... II 1578  
 + CsCl ..... I 885  
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 + MnCl<sub>2</sub> ..... II 553  
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 in aq. NH<sub>3</sub> ..... II 1568  
 + NaBr  $\rightleftharpoons$  NaCl + TlBr ..... II 847  
 + NaCl ..... II 1011  
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 + ZnCl<sub>2</sub> + H<sub>2</sub>O ..... II 1573  
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 + NaF + ZrF<sub>4</sub> ..... II 1040  
 + ZrF<sub>4</sub> + NaF ..... II 1040  
**UF<sub>6</sub>** + Br<sub>2</sub> ..... II 1609  
 + BrF<sub>3</sub> ..... II 1609  
 + BrF<sub>5</sub> ..... II 1609  
 + ClF<sub>6</sub> ..... II 1609  
 + HF ..... II 1124  
 + HF ..... II 1609  
**U(HPO<sub>4</sub>)<sub>2</sub>** + Cl<sub>2</sub>O<sub>7</sub> + H<sub>2</sub>O ..... II 1623  
**UO<sub>2</sub>** + CaO ..... I 630  
 in aq. HClO<sub>4</sub> ..... II 1621  
 + Na<sub>2</sub>O + CO<sub>2</sub> + H<sub>2</sub>O ..... II 1172  
 in aq. NaOH ..... II 1621  
 + P<sub>2</sub>O<sub>5</sub> + H<sub>2</sub>O ..... II 1622  
 in steam ..... II 1621  
**UO<sub>2</sub><sup>++</sup>** extn. from aq. HF by ethyl ether ..... II 1608  
 extn. from organic compds. ..... II 1601  
**UO<sub>2</sub> acetate** in aq. acetic acid ..... II 1599  
 in acetone ..... II 1600  
 in H<sub>2</sub>O ..... II 1600  
 in H<sub>2</sub>O ..... II 1599  
 in methyl alc. ..... II 1600  
**UO<sub>2</sub> antipyrine perchlorate** in H<sub>2</sub>O ..... II 1607  
**UO<sub>2</sub> butyrate** in H<sub>2</sub>O ..... II 1600  
**UO<sub>2</sub>CO<sub>3</sub>** in Na<sub>2</sub>CO<sub>3</sub> ..... II 1601  
**UO<sub>2</sub>CO<sub>2</sub>(CO<sub>3</sub>)<sub>2</sub>·10H<sub>2</sub>O** in H<sub>2</sub>O ..... I 556  
**UO<sub>2</sub>CO<sub>3</sub>** + Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O ..... II 940  
**UO<sub>2</sub>CO<sub>3</sub>·2(NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub>** in H<sub>2</sub>O ..... II 1602  
**UO<sub>2</sub>C<sub>2</sub>O<sub>4</sub>** + BaC<sub>2</sub>O<sub>4</sub> + H<sub>2</sub>O ..... I 333  
 + CaC<sub>2</sub>O<sub>4</sub> + H<sub>2</sub>O ..... I 563  
 in H<sub>2</sub>O ..... II 1602, 3  
 in aq. H<sub>2</sub>C<sub>2</sub>O<sub>4</sub> ..... II 1603  
 in HNO<sub>3</sub> solns. .... II 1604  
 in H<sub>2</sub>PO<sub>4</sub> ..... II 1603  
 in aq. H<sub>2</sub>SO<sub>4</sub> ..... II 1603  
 + K<sub>2</sub>C<sub>2</sub>O<sub>4</sub> + H<sub>2</sub>O ..... II 1604  
 in Na<sub>2</sub>C<sub>2</sub>O<sub>4</sub> ..... II 1605  
 + (NH<sub>4</sub>)<sub>2</sub>C<sub>2</sub>O<sub>4</sub> + H<sub>2</sub>O ..... II 1605  
 + Na<sub>2</sub>(COO)<sub>2</sub> + H<sub>2</sub>O ..... II 956, 7  
 + SrC<sub>2</sub>O<sub>4</sub> + H<sub>2</sub>O ..... II 1495  
**UO<sub>2</sub>Cl<sub>2</sub>** in H<sub>2</sub>O ..... II 1605  
**UO<sub>2</sub> chlorides** in H<sub>2</sub>O ..... II 1606  
**UO<sub>2</sub>C<sub>2</sub>O<sub>4</sub>** + CrO<sub>3</sub> + H<sub>2</sub>O ..... II 1608  
 + H<sub>2</sub>O ..... II 1607  
**2UO<sub>2</sub>CrO<sub>4</sub>·H<sub>2</sub>CrO<sub>4</sub>** in H<sub>2</sub>O ..... II 1608  
**UO<sub>2</sub> camphorcarbonate** in several solvents ..... II 1602  
**UO<sub>2</sub>F<sub>2</sub>** in H<sub>2</sub>O ..... II 1608  
 + H<sub>2</sub>O ..... II 1608  
**UO<sub>2</sub> fluorides** with organic bases ..... II 1609  
**(UO<sub>2</sub>)<sub>2</sub>F<sub>2</sub>(CN)<sub>6</sub>** in H<sub>2</sub>O ..... II 1601  
**UO<sub>2</sub> formate** in aq. formic acid ..... II 1598, 9  
 in H<sub>2</sub>O ..... II 1600  
 in H<sub>2</sub>O ..... II 1598  
**UO<sub>2</sub>HPO<sub>4</sub>** ..... II 1622  
**UO<sub>2</sub>(IO<sub>3</sub>)<sub>2</sub>** in H<sub>2</sub>O ..... II 1610  
**UO<sub>2</sub>K** butyrate in H<sub>2</sub>O ..... II 1600  
**UO<sub>2</sub>K** propionate in H<sub>2</sub>O ..... II 1600  
**UO<sub>2</sub>KPO<sub>4</sub>** ..... II 1622  
**UO<sub>2</sub>NH<sub>4</sub>PO<sub>4</sub>** ..... II 1622  
**UO<sub>2</sub> nitrates** ..... II 1611  
**UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub>** + acetone + H<sub>2</sub>O ..... II 1615  
 + t-butyl alc. + H<sub>2</sub>O ..... II 1616  
**UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub>** + isobutyl alc. + H<sub>2</sub>O ..... II 1616  
 + Ba(NO<sub>3</sub>)<sub>2</sub> + H<sub>2</sub>O ..... II 1612  
 + Ca(NO<sub>3</sub>)<sub>2</sub> + H<sub>2</sub>O ..... II 1612  
 + diethyl cellosolve + H<sub>2</sub>O ..... II 1615  
 in ether ..... II 1618  
 + ethyl ether + H<sub>2</sub>O ..... II 1612, 3  
**UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub> etherates** in ether ..... II 1618  
**UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub> + H<sub>2</sub>O** ..... II 1615  
 distr. between ether and HNO<sub>3</sub> ..... II 1613, 4  
 + H<sub>2</sub>O ..... II 1610  
**UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O** in organic solvents ..... II 1619, 20  
 in aq. HNO<sub>3</sub> ..... II 1611  
**UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub> + HNO<sub>3</sub> + H<sub>2</sub>O** ..... II 1611  
 extn. from HNO<sub>3</sub> + NH<sub>4</sub>NO<sub>3</sub> ..... II 1614  
 + KNO<sub>3</sub> + H<sub>2</sub>O ..... II 267, 8  
**UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub>·KNO<sub>3</sub>** in aq. HNO<sub>3</sub> ..... II 1612  
**UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub>·2KNO<sub>3</sub>** in aq. HNO<sub>3</sub> ..... II 1612  
**UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub>** extn. from Li, Na, K, Fe, Al, Cd, NH<sub>4</sub>, Mg,  
 Sr, Ba, Zn nitrates ..... II 1614  
 + methyl isobutyl ketone + H<sub>2</sub>O ..... II 1516  
 + NH<sub>4</sub>NO<sub>3</sub> + H<sub>2</sub>O ..... II 718  
 in organic solvents ..... II 1618, 9  
 distr. between organic compds. and aq. solns. .... II 1617, 8  
 + Sr(NO<sub>3</sub>)<sub>2</sub> + H<sub>2</sub>O ..... II 1612  
 + Th(NO<sub>3</sub>)<sub>4</sub> + ethyl ether ..... II 1541  
**(UO<sub>2</sub>)<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>** in aq. HClO<sub>4</sub>, H<sub>3</sub>PO<sub>4</sub> ..... II 1622  
**UO<sub>2</sub> propionate** in H<sub>2</sub>O ..... II 1600  
**UO<sub>2</sub>NH<sub>4</sub> propionate** in H<sub>2</sub>O ..... II 1600  
**UO<sub>2</sub>SO<sub>4</sub>** in H<sub>2</sub>O ..... II 1623  
 in aq. H<sub>2</sub>SO<sub>4</sub> ..... II 1624  
 + K<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... I 320  
**UO<sub>2</sub>SO<sub>4</sub>·K<sub>2</sub>SO<sub>4</sub>·2H<sub>2</sub>O** in H<sub>2</sub>O ..... II 1624  
**UO<sub>2</sub>SO<sub>4</sub>·2K<sub>2</sub>SO<sub>4</sub>·2H<sub>2</sub>O** + UO<sub>2</sub>SO<sub>4</sub>·K<sub>2</sub>SO<sub>4</sub>·2H<sub>2</sub>O + H<sub>2</sub>O ..... II 1625  
**UO<sub>2</sub>SO<sub>4</sub>** + (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> ..... I 766  
**UO<sub>2</sub>SO<sub>4</sub>** in several solvents ..... II 1624  
**(UO<sub>2</sub>)<sub>2</sub>(SO<sub>4</sub>)<sub>2</sub>** ..... II 1628  
**UO<sub>2</sub>SeO<sub>3</sub>** ..... II 1626  
**UO<sub>2</sub> valerate** in H<sub>2</sub>O ..... II 1600  
**UO<sub>3</sub>** in aq. HClO<sub>4</sub> ..... II 1621  
 + H<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 1621  
 in aq. NaOH ..... II 1621  
 + Na<sub>2</sub>O + H<sub>2</sub>O ..... II 1171, 2  
**Urea** + biuret f.p., soly, etc. .... II 640  
 + biuret + NH<sub>4</sub>HCO<sub>3</sub> f.p., soly, etc. .... II 640  
 + CNNH<sub>2</sub> ..... I 453  
 + CN<sub>2</sub>NH<sub>2</sub> f.p., soly, etc. .... II 640  
 + CO<sub>2</sub> + NH<sub>3</sub> ..... I 484  
 + CaBr<sub>2</sub> + H<sub>2</sub>O ..... I 505  
 + CaCl<sub>2</sub> + H<sub>2</sub>O ..... I 590  
 + Ca(NO<sub>3</sub>)<sub>2</sub> ..... I 625  
 + Ca(NO<sub>3</sub>)<sub>2</sub> + H<sub>2</sub>O ..... I 625  
 + CaSO<sub>4</sub> + H<sub>2</sub>O ..... I 684, 5  
 + H<sub>2</sub>O f.p., soly, etc. .... II 640  
 + H<sub>2</sub>O<sub>2</sub> + H<sub>2</sub>O ..... I 1147  
 + KBr + H<sub>2</sub>O ..... II 27  
 + KCl + H<sub>2</sub>O ..... II 163, 4  
 + KH<sub>2</sub>PO<sub>4</sub> + H<sub>2</sub>O ..... II 290  
 + KNO<sub>3</sub> ..... II 273  
 + KNO<sub>3</sub> + H<sub>2</sub>O ..... II 272  
 + KOH + H<sub>2</sub>O ..... II 279  
 + K<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O ..... II 325  
 + LiNO<sub>3</sub> ..... II 426  
 + MgSO<sub>4</sub> + H<sub>2</sub>O ..... II 536, 7  
 + N<sub>2</sub>H<sub>4</sub> f.p. .... II 785  
 + NH<sub>4</sub>NO<sub>3</sub> + NaNO<sub>3</sub> ..... II 1082  
 + NaNO<sub>3</sub> ..... II 1082  
 + NaNO<sub>3</sub> + H<sub>2</sub>O ..... II 1081  
 + NaNO<sub>3</sub> + NH<sub>4</sub>NO<sub>3</sub> ..... II 728  
 + Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> ..... II 1154  
 + NH<sub>3</sub> f.p., soly, etc. .... II 640  
 + NH<sub>3</sub> + H<sub>2</sub>O f.p., soly, etc. .... II 640  
 + NH<sub>4</sub>CO<sub>2</sub>NH<sub>2</sub> f.p., soly, etc. .... II 640  
 + NH<sub>4</sub>HCO<sub>3</sub> f.p., soly, etc. .... II 640  
 + NH<sub>4</sub>H<sub>2</sub>PO<sub>4</sub> + H<sub>2</sub>O ..... II 744, 5  
 + NH<sub>3</sub> + NH<sub>4</sub>CO<sub>2</sub>NH<sub>2</sub> f.p., soly, etc. .... II 640  
 + NH<sub>4</sub>NO<sub>3</sub> ..... II 728  
 + NH<sub>4</sub>NO<sub>3</sub> + H<sub>2</sub>O ..... II 719, 20  
 + S ..... II 1402  
 + SrBr<sub>2</sub> + H<sub>2</sub>O ..... II 1481  
 + ZnSO<sub>4</sub> + H<sub>2</sub>O ..... II 1688  
**Urea nitrate** + NaNO<sub>3</sub> + NH<sub>4</sub>NO<sub>3</sub> ..... II 728  
**Urethan** + AlCl<sub>3</sub> + H<sub>2</sub>O ..... I 109

<b>Urethane</b> + AsBr <sub>3</sub> .....	I 230	+ H <sub>2</sub> S .....	II 1634
+ CaCl <sub>2</sub> + H <sub>2</sub> O .....	I 591	in hydrocarbons .....	II 1633
+ HgCl <sub>2</sub> .....	I 1229	+ methyl ether .....	II 1634
+ HgCl <sub>2</sub> + nitronaphthalene .....	I 1229	+ methyl alc. .....	II 1634
+ HgCl <sub>2</sub> + p-nitrotoluene .....	I 1229	in O <sub>2</sub> (liq.) .....	II 1634
+ KCl + H <sub>2</sub> O .....	II 164	in aq. salts .....	II 1632
+ KI + H <sub>2</sub> O .....	II 227	+ SO <sub>2</sub> .....	II 1634
+ K <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O .....	II 324	+ trimethylboron .....	II 1634
+ MgSO <sub>4</sub> + H <sub>2</sub> O .....	II 538	<b>p-Xylene</b> + AlBr <sub>3</sub> .....	II 1634
+ MnSO <sub>4</sub> + H <sub>2</sub> O .....	II 571	<b>Xylene</b> + HBr .....	I 1161
+ (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + H <sub>2</sub> O .....	II 772	+ SO <sub>2</sub> + n-decane .....	II 1419
+ NH <sub>4</sub> Cl + H <sub>2</sub> O .....	II 676	<b>Xylenes</b> + SbBr <sub>3</sub> .....	II 1426
+ Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> + H <sub>2</sub> O .....	II 1154	+ SbCl <sub>3</sub> .....	II 1434
+ ZnSO <sub>4</sub> + H <sub>2</sub> O .....	II 1688	<b>Xylene sulfonate</b> + benzoic acid + H <sub>2</sub> O .....	II 883
<b>U(SO<sub>4</sub>)<sub>2</sub></b> in H <sub>2</sub> O .....	II 1625	<b>o-Xylidine (as.)</b> + CO <sub>2</sub> (v.p.) .....	I 484
in aq. H <sub>2</sub> SO <sub>4</sub> .....	II 1625	<b>Y acetate</b> in ethylenediamine .....	II 1634
in aq. solns. .....	II 1626	in H <sub>2</sub> O .....	II 1634
<b>V</b> in Hg .....	II 1626	<b>Y acetylacetonate</b> in organic solns. .....	II 1636
extrn. from aq. HF by ethyl ether .....	II 1627	<b>YBr<sub>3</sub></b> in H <sub>2</sub> O .....	II 1634
<b>VC(SO<sub>4</sub>)<sub>2</sub></b> in H <sub>2</sub> O .....	I 902	<b>YCl<sub>3</sub></b> in alc. .....	II 1638
<b>VO<sub>3</sub></b> + CaO .....	II 1627	in HCl .....	II 1638
+ SO <sub>3</sub> + H <sub>2</sub> O .....	II 1628	in H <sub>2</sub> O .....	II 1638
<b>V<sub>2</sub>O<sub>3</sub></b> + SiO <sub>2</sub> .....	II 1627	in pyridine .....	II 1638
<b>V<sub>2</sub>O<sub>5</sub></b> in acid solns. .....	II 1627	<b>Y cobalticyanide</b> in HCl .....	II 1636
+ CoO .....	I 629	<b>Y(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub></b> in ethylamine oxalate .....	II 1637
+ CoO .....	II 1628	in H <sub>2</sub> O .....	II 1637
+ HF + H <sub>2</sub> O .....	II 1626	<b>Y<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub>·9H<sub>2</sub>O</b> in HNO <sub>3</sub> solns. .....	II 1638
in H <sub>2</sub> O .....	II 1626	<b>Y<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub></b> in H <sub>2</sub> SO <sub>4</sub> .....	II 1637
in H <sub>2</sub> SO <sub>4</sub> solns. .....	II 1630	<b>Y<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub>·4K<sub>2</sub>C<sub>2</sub>O<sub>4</sub>·12H<sub>2</sub>O</b> in H <sub>2</sub> O .....	II 1637
+ K <sub>2</sub> CO <sub>3</sub> .....	II 101	<b>Y<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub></b> in methylamine oxalate .....	II 1637
+ K <sub>2</sub> O .....	II 280	in (NH <sub>4</sub> ) <sub>2</sub> C <sub>2</sub> O <sub>4</sub> ·H <sub>2</sub> O .....	II 1637
+ K <sub>2</sub> SO <sub>4</sub> .....	II 326	in triethylamine oxalate .....	II 1637
+ K <sub>2</sub> S <sub>2</sub> O <sub>7</sub> .....	II 326	<b>Y dimethyl phosphate</b> in H <sub>2</sub> O .....	II 1641
+ KVO <sub>3</sub> .....	II 340	<b>YF<sub>3</sub></b> + CsF .....	I 889
+ Li <sub>2</sub> O .....	II 431	+ KF .....	II 211
+ MoO <sub>3</sub> .....	II 574	+ LiF .....	II 414
+ Na <sub>2</sub> O .....	II 1178	+ RbF .....	II 1370
+ Na <sub>2</sub> O + H <sub>2</sub> O .....	II 1174, 5, 6	<b>Y ferrocyanides</b> .....	II 1636
+ Na <sub>2</sub> SO <sub>4</sub> .....	II 1149	<b>Y glycolate</b> in H <sub>2</sub> O .....	II 1635
+ Na <sub>2</sub> O + SO <sub>3</sub> + H <sub>2</sub> O .....	II 1629	<b>Y hexaantipyrine iodide</b> in H <sub>2</sub> O .....	II 1639
+ Na <sub>2</sub> O + SO <sub>3</sub> + H <sub>2</sub> O .....	II 1136	<b>Y hexaantipyrine perchlorate</b> in H <sub>2</sub> O .....	II 1639
+ NaVO <sub>3</sub> .....	II 1178	<b>Y(IO<sub>3</sub>)<sub>3</sub>·3H<sub>2</sub>O</b> in H <sub>2</sub> O .....	II 1639
+ PbO .....	II 1313	<b>Y lactate</b> in H <sub>2</sub> O .....	II 1635
+ SO <sub>3</sub> + H <sub>2</sub> O .....	II 1629, 30	<b>Y malonate</b> in NH <sub>4</sub> malonate solns. .....	II 1635
+ Ti <sub>2</sub> O .....	II 1590	<b>Y Na ethylene diamine tetracetate</b> in H <sub>2</sub> O .....	II 1635
<b>VO<sub>3</sub>F<sub>2</sub></b> + 2KNO <sub>3</sub> = VO <sub>2</sub> (NO <sub>3</sub> ) <sub>2</sub> + KF + H <sub>2</sub> O .....	II 205	<b>Y(NO<sub>3</sub>)<sub>3</sub></b> distr. betwn. tributyl phosphate + H <sub>2</sub> O .....	II 1639
<b>VO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub></b> + KF = 2KNO <sub>3</sub> + VO <sub>2</sub> F <sub>2</sub> + H <sub>2</sub> O .....	II 205	in n-hexyl ketone + H <sub>2</sub> O .....	II 1639
<b>(VO<sub>3</sub>)(PO<sub>4</sub>)<sub>2</sub></b> .....	II 1628	in ethyl ether .....	II 1639
<b>(V<sub>2</sub>O<sub>5</sub>)(SO<sub>4</sub>)<sub>3</sub></b> .....	II 1629	in H <sub>2</sub> O .....	II 1639
<b>Valeric acid</b> + NaH <sub>4</sub> .....	II 785	in isooxymyl alc. .....	II 1639
<b>Vinyl chloride</b> + SO <sub>2</sub> .....	II 1421	in methyl n-hexyl ketone .....	II 1639
<b>W</b> + WO <sub>3</sub> + K <sub>2</sub> WO <sub>4</sub> .....	II 340	+ Y(OH) <sub>3</sub> + H <sub>2</sub> O .....	II 1640
+ WO <sub>3</sub> + Na <sub>2</sub> WO <sub>4</sub> .....	II 1179	<b>Y<sub>2</sub>O<sub>3</sub></b> in ether .....	II 1639
+ WO <sub>3</sub> + Na <sub>2</sub> WO <sub>4</sub> + K <sub>2</sub> WO <sub>4</sub> .....	II 340	in ether + HCl + H <sub>2</sub> O .....	II 1638
<b>WO<sub>3</sub></b> + CaF .....	I 889	in HCl + H <sub>2</sub> O .....	II 1638
in aq. HCl .....	II 1631	in H <sub>2</sub> O .....	II 1640
in HCl solns. .....	II 1631	ppt from NH <sub>4</sub> acetate .....	II 1640
+ HF + H <sub>2</sub> O .....	II 1631	<b>3Y<sub>2</sub>O<sub>3</sub>·4H<sub>2</sub>O<sub>3</sub>·2H<sub>2</sub>O</b> .....	II 1640
+ KF .....	II 211	<b>Y(OH)<sub>3</sub></b> .....	II 1640
in aq. KF .....	II 1631	+ Y(NO <sub>3</sub> ) <sub>3</sub> + H <sub>2</sub> O .....	II 1640
+ K <sub>2</sub> MoO <sub>4</sub> .....	II 246	<b>Y<sub>4</sub>(P<sub>2</sub>O<sub>6</sub>)<sub>3</sub></b> in aq. HCl .....	II 1640
+ K <sub>2</sub> WO <sub>4</sub> .....	II 340	<b>Y<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub></b> in H <sub>2</sub> O .....	II 1641
+ LiF .....	II 414	<b>Y<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub></b> in aq. Na <sub>2</sub> SO <sub>4</sub> .....	II 1642
+ Li <sub>2</sub> WO <sub>4</sub> .....	II 441	in aq. UO <sub>2</sub> SO <sub>4</sub> .....	II 1642
+ MoO <sub>3</sub> .....	II 574	<b>Y sulfonates</b> in H <sub>2</sub> O .....	II 1636
+ NaF .....	II 1040	<b>Y tartrate</b> in NH <sub>4</sub> tartrate soln's .....	II 1635
+ Na <sub>2</sub> WO <sub>4</sub> .....	II 1179	in aq. tartaric acid .....	II 1635
+ PbO .....	II 1313	<b>Yb bromonitrobenzene sulfonate</b> in H <sub>2</sub> O .....	II 1643
+ RbF .....	II 1370	<b>YbCl<sub>3</sub></b> in aq. HCl .....	II 1643
+ Rb <sub>2</sub> WO <sub>4</sub> .....	II 1381	<b>Yb cobalticyanide</b> in aq. HCl .....	II 1642
+ W + K <sub>2</sub> WO <sub>4</sub> .....	II 340	<b>Yb<sub>2</sub>(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub></b> in (COOH) <sub>2</sub> + Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub> .....	II 1643
+ W + Na <sub>2</sub> WO <sub>4</sub> .....	II 1179	in H <sub>2</sub> O .....	II 1642
+ W + Na <sub>2</sub> WO <sub>4</sub> + K <sub>2</sub> WO <sub>4</sub> .....	II 340	in aq. soln. .....	II 1642
<b>Xe</b> in aniline .....	II 1633	<b>Yb dimethyl phosphate</b> in H <sub>2</sub> O .....	II 1643
+ BF <sub>3</sub> .....	I 261	<b>Yb<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub></b> in H <sub>2</sub> O .....	II 1643
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+ diborane .....	II 1634	+ Ga .....	II 1644
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 in  $\text{H}_2\text{SiF}_6$  ..... II 1666  
**ZnSiO<sub>3</sub> + CdSiO<sub>3</sub>** ..... I 763  
**Zn stearate** ..... II 1656  
**Zn tartrate** in  $\text{H}_2\text{O}$  ..... II 1651  
**Zn tetramine perchlorate** in aq.  $\text{NH}_3$  ..... II 1680  
**Zn tetrachlorophthalate** in  $\text{H}_2\text{O}$  ..... II 1652  
**Zn valerate** in aq. alc. ..... II 1651  
**Zn xanthate** ..... II 1651  
**Zn xanthopentate** in  $\text{H}_2\text{O}$  ..... II 1651  
**Zr + O + H** ..... II 1689  
 $+ \text{ZrO}_2$  ..... II 1689  
**ZrC + NbC** ..... II 1181  
**Zr<sub>4</sub>V** extr'n. from  $\text{HCl}$  by butyl phosphate ..... II 1691  
 extrn. from  $\text{HF}$  by diethyl ether ..... II 1692  
 extr'n. by fluorinated diketones ..... II 1692  
 extrn. by methyl isobutyl ketone ..... II 1695  
**ZrC<sub>2</sub>O<sub>4</sub> + Na<sub>2</sub>(COO)<sub>2</sub> + H<sub>2</sub>O** ..... II 957  
**ZrCl<sub>4</sub>** ..... II 1691  
 $+ \text{KCl}$  ..... II 1691  
 $+ \text{MgCl}_2$  ..... II 494  
 $+ \text{NaCl}$  ..... II 1012, 1691  
 $+ \text{NaCl} + \text{KCl}$  ..... II 1691  
 $+ \text{NbCl}_5$  ..... II 1181  
 in nitrobenzene +  $\text{POCl}_3$  ..... II 1244  
 $+ \text{POCl}_3$  ..... II 1691  
 in  $\text{SO}_2$  (liq.) ..... II 1691  
**Zr cupferrate** in acidic solution ..... I 1177  
**Zr cupferrate** in acidic solns. .... II 1690  
**ZrF<sub>4</sub>** in  $\text{HF}$  ..... II 1692  
 $+ \text{HF} + \text{H}_2\text{O}$  ..... II 1692  
 in  $\text{HNO}_3$  ..... II 1692  
 in  $\text{H}_2\text{O}$  ..... II 1692  
 $+ \text{NaF}$  ..... II 1040  
 $+ \text{UF}_4 + \text{NaF}$  ..... II 1040  
**ZrK<sub>2</sub>F<sub>6</sub>** in aq.  $\text{HF}$  ..... II 1692  
**Zr(NH<sub>4</sub>) fluorides** in  $\text{H}_2\text{O}$  ..... II 1693  
**Zr(NH<sub>4</sub>)<sub>2</sub>F<sub>6</sub> + Zr(NH<sub>4</sub>)<sub>2</sub>F<sub>7</sub> + H<sub>2</sub>O** ..... II 1693  
**Zr(NH<sub>4</sub>)<sub>2</sub>F<sub>7</sub>** in aq.  $\text{NH}_4\text{F}$  ..... II 1693



<b>Zr(OH)<sub>4</sub></b> .....	II 1695	+ Zr(NH <sub>4</sub> ) <sub>2</sub> F <sub>6</sub> + H <sub>2</sub> O .....	II 1693
in H <sub>2</sub> O .....	II 1695	<b>Zr(NO<sub>3</sub>)<sub>4</sub></b> in ethyl ether .....	II 1695
<b>ZrO(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub></b> in aq. HCl .....	II 1695	in HNO <sub>3</sub> solns. ....	II 1694
<b>ZrO(NO<sub>3</sub>)<sub>2</sub></b> in isoamyl alc. ....	II 1695	<b>ZrO<sub>2</sub></b> + BaO .....	I 383
<b>Zr(SCN)<sub>4</sub></b> distr. betwn. H <sub>2</sub> O and ether .....	II 1690, 1	+ CaCl <sub>2</sub> .....	I 597
<b>Zr(SO<sub>4</sub>)<sub>2</sub></b> in H <sub>2</sub> O .....	II 1699	+ CaCl <sub>2</sub> .....	II 1695
in H <sub>2</sub> SO <sub>4</sub> solns. ....	II 1696, 7	in cryolite .....	II 1695
<b>2Zr(SO<sub>4</sub>)<sub>2</sub>·7Ti<sub>2</sub>SO<sub>4</sub>·8H<sub>2</sub>O</b> .....	II 1699	+ SO <sub>3</sub> + H <sub>2</sub> O .....	II 1698
<b>Zr sulfates</b> distr. betwn. H <sub>2</sub> O and ether .....	II 1699	+ Zr .....	II 1689
<b>Zr(SO<sub>4</sub>)<sub>2</sub></b> , <b>Zr(NO<sub>3</sub>)<sub>4</sub></b> in HCl + H <sub>2</sub> SO <sub>4</sub> .....	II 1691	<b>ZrOBz<sub>2</sub></b> in aq. HBr .....	II 1690
<b>Zr(SO<sub>4</sub>)<sub>2</sub></b> in ZrO <sub>2</sub> solns. ....	II 1699	<b>ZrOC<sub>2</sub>O<sub>4</sub></b> + Cs oxalate + H <sub>2</sub> O .....	I 880
<b>4Zr(SO<sub>4</sub>)<sub>2</sub>·3SO<sub>2</sub>·14H<sub>2</sub>O</b> .....	II 1696	+ K <sub>2</sub> C <sub>2</sub> O <sub>4</sub> + H <sub>2</sub> O .....	II 112
<b>Zr(SO<sub>4</sub>)<sub>2</sub>·2Ti<sub>2</sub>SO<sub>3</sub>·4H<sub>2</sub>O</b> .....	II 1699	+ Li <sub>2</sub> C <sub>2</sub> O <sub>4</sub> + H <sub>2</sub> O .....	II 388
<b>ZrSiO<sub>4</sub></b> + Li <sub>4</sub> SiO <sub>4</sub> .....	II 440	+ Rb <sub>2</sub> C <sub>2</sub> O <sub>4</sub> + H <sub>2</sub> O .....	II 1362
<b>Zr thenoyl trifluoro acetate</b> in benzene, + HClO <sub>4</sub> .....	II 1690	<b>ZrOCl<sub>2</sub></b> in aq. HCl .....	II 1691
		<b>ZrOF<sub>2</sub></b> in aq. HF .....	II 1694